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Utilization of 'Alugbati' (*Basella alba* L.) Leaves Powder to Increase Vitamin A Content of Fresh Egg Noodles

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In the Philippines, indigenous vegetables like 'alugbati' (*Basella alba* L.) can be utilized to address micronutrient deficiencies, such as vitamin A deficiency (VAD). This study aimed to develop fresh egg noodles with higher vitamin A content through the utilization of 'alugbati' leaves powder. Powder from 'alugbati' leaves was produced through dehydration of fully expanded leaves. The resultant powder was used to create three formulations of fresh egg noodles at 10%, 15%, and 20% substitution levels, with 100% wheat flour serving as the control. All formulations and the control were subjected to a water disintegration test and preference ranking test. The most preferred formulation was further evaluated for proximate composition, total carotenoid content (TCC), color, physical characteristics, and consumer acceptability. Data from triplicate experiments were statistically analyzed ($p \leq 0.05$). Results showed that all samples were resistant to water disintegration (20 min in boiling water) and egg noodle with 15% substitution level was the most preferred. This sample had significantly higher ash (2.27 ± 0.28), fiber (1.77 ± 0.38), and protein (11.50 ± 0.11) contents than the control. A significantly higher TCC (1550 µg/g) compared to the control (610 µg/g) also signified that substituting with 'alugbati' leaves powder increased the vitamin A content of the noodles. From this, consuming 5–10 g of 'alugbati' egg noodles will be able to provide the vitamin A requirement of 400–800 µg retinol equivalent (RE). The egg noodles with a 15% substitution level also had a significantly darker green color and significantly lower elasticity. Moreover, this formulation was generally acceptable with mean Hedonic scores ranging from 7.20 (Like Moderately) to 7.80 (Like Very Much). This study demonstrated that fresh egg noodles with 'alugbati' leaves powder can be a good source of vitamin A. Clinical studies should be conducted to determine the role of the product in alleviating VAD especially in children and pregnant women.

Keywords: 'alugbati,' egg noodles, vitamin A

INTRODUCTION

Micronutrient deficiency is a state wherein the body lacks the essential vitamins and minerals that are needed for growth and development (Black 2003). This leads to stunting, wasting, and other severe illnesses. The three most common forms of malnutrition worldwide are iron deficiency anemia, iodine deficiency disorder, and VAD. VAD remains a public health issue among children and pregnant women in underdeveloped and developing countries (WHO 2017). In the Philippines, the quintennial National Nutrition Survey conducted by the FNRI (2015a) stated that the mortality rates caused by VAD have

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declined over the years. However, the overall prevalence rate of VAD increased from 5.9% in 2008 to 6.1% in 2013. Among preschool children, VAD had 20.4% prevalence.

Several government and non-government organizations and institutions continue to exert efforts in addressing the issue of micronutrient deficiency. Aside from the programs implemented to improve Filipino nutrition, several product development studies were also conducted. For instance, "Pancit Canton with Squash" and "Rice-Mongo Curls" are made from locally available crops and indigenous vegetables (FNRI 2019).

Indigenous vegetables are crops that originate from certain geographical locations, including naturalized species and/or evolved varieties (Oraye *et al.* 2017). These are considered good sources of vitamins and minerals and can diversify the Filipino diet by providing micronutrients and fiber, leading to increased nutritional intake. However, indigenous vegetables are generally underutilized due to the lack of information about crop use and importance and the negative notion that regards it as "food for the poor" (FAO 2014). In the Philippines, some commonly used indigenous vegetables include bitter gourd ('ampalaya'), squash ('kalabasa'), and Malabar spinach ('alugbati').

'Alugbati' (*Basella alba* L.) is primarily utilized as food. It also has medicinal value. The two varieties mainly used in the country are red-stemmed and green-stemmed. 'Alugbati' is rich in saponins, xanthone, and other vitamins and minerals. It is also regarded as a good source of vitamin A. Tongco *et al.* (2015) reported that fresh 'alugbati' leaves are relatively high in crude ash and crude protein, which signifies that it has a high mineral content and can help address protein energy malnutrition (PEM) in the country. Thus, 'alugbati' can be utilized in food fortification and enrichment in certain products, such as noodles.

Noodles can be used as carriers of nutrients through the incorporation of plant-based or animal-based ingredients, which can enhance the nutrient content and/or provide specific physiological functions (Alemayehu *et al.* 2016). There are already existing products and studies applying vegetables in noodles. However, the utilization of 'alugbati' leaves powder in the production of egg noodles had not yet been explored.

This study generally aimed to utilize 'alugbati' leaves powder in fresh egg noodles as a good source of vitamin A. The specific objectives were to (1) characterize the 'alugbati' leaves powder in terms of proximate composition, TCC, and color; (2) determine the most preferred formulation of fresh egg noodles with 'alugbati' leaves powder; (3) assess its proximate composition; (4) evaluate its quality in terms of resistance to water disintegration, vitamin A content, color, and physical characteristics; and (5) assess its consumer acceptability.

MATERIALS AND METHODS

Preparation of Powder from 'Alugbati' (*Basella alba* L.) Leaves

'Alugbati' (green variety) was purchased from Mintal Public Market, Davao City, Philippines. The powder was prepared from the fully expanded leaves according to the methods described by Alemayehu *et al.* (2016) and Chang and Wu (2008) with modifications. The 'alugbati' leaves were separated from the stem and then washed with tap water. The leaves were placed on a tray and air-dried for 1–2 h, after which they were dried in a food dehydrator (Ambiano, Australia) for 7 h at 70 ºC. The dried leaves were blended to a fine powder using a blender (Blendtec, USA). The resulting powder was transferred into a sealed plastic bag and stored in a cool, dry place until use. The powder was partially characterized in terms of proximate composition, TCC, and color.

Preparation of 'Alugbati' Egg Noodles

'Alugbati' egg noodles were prepared according to the formulations described by Alemayehu *et al.* (2016) with some modifications. The 10%, 15%, and 20% of the wheat flour used was replaced with 'alugbati' leaves powder. Noodles without 'alugbati' leaves powder were also prepared as the control.

The wheat flour, 'alugbati' leaves powder, and salt were sifted into a mixing bowl and a well was formed in the center. The wet ingredients (egg yolk and water) were then added into the well. The ingredients were mixed and kneaded into a smooth dough, which was wrapped and rested in a bowl for 1 h at ambient temperature (25 ºC).

The dough was rolled out into a thin, rectangular sheet using a rolling pin. The rectangular dough was then passed through the manual noodle cutter with the rollers consistently dusted with flour. The width of the noodles was 2 mm. After cutting, the noodles were set aside for 1 h (Lee 2014). These were then boiled in 1000 mL tap water for 60 s and immediately rinsed with cold water then drained. The noodles were stored in a sealed plastic bag at 2–3 ºC until further use.

For the cooking quality, the doneness of the noodles was determined through obtaining a single strip from the pot and slicing the strip in the middle. The absence of any white spot on the core of the noodle strip indicated that it was cooked. This procedure was done thrice to ensure that the noodles were cooked uniformly. The average cooking period was then determined from the time obtained from three trials.

Resistance to Water Disintegration

The 'alugbati' egg noodle formulations including the control were subjected to a water disintegration test adapted and modified from Fishman *et al.* (1996). Noodle strips were weighed (5 g each) and cut to a length of 5 cm. These were cooked in 100 mL distilled water at 100 ºC. The time required for the noodle strips to visually disintegrate was determined. The noodle strips were observed qualitatively during the test and those that remained undissolved after 20 min were considered resistant to water disintegration.

Preference Ranking Test

The four noodle formulations were separately cooked into stir-fried noodles. Minced garlic (7 g) and 14 g chopped onions were sautéed, then 64 g julienned carrots, 128 g thinly sliced cabbage, and 4 g diced red bell pepper were added along with 100 g diced chicken breast. Chicken broth (238 mL) was poured and the mixture was allowed to boil. The egg noodles (250 g) were then added. The sauce mixture with 5 mL each of sesame oil, soy sauce, and oyster sauce was incorporated in the mixture and the noodles were allowed to cook for 3–5 min, after which salt was added to taste. The stir-fried noodles were subjected to a preference ranking test employing 50 untrained panelists, which included students from 18–22 yr of age who gave their consent to participate in the sensory evaluation exercise. The panelists were asked to rank the four samples based on their preference using a score sheet with "1" as the most preferred and "4" as the least preferred. In addition to ranking the products, the panelists were also asked to qualitatively describe the noodles.

Proximate Analysis

The 'alugbati' leaves powder, most preferred 'alugbati' egg noodle formulation (boiled), and the control (boiled) were subjected to proximate analysis. Samples were analyzed for moisture (AOAC 925.10), ash (AOAC 923.03), fat (AOAC 920.39C), fiber (AOAC 984.04), and protein (AOAC 984.14) content. The carbohydrate content of the powder was calculated by difference (100 – Ash – Protein – Fat – Moisture).

TCC Analysis

The TCC of the powder and the egg noodle samples was determined, employing the method of Sahabi *et al.* (2012). From this, the TCC of the sample was calculated using the equation from Wang and Liu (2009):

$$TC\ (mg\ per\ 100g) = \frac{A\ x\ y(mL) x\ 10^6}{A_{1cm}^{\%}\ x\ 1000\ x\ w} \quad (1)$$

where A was the absorbance of the extract at 450 nm, y was the volume of the extract (mL), $A_{1cm}^{\%}$ was the extinction coefficient of carotenoids, and w was the weight of the sample (g).

In calculating the vitamin A content of the product in terms of μg RE, the following conversion units were used:

1 RE = 1 μg retinol = 12 μg β-carotene

Color Analysis

The color of the 'alugbati' leaves powder as well as that of the control and the most preferred formulation before and after cooking was analyzed. The color analysis was conducted using a colorimeter (Konica Minolta) and was measured through the CIELAB color values in triplicate readings. The color was expressed in three numerical values: $L*$ indicates lightness, where $L* = 0$ means black and $L* = 100$ means white. The a* value signifies redness (+) and greenness (–), while the b* value implies yellowness (+) and blueness (–) (Khouryieh *et al.* 2006). Chroma indicates the brightness, vividness, or intensity of the color, while the hue angle describes the hue or intensity of the samples. Hue angle and chroma were calculated respectively according to the following equations (Levent and Yesil 2019).

$$Hue\ angle = (\arctan\left[\frac{b^*}{a^*}\right] + 180) \quad (2)$$

$$Chroma = \sqrt{[a^{*2} + b^{*2}]} \quad (3)$$

In analyzing the color of the egg noodles, "before cooking" refers to the fresh egg noodles boiled for 60 s prior to cooking, whereas "after cooking" refers to the cooked fresh egg noodles boiled for 3–4 min.

Physical Characteristics Evaluation

The physical characteristics which include tensile strength and elongation were evaluated using a texture analyzer (Model EZ-SX, Shimadzu, Japan). In this analysis, the noodle tensile jig was used. It conducts tension tests on samples to assess their elasticity and breaking strength in tension. The noodles were boiled for 1–3 min and then blot dried prior to attachment in the tensile jig. A 10–20 cm noodle strip was obtained from each of the noodle samples. It was looped through the slots and wound round parallel friction rollers two or three times. This was done to reduce any possibility of slippage and to anchor the ends. The noodle strips were pulled apart until a break in the extended region occurred (Smewing 2016). The jig speed during the test was set at 1 mm/s. The noodles were analyzed in triplicates at ambient temperature within 5 min after cooking.

Consumer Acceptability Test

The most preferred formulation of the 'alugbati' egg noodles was subjected to a consumer acceptability test against plain egg noodles (control). Both samples were presented as stir-fried noodles. One hundred panelists who gave their prior consent to participate in the consumer test included children (38%) and adults (62%) with 45% of the total respondents belonging to the age range of 19–29 years old. Using a nine-point Hedonic Scale, one hundred panelists were asked to assess their degree of liking or disliking using a scale of 1 (Dislike Extremely) to 9 (Like Extremely). The panelists evaluated the acceptability of the product in terms of appearance, texture, flavor, and overall acceptability. In addition to determining the product acceptability, the panelists were also asked to give qualitative comments on the 'alugbati' egg noodles.

Statistical Analysis

Data from triplicate experiments were statistically analyzed using the GNU PSPP 1.0.1-g818227 statistical analysis software. Results from the preference ranking test were analyzed using Friedman's test. An independent t-test was used to analyze results for proximate composition, TCC, physical characteristics, and consumer acceptability. Two-way analysis of variance was used to analyze color. The statistical analyses were conducted at 0.05 level of significance.

RESULTS AND DISCUSSION

Properties of 'Alugbati' Leaves Powder

'Alugbati' leaves (Figure 1a) were used to obtain 'alugbati' leaves powder (Figure 1b) at a 15% recovery. The proximate composition and TCC of the powder are presented in Table 1. Results indicated that the powder has a high protein content (21.38%), making it suitable for addressing PEM. One study showed that dried 'alugbati' leaves were relatively high in protein (17.55%) (Tongco *et al.* 2015), accounting for the corresponding high protein content of the resultant powder obtained in this study. The powder also exhibited a high ash content (16.17%), which can be attributed to the presence of minerals like calcium, magnesium, and iron in the vegetable. Moreover, the TCC of the 'alugbati' leaves powder was found to be 11490 µg/g (Table 1) corresponding to 957.50 µg RE/g. Based on the Philippine Dietary Reference Intake tables for vitamins, the Recommended Dietary Allowance (RDA) for vitamin A ranges from 400–800 µg RE depending on the age group and gender (FNRI 2015b). This suggests that the µg RE of 1 g 'alugbati' leaves powder from this study exceeds the RDA for vitamin A by at least 20%. Hence, the 'alugbati' leaves powder can be utilized for vitamin A fortification in certain products such as egg noodles.

Table 1. Proximate composition, TCC, and color of 'alugbati' leaves powder.

Moisture content (%)	12.06 ± 0.36
Ash (%)	16.17 ± 0.28
Crude fat (%)	10.36 ± 0.44
Crude fiber (%)	4.66 ± 0.45
Crude protein (%)	21.38 ± 1.58
Carbohydrate content* (%)	40.03
TCC (µg/g)	11490.00 ± 0.64
L^*	35.83 ± 0.08
a^*	–81.00 ± 1.73
b^*	3.49 ± 0.04
Hue angle	177.53 ± 0.02
Chroma	81.08 ± 1.73

Values are expressed as means ± SD, n = 3.
*Carbohydrate value was calculated by 100 – Ash – Protein – Fat – Moisture.

In terms of color, the 'alugbati' leaves powder was significantly darker (L^* = 35.83) and had a greener shade (a^* = –81.00) than wheat flour (L^* = 77.41; a^* = 0.30). The CIELAB color chart shows yellow at 90º and

Figure 1. Fresh 'alugbati' leaves (A) and alugbati' leaves powder prepared by dehydration (B).

green at 180º. The calculated hue angle of the 'alugbati' leaves powder is 177.53º (Table 1), which means that the powder retained the green color of the leaves. The chroma of 81.08, on the other hand, means a vivid color. Color from agricultural produce is derived from natural pigments such as chlorophyll (green), carotenoids (yellow, orange, and red), water-soluble anthocyanins (red, blue), flavonoids (yellow), and betalains (red). However, these pigments may change as the plant undergoes maturation, ripening, and processing (Barrett *et al.* 2010). Noodle quality, especially color, depends on the characteristics of the corresponding flour as well as conditions during noodle preparation (Levent and Yesil 2019).

Properties of Egg Noodles

Cooking quality. Three formulations of 'alugbati' egg noodles were developed with 10%, 15%, and 20% substitution levels, as shown in Figure 2. The average cooking periods for the three formulations were 3 min and 15 s, 3 min and 6 s, and 2 min and 35 s, respectively, while the cooking time for the control was 3 min and 25 s. These cooking times coincided with the estimated cooking time for fresh egg noodles (3–4 min) as reported by Tecstra Systems (2018). Fresh egg noodles usually cook faster than dry durum wheat pasta, which usually takes 10–12 min. The cooking time required to cook noodles depends on the type of noodles, whether it is fresh or dried, pre-soaked or not (Lee 2014).

Resistance to water disintegration. Results showed that all noodle samples were resistant to water disintegration. Disintegration in this context signified the reduction of the noodles into smaller particles. Noodles with disintegration time exceeding 20 min are considered resistant to water disintegration and, in this study, the noodle strips were still intact after 20 min. Recent studies showed that aside from gluten properties, wheat starch properties also contribute to the wheat noodle structure (Collado and Corke 2003). Starch solubility is also directly proportional to temperature (Ahmad and Williams 1998). Noodles that are resistant to water disintegration are a result of satisfactory noodle production and are guaranteed to not fall apart when overcooked.

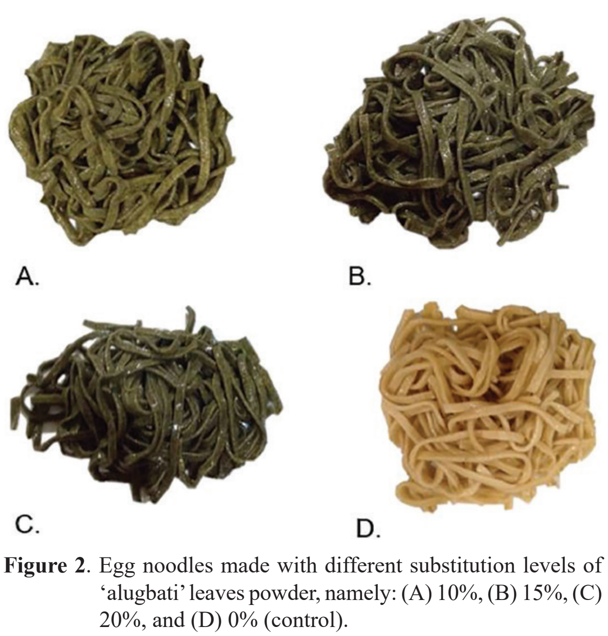

Figure 2. Egg noodles made with different substitution levels of 'alugbati' leaves powder, namely: (A) 10%, (B) 15%, (C) 20%, and (D) 0% (control).

Preference ranking test. Results from the preference ranking test showed that noodles with 10% and 15% substitution levels were similarly preferred and significantly more preferred than the 20% substitution level and the control (Table 2). Compared to the 10% substitution level, a higher substitution level at 15% also signifies a higher amount of 'alugbati' and consequently higher fortification rate. Therefore, the formulation with a 15% substitution level was selected for further evaluation. The panelists also commented that despite the "unappealing" color of the 'alugbati' egg noodles, this product was still preferred over the control due to its "distinct flavor." The control was also described as "heavy and bland."

Proximate analysis. The proximate composition data for the noodles prepared with 15% substitution level and the control are listed in Table 3. There was no significant

Table 2. Preference ranking test results for the control sample and the different 'alugbati' egg noodle formulations.

% 'Alugbati' leaves powder	Rank sum
0	149^{b}
10	110^{a}
15	109^{a}
20	132^{b}

Rank sums not sharing the same letter are significantly different ($p < 0.05$); a lower rank sum indicates a higher preference.

Table 3. Proximate composition, TCC, and RE of the egg noodles.

Composition	Egg noodles substituted with 15% 'alugbati' leaves powder (%)	Control (%)
Moisture (%)	$64.65^{a} \pm 0.67$	$65.09^{a} \pm 0.11$
Ash (%)	$2.27^{b} \pm 0.28$	$1.40^{a} \pm 0.45$
Fat (%)	$8.95^{a} \pm 1.93$	$6.12^{a} \pm 1.25$
Fiber (%)	$1.77^{b} \pm 0.38$	$1.09^{a} \pm 0.08$
Protein (%)	$11.50^{b} \pm 0.11$	$10.42^{a} \pm 0.35$
TCC (β-carotene) (μg/g)	$1550^{b} \pm 0.37$	$610^{a} \pm 0.10$
RE (μg RE)	129.17^{b}	50.83^{a}

Values in the same row not sharing the same letters are significantly different ($p < 0.05$).

difference between the moisture content of the 'alugbati' egg noodles and the control which ranged from 64.65–65.09%. Robertson (2016) explained that the moisture content of fresh noodles is at least 24% and may increase up to 50–60% when fresh noodles are partially boiled for 1–2 min. The high moisture content of the noodles suggests shorter shelf life than the dried counterpart, hence the need for refrigeration.

'Alugbati' egg noodles at 15% substitution level exhibited significantly higher values than the control for crude ash, crude fiber, and crude protein. Crude ash in food samples is an estimate of the total mineral content – including calcium, magnesium, and iron. For plain egg noodles, the maximum ash content is 1.3% (BPPA 2001). Although a good source of energy, noodles have little to no mineral content due to the losses that occur during processing. Tongco *et al.* (2015) indicated that dried 'alugbati' leaves contained high amounts of ash at 15%. This reported high ash content of the leaves may have contributed to the corresponding high ash content of the resultant powder (16.17%), which was used in the egg noodles. According to Mihiranie *et al.* (2017), all-purpose wheat flour has 0.49% ash compared to 16.17% ash in 'alugbati' leaves powder, explaining why the 'alugbati' egg noodles had significantly higher ash content than the control. For crude fiber, the resulting values were within the standard fiber content for noodles, ranging from 1–3% (Stephen 1997). The 'alugbati' leaves powder was shown to increase the fiber content of the fresh egg noodles. 'Alugbati' leaves powder contains 4.66% crude fiber, which is higher than the reported value of 0.51% for all-purpose wheat flour (Mihiranie *et al.* 2017), accounting for the significantly higher fiber content of the 'alugbati' egg noodles. For crude protein, the results obtained were slightly lower than the standard protein content for egg noodles, which is from 12–14% (Stephen 1997), as the heat-sensitive proteins may have been denatured during boiling (Li *et al.* 2017). According to the results, incorporation of 'alugbati' leaves powder allowed for higher protein content of the noodles. Comparing the protein content of all-purpose wheat flour (9.57%) (Mihiranie *et al.* 2017) with that of 'alugbati' leaves powder (21.38%), the latter is higher, causing the significantly higher protein of the egg noodles substituted with 15% 'alugbati' leaves powder. Moreover, the standard crude fat content of vegetable pasta or noodles ranges from 2%–5% (Stephen 1997). The slightly higher fat content of both samples may be attributed to the addition of egg yolks in the formulation.

TCC. The TCC of 'alugbati' egg noodles was significantly higher than the control (Table 3). The incorporation of the 'alugbati' leaves powder increased the TCC by 54.19%. 'Alugbati' is considered to be a good source of vitamin A, as 1158 IU of vitamin A can be acquired per 100 g of cooked 'alugbati' (USDA 2016). Consuming 5–10 g of the 'alugbati' egg noodles can help provide the required RDA of vitamin A for children, lactating and pregnant women, adults, and the elderly.

Vitamin A intakes are usually expressed as RE. The carotenoids present in the sample were converted to retinol, the active form of vitamin A. The most common carotenoids with pro-vitamin A activity are α-carotene and β-carotene; however, they are susceptible to degradation through isomerization and oxidation, which usually happen during cooking (Carvalho *et al.* 2014).

Color profile. There were significant differences in the L^*, a^*, b^*, hue angle, and chroma values of the 'alugbati' egg noodles and the control sample both before and after cooking (Table 4). The use of 'alugbati' leaves powder significantly lowered the yellowness and increased the darkness and greenness of the noodles. This result was expected since the 'alugbati' egg noodles had been incorporated with 'alugbati' leaves powder, which is dark green in color (refer to Figure 2B and 2D). This is further shown in the hue angle values wherein the 177.23º of the 'alugbati' egg noodles and 91.75º of the control are close to the hue angles of green (180º) and yellow (90º), respectively. Based on chroma, the 'alugbati' egg noodles were more vivid or more color-saturated than the control. Cooking also affected the color of the product. The color of the 'alugbati' egg noodles and the control significantly changed in L^* and a^* values after cooking. The control noodles had higher hue angle and lower chroma values after cooking, indicating a further shift from yellow and

Table 4. Color profile of the egg noodle samples before and after cooking.

% 'Alugbati' leaves powder	Conditions									
	Before cooking					After cooking				
	L^*	a^*	b^*	Hue angle	Chroma	L^*	a^*	b^*	Hue angle	Chroma
15	35.89^{Ac} ± 0.25	-66.00^{Ad} ± 1.73	3.19^{Ac} ± 0.23	177.23^{Bc} ± 0.12	66.08^{Bc} ± 1.74	38.33^{Ad} ± 0.26	-100.32^{Ac} ± 0.01	5.03^{Ac} ± 0.14	177.13^{Bc} ± 0.08	100.45^{Bd} ± 0.02
0	69.03^{Bc} ± 0.35	-0.47^{Bd} ± 0.12	15.53^{Bc} ± 0.75	91.75^{Ac} ± 0.52	15.54^{Ad} ± 0.75	70.34^{Bd} ± 0.61	-0.99^{Bc} ± 0.04	13.49^{Bc} ± 0.43	94.20^{Ad} ± 0.24	13.53^{Ac} ± 0.43

^{AB}Values in the same column not sharing the same letters are significantly different ($p < 0.05$); ^{cd}values in the same row not sharing the same letters are significantly different ($p < 0.05$); before cooking refers to the fresh egg noodles boiled for 60 s prior to cooking; after cooking refers to the cooked fresh egg noodles boiled for 3–4 min.

decreased color intensity. On the other hand, cooking did not significantly affect the hue angle of the 'alugbati' egg noodles, preserving the greenness of the product. Moreover, the 'alugbati' egg noodles had a more intense color after 3–4 min of cooking. Measuring the color of new food products developed is necessary as this physical parameter directly affects the initial acceptance of consumers (Cheng and Bhat 2016).

Physical characteristics. The 'alugbati' egg noodles were also subjected to tensile strength and elongation tests and compared to the control (Table 5). These tests were used to measure elasticity and the distance to which a product can be extended or stretched before breaking (SMS 2017).

Table 5. Physical characteristics of the egg noodle samples.

% 'Alugbati' leaves powder	Tensile strength (N)	Elongation (mm)
15	$0.015^{a} \pm 0.003$	$16.01^{a} \pm 3.060$
0	$0.021^{a} \pm 0.004$	$34.96^{b} \pm 1.352$

Values in the same column not sharing the same letters are significantly different ($p < 0.05$).

Results showed that there was no significant difference between the tensile strength of the two samples, signifying that both samples needed the same amount of force to break. However, it can be observed that the 'alugbati' egg noodles had significantly lower elasticity as described by lower elongation values compared to the control as the former broke faster when stretched. This may have been caused by the variation in the amounts of wheat flour incorporated in the noodle samples. The gluten strength of the wheat flour in the 'alugbati' egg noodle may have been diluted due to the substitution with 'alugbati' leaves powder. Substitution of wheat flour would render the gluten matrix impaired, leading to a weakened noodle texture (Ritthiruangdej *et al.* 2011). The sufficient elasticity of the matrix is important for better processing and eating properties of the final product. In this study, the 'alugbati' egg noodles had high protein content but the type of protein present did not have the visco-elastic property of gluten, resulting in noodles with lower elasticity (Ahmed *et al.* 2016).

Consumer acceptability. The 'alugbati' egg noodles with a 15% substitution level were further subjected to a consumer acceptability test against the control using a nine-point Hedonic scale. There was no significant difference in consumer acceptability between the two samples in terms of appearance, texture, flavor, and overall acceptability. The mean Hedonic scores of the 'alugbati' egg noodles ranged from 7.20–7.80 for all sensory attributes, which means that the product was generally acceptable and substitution with 'alugbati' leaves powder did not significantly alter the sensory characteristics of the egg noodles. Most of the panelists also found the 'alugbati' egg noodles "tasty and delicious" (Table 6). Comments regarding the color of the product mostly consisted of "unusual" and "unique." While Asenstorfer *et al.* (2006) explained that people prefer the shining or light-colored yellow noodles than the dark-colored ones, which are generally viewed as less attractive, this study showed no significant difference in consumer acceptability in terms of the appearance of both products.

Table 6. Qualitative comments on the egg noodle samples.

Egg noodles substituted with 15% 'alugbati' leaves powder		Control	
Comment	Number of panelists	Comment	Number of panelists
Tasty and delicious	9	Slightly bland	3
Evident 'alugbati' taste/aroma	3	Good taste	2
Good and balanced flavor	2	Good flavor	1
Moderately good aroma	1	Heavy	1
Good texture	2	Good texture	1
Unusual and unique color/appearance	5	Overpowering oily texture	1

CONCLUSION

The general objective of the present study was to develop a product utilizing 'alugbati' leaves powder in fresh egg noodles as a good source of vitamin A. The 'alugbati' leaves powder, which had a dark green color, was shown to be relatively high in ash and crude protein. The high RE of the powder also signified that it can be utilized for vitamin A fortification. Results from the preference ranking test on fresh egg noodles with 'alugbati' leaves powder indicated that a substitution level of 15% was the most preferred formulation. This was thus subjected to further evaluation.

The 'alugbati' egg noodles with 15% substitution level had significantly higher ash (2.27 ± 0.28), fiber (1.77 ± 0.38), and protein (11.50 ± 0.11) contents compared to the control. This increase may be attributed to the nutrients and minerals added by the 'alugbati' leaves powder in the noodle composition. The noodles were also resistant to water disintegration. Consuming the product can help provide the recommended dietary allowance of vitamin A especially for children, pregnant and lactating women, and the elderly. Moreover, the 'alugbati' leaves powder can be incorporated into other products that need fortifying as it has a relatively high TCC.

The noodles with a 15% substitution level had significantly darker, less yellow, greener, and more intense color. This result was expected due to the incorporation of 'alugbati' leaves powder which had a dark green color. Results also revealed that the 'alugbati' egg noodles had a significantly lower elasticity (elongation = 16.01 mm) compared to the control. Substitution with 'alugbati' leaves powder may have weakened the gluten network, making the noodle easy to break.

Furthermore, the 'alugbati' egg noodles were generally acceptable in terms of appearance, texture, flavor, and overall acceptability, and no significant difference from the control was noted.

For future research, other products that can utilize the other parts of the 'alugbati' plant (*i.e.* stems of the shoot part) can be developed to prevent or reduce food waste.

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