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The Acceptance and Nutritional Value of Crispy Noodles Supplemented with *Moringa oleifera* as a Functional Snack for Children in a Food Insecure Area

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ABSTRACT: Wild foods and underutilized foods are a significant source of nutrients and bioactive components for rural and poor households in food insecure areas. *Moringa oleifera* (or “Kelor” in Indonesia) is a wild plant that can be utilized as a raw food material. The purpose of this study was to analyse preference of and nutrition and bioactive contents in crispy noodles supplemented with *M. oleifera* leaf puree. This work applied a randomized experimental study design with six repetitions. To determine the difference between formulas (F0=0%, F1=10%, and F2=20%), organoleptic properties with hedonic test and data concerning organoleptics were processed using Friedman test and Wilcoxon signed-rank test ($\alpha=0.05$). An organoleptic test from 30 untrained panellists showed that formula F1 (10% of *M. oleifera* leaf puree) was the most preferred level added to the crispy noodles. The content of *M. oleifera* leaf puree significantly influenced the level of aroma and taste of the crispy noodles ($P<0.05$), but not the texture or colour. In addition, crispy noodles supplemented with *M. oleifera* leaf puree provided enough nutrients (protein, vitamin A and C, calcium, and zinc), as well as polyphenol and flavonoid substances, which show several health benefits. Taken together, crispy noodles supplemented with *M. oleifera* leaf puree is a promising functional snack for children at food insecure areas.

Keywords: flavonoid, *Moringa oleifera*, noodle, organoleptic, supplementation

INTRODUCTION

A wild food is a wild plant or animal naturally grown without cultivation or farmed and are usually unused as food (Heywood, 1999; Grosskinsky and Gullick, 1999). Particularly in the food insecure area Madura Island, Indonesia, wild foods show great potency as a source of both macro and micronutrients at the same or even higher levels than conventional cultivated foods. In addition, wild foods contain bioactive phytochemical substances with antioxidant and prebiotic properties (Adi et al., 2013). Wild food such as leaves are rich of vitamins, minerals, and phytonutrients as well as α -tocopherol and phenol (Simopoulos, 2004). However, the potency of these foods have not been explored and it is not known if they are a good food source elsewhere, including in Madura Island, Indonesia and, particularly, for the younger generation and school-age children (Adi et al., 2013; Adi et al., 2014).

Kelor (*Moringa oleifera*) is a wild plant rich in nutrition

that grows abundantly in Madura Island, Indonesia, but has not yet been explored as a food source. The content of protein in 100 g of *Kelor* is 2-fold that in yoghurt, and the calcium content is 4-fold that in milk. The *Kelor* leaf contains vitamin A, C, and E as well as pro-vitamins (Hiawatha, 2018). The World Health Organization has recommended *Kelor* should be used as an affordable supplement for low income countries worldwide, including Indonesia, particularly for school-age children (Hekmat et al., 2015). Furthermore, national data has reported that intake of vegetables by schoolchildren in Indonesia is only 33.9%, far below the recommended intake (Indonesia Ministry of Health, 2014). Low intake of vegetables increases the risk of vitamin deficiency.

Basic school-aged children in Indonesia are 6~12 years of age, which is the age children are most likely to play and consume snacks at school. Snacks at school are predominantly provided by peddlers and have low content of nutrients. In addition, good canteens are rarely availability in schools. According to the Indonesian Food and Drug

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Administration of Republic of Indonesia, more than 99% of school-age children consume snacks at school to fulfil their energy requirements. These snacks affect the health and vitality of students, given that of a student's daily intake 31.1% of energy and 27.4% of protein comes from school meals (Indonesian Food and Drug Administration of Republic of Indonesia, 2013). An analysis of national data found that protein intake of schoolchildren is 8.1 g below recommended levels, and 17.8% schoolchildren were classed as severely deficit (Salimar and Irawati, 2016). It is therefore important to make a snack formula that is highly nutritious for schoolchildren.

Raw food ingredients are not a main consideration during food consumption. More important considerations are how snacks are prepared and how they are served to attract children to eat them. A preliminary study found that *chiki*, macaroni, wafer, and noodles are popular snacks among children and are readily found at schools (Adi et al., 2015). Food formulations based on wild *Kelor* leaves enable these leaves to be implemented in popular snacks such as "crispy noodles" to improve the health benefits of snack with good acceptance by school-age children, particularly in food insecure areas. This project aimed to develop a snack formulation based on wild *Kelor* leaves as a functional crispy noodle snack for school-age children in food insecure areas, and to analyse its acceptance, nutritional value, and biochemical content.

MATERIALS AND METHODS

Research design

This study applied a completely randomized experimental research design with six repetitions. Different crispy noodle formulas were developed using various contents of *Kelor* leaf puree. The parameters observed in this study including aroma, taste, colour, and texture. Informed consent was given before the study by parents since the respondents was <18 years of age. Study withdrawal did not bring any negative consequences. This study was approved by The Health Research Ethics Committee at Faculty of Public Health, Universitas Airlangga (IRB number: 303-KEPK).

Development of crispy noodles supplemented with *M. oleifera*

All cooking processes, including making *Kelor* leaf puree and crispy noodles containing *Kelor* leaf puree, were conducted in the Nutrition Laboratory, Department of Nutrition, Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia. Three formulas were developed in this study: F1, F2, and F3 (Table 1). F1 and F2 were crispy noodles supplemented with 40 and 80 g of *Kelor* leaf puree, respectively. The percentages of *M. oleifera* added to

snacks were decided based on nutritional values that we aimed to increase, i.e. protein and vitamins (A, C, and E), as well as from that reported in the literature, such as amounts that would not change the texture of the noodles (Susilowati and Rizal, 2017). Organoleptic tests with untrained panelists was conducted at selected elementary schools: SDN Patereman 1 and SDN Patengteng 2, Blega sub-district, Bangkalan, Madura Island, Indonesia. Inclusion criteria for organoleptic assessments included student attending elementary school from 4th~6th grade and ability to write and read, and exclusion criteria included colour-blindness. The tools used to prepare *M. oleifera* crispy noodles were a rolling pin, dough mixer maker, manual noodle maker, food processing machine, digital balance spatula, and strainer.

Research duration

This study took four months from preparation to data analysis. We first prepared pure *M. oleifera* leaves as the supplement to be added to noodles, cooked the noodles, carried out organoleptic assessments, and identified the nutritional and bioactive values. To prepare pureed *M. oleifera* leaves, young *Kelor* leaves were cleaned then blanched for 2 min and separated from the water. The young *Kelor* leaves were then mashed using a food processor without water. Table 1 shows the ingredients of each formulation of crispy noodles supplemented with pureed *M. oleifera* leaves.

All ingredients shown in Table 1 were mixed for each formula using a dough mixer with a speed of scale 1. The mixer speed was slowly increased to scale 2, and the oil was added gradually with constant agitation for 20 min until the mixture was dull. The mixture was subsequently divided into several parts (100 g). Further, each part of the mixture was pressed using a rolling pin, and moulded manually using a noodle maker. The noodles were deep fried at 80°C until perfectly cooked with a crispy texture.

Study procedure description

Organoleptic assessment, including assessment of aroma, color, taste, and texture, were collected using a question-

Table 1. The ingredient of *Moringa oleifera* crispy noodles (unit: g)

Ingredient	Formula		
	F0 (0%)	F1 (10%)	F2 (20%)
High protein wheat flour	350	350	350
Cassava flour	50	50	50
Egg	120	120	120
Oil	50	50	50
Salt	10	10	10
<i>Kelor</i> leaf	0	40	80

naire with Likert scale from 1~3 (1=dislike, 2=moderate, and 3=like) to 30 untrained elementary school-age panelists (4th and 5th grade). Panelists were also given mineral water and instructed to drink water before consuming each crispy noodle formula. Analysis of nutritional content was carried out at the Nutrition Laboratory, Department of Nutrition, Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia, while the active components were calculated by comparing theoretical data on bioactive components in *M. oleifera* leaves with the content after preparation.

Statistical analysis

Data analysis was conducted using Friedman tests ($\alpha=0.05$). If a difference was identified, analysis was continued by Wilcoxon signed-rank tests ($\alpha=0.05$). Statistical analysis was carried using IBM Statistics SPSS 22 (IBM Corp., New York, NY, USA).

RESULTS

Three formulas of crispy noodle enriched with *M. oleifera* leaf puree were tested for organoleptic compounds, nutritional value, and bioactive components. Ingredients and quantities used for each formula are presented in Table 1. The content of pure *M. oleifera* leaves in each formulation were 0% (F0), 10% (F1), and 20% (F2).

Organoleptic test results

All organoleptic properties of the 3 formulations measured using hedonic tests showed an average score of 2 (Table 2). Of the three formulas, F1 with addition of 10% *Kelor* leaf puree showed the highest average score (2.71). Each indicator of the hedonic tests will be discussed later.

Aroma

The most accepted aroma of crispy noodles enriched with *Kelor* leaf puree was reported for F2 (20%) with a score of 2.77 (Table 2). The level of aroma preference of crispy noodle supplemented with *Kelor* leaf puree was 43.3%, 66.7%, and 76.7% for F0, F1, and F2, respectively (Fig. 1A).

Table 2. The hedonic test result of crispy noodles containing *Moringa oleifera* leaf puree

Indicator	Formula		
	F0 (0%)	F1 (10%)	F2 (20%)
Aroma	2.30	2.60	2.77
Color	2.53	2.70	2.67
Texture	2.67	2.67	2.67
Taste	2.63	2.87	2.57
Total	10.13	10.84	10.68
Average	2.53	2.71	2.67

Color

The level of color preference of crispy noodles supplemented with *M. oleifera* leaf puree were 76.7%, 70.0%,

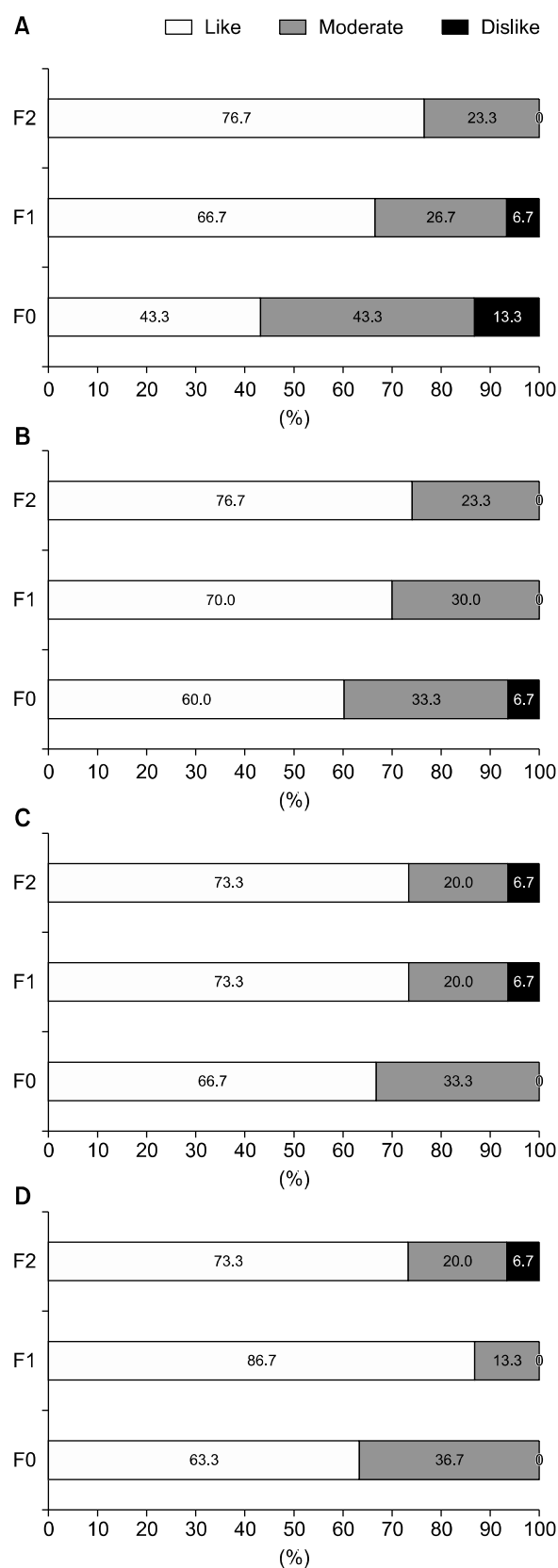


Fig. 1. The level of (A) aroma, (B) color, (C) texture, and (D) taste preference of crispy noodle enriched *Kelor* leaf.

and 60.0% for F2, F1, and F0, respectively (Fig. 1B). The most accepted formulas based on the color aspect were F1 with score of 2.70 and no panelist did not like the color (Table 2).

Texture

The texture of all crispy noodle formulas (F0, F1, and F2) showed a similar average score of 2.67 (Table 2). However, formulas F1 and F2 were more accepted by most panelists (73.3%). There was a slight difference in the textures of formulas F1-F2 and the formula of F0 (66.7%). 6.7% of respondents disliked the texture of F1 and F2 (Fig. 1C).

Taste

Crispy noodles supplemented with 10% *M. oleifera* leaf puree (F1) showed the highest score for taste (2.87; Table 2), and gained the most positive response (86.7% likes). This response was followed by supplementation with F2 (73.3% likes), for which only 6.7% of panelists did not like the taste (Fig. 1D).

Statistical analysis using Friedman test was performed to assess the differences in aroma, color, taste, and texture responses between. Of the three formulas, only responses for aroma and taste were significantly different ($P < 0.05$). This result also demonstrates the panelists' formula preferences. Based on the mapping shown in Fig. 2, F1 was the most accepted formula with the average score of 2.71 and had good acceptance in terms of aroma and taste.

Nutrition and bioactive value

Crispy noodles enriched with *M. oleifera* leaf puree (F1 and F2) contained macronutrients and micronutrients in addition to other bioactive components (Table 3).

DISCUSSION

Acceptability based on organoleptic test

As described above, crispy noodles supplemented with different contents of *M. oleifera* leaf puree has acceptable organoleptic properties, including aroma, taste, color, and texture.

Color is undoubtedly a most important product-intrinsic sensory cue that affect people's food and beverage consumption, including snacks (Spence, 2015). Addition of 10% or 20% *M. oleifera* leaf puree gave the noodle product greenish spots (Fig. 3). The more *Kelor* leaf puree added, the more spots were detected. Crispy noodles obtained a green color by *Kelor* leaves due to magnesium in the chlorophyll (Ali et al., 2014). However, during to the noodle cooking process (high temperature then drying) the color of noodles became less green compared with

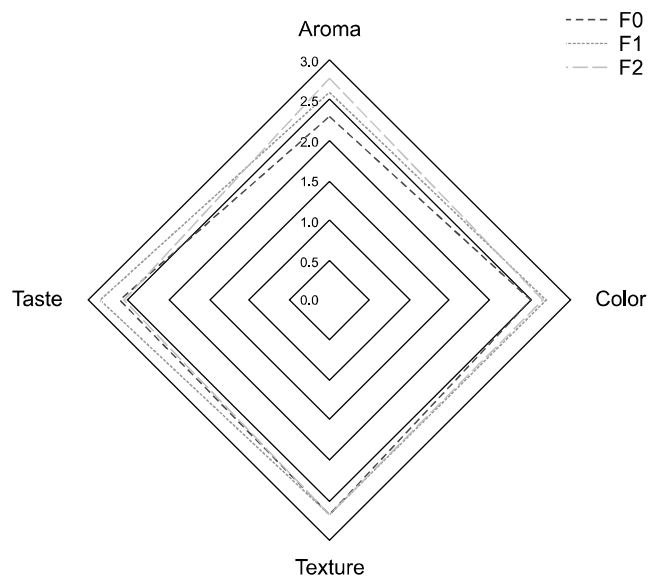


Fig. 2. Mapping of the hedonic test of crispy noodle enriched *Kelor* leaf.

Table 3. The nutrition and bioactive content of crispy noodles enriched with *Moringa oleifera* leaf puree (unit: per 100 g)

Nutrient/bioactive component	Formula		
	F0 (0%)	F1 (10%)	F2 (20%)
Protein (g)	9.4	9.1	9.0
Vitamin A (μg)	470.3	485.2	498.3
Vitamin C (mg)	0	24.2	27.5
Calcium (mg)	20.3	46.3	71.3
Zinc (mg)	1.4	1.4	1.3
Phenol (g)	0	0.2	0.4
Flavonoid			
Myrecytin (mg)	0	57.7	115.4
Quercetin (mg)	0	1.3	2.4
Kaempferol (mg)	0	48.8	91.8

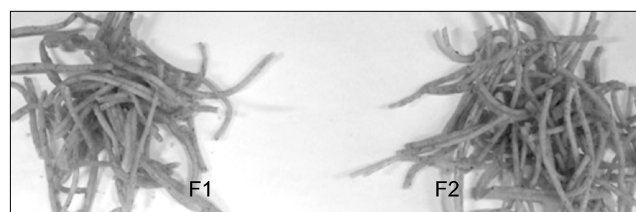


Fig. 3. Color different of crispy noodle with 10% (F1) and 20% (F2) addition of *Kelor* leaf puree.

fresh leaves due to changes in the magnesium molecules to pyropheophytin and pheophytin (Buchaillet et al., 2009).

In terms of taste and aroma, crispy noodle supplemented with F1 were given the highest score. This indicates that addition of pure *M. oleifera* leaves, is able to improve the acceptability of both organoleptic properties. However, too much pure *M. oleifera* leaves added to the noodles was liked less by the panelists. This result is in

accordance with data reported by Diantoro et al. (2015), in which addition of up to 7% *Kelor* leaf extract to yogurt was accepted least by panelists in terms of aroma, while 3% extract was liked most by the panelists. Likewise, a report by Karyantono et al. (2016) also reported that making *Kelor* leaf puree by blanching reduced phytate levels in *Kelor* leaves that cause unpleasant odors.

The texture of crispy noodles is one organoleptic aspect that was not influenced by addition of pure *M. oleifera* leaves. It was confirmed by similar assessment scores for all the formulas (2.67). Various surface characteristics in food products influence product performance and texture perception (Lawless and Heimann, 2016).

Nutrition and bioactive value

As shown in Table 3, F1 and F2 showed the highest content of vitamin A, vitamin C, and calcium compared with F0 (noodles without *Kelor* leaf puree), and also fulfilled the nutritional value required for supplementary food for school-age children. The protein and zinc contents were relatively similar for all formulas. Adequate intake for elementary school children aged 7~9 years for vitamin A is 500 µg/d and for vitamin C is 45 mg/d. If the content of one portion of crispy noodles enriched with *M. oleifera* leaf puree is 35 g, it could contribute to 30~35% of vitamin A and vitamin C daily requirements. *M. oleifera* contains vitamin C, which beneficial for improving the immune system of children (Carr and Maggini, 2017). Vitamin C is a water-soluble vitamin that is unstable, easily oxidized and can be destroyed at high temperature. This study employed several cooking processes that may have reduced vitamin C levels in *M. oleifera* crispy noodles, including bleaching and frying. A previous study has shown that bleaching may reduce vitamin C content by 20~35% (Singh and Harshal, 2016), whereas frying may reduce vitamin C by 60~72% (Ikanone and Oyekan, 2014). However, our study still showed that addition of *M. oleifera* leaf puree increased vitamin C content by up to 27.5 mg/100 g crispy noodles. Thus, we concluded that crispy noodles supplemented with *M. oleifera* could be a healthier snack choice for schoolchildren.

Furthermore, supplementation with *M. oleifera* leaf puree can increase the calcium content of noodles by 2- to 3-fold. If the adequate amount of calcium children should consume is 1,000 mg/d, crispy noodles containing pure *M. oleifera* leaf puree contributes 10~15% of their % recommended dietary allowance. The greater the addition of pure *M. oleifera* leaves, the greater the calcium content of the noodle product. The calcium content in 100 g of *Kelor* leaves is 4 times greater than the amount of calcium in 100 g of milk (Joni et al., 2008; Amzu, 2014).

The most potent bioactive components in *Kelor* leaves are flavonoids and phenols. Flavonoids have antioxidant

activity and are therapeutically beneficial when consumed at 50~500 mg/d, while consuming 20~80 mg/d is sufficient (Kumar et al., 2013). One portion of crispy noodles containing *M. oleifera* leaf puree (35 g), contributes 17.1~32.1 mg flavonoids, which means consuming one portion every day could give beneficial effects. Compared with formula 0, crispy noodles without added *M. oleifera*, noodles supplemented with *M. oleifera* addition contain a greater amount of bioactive components, including myricetin, quercetin, and kaempferol, and can therefore be considered a healthy snack for children (Timumun et al., 2016).

Crispy noodles supplemented with *M. oleifera* leaf puree is accepted as a functional snack for children and is safe to consume. The percentage of pure *M. oleifera* leaf significantly influences the aroma and taste of the noodle product ($P<0.05$), but not on its color and texture. The best formula investigated was formula F1 which contains 10% *M. oleifera* leaf puree. F1 is both liked by children and shows potential health benefits due to its nutritional content (vitamin A, vitamin C, and calcium) and the bioactive components (flavonoid and phenol). As the contents of both flavonoids and phenolic compounds are high enough, crispy noodle supplemented with F1 may be a promising healthy snack for children, especially those in food insecure area. This crispy noodle is also easy to cook in both household and school canteen setting and the ingredients are easy to find and are widely available and cheap; thus, it is feasible that crispy noodles supplemented with *M. oleifera* leaf puree can be adapted consumption in a school canteen setting.

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AUTHOR DISCLOSURE STATEMENT

The authors declare no conflict of interest.

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