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The effect of snakehead fish *(Channa striata)* snacks on nutrition outcomes of adolescence female at risk of chronic energy deficiency

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ABSTRACT

Background: *Chronic energy deficiency (CED) is still prevalent in Indonesia, affecting 36.3% adolescent females. The high protein content in snakehead fish presents a promising solution to address the problem.* ***Objectives:*** *This study was aimed to determine the effect of snacks developed using snakehead fish on nutrition outcomes of adolescence females.* ***Methods:*** *The study was conducted using a quasi-experimental quantitative design with a one-group pre-test and post-test approach. Three types of snakehead fish-based snacks —Ekado, Soymay, and Nuggets —were developed and administered to female senior high school students at risk of CED. The snacks were provided twice a week for a period of two months. Nutrient intakes, mid-upper arm circumference (MUAC), and body mass index (BMI) were measured at the commencement and conclusion of the study. The results were then compared to examine the snacks effects.* ***Results:*** *Before the study, most subjects were deficient in energy and macro nutrients. The subjects well accepted the developed snacks. The administration of the snacks significantly increased ($p < 0.05$) the intake of energy from 61.06 to 73.01 percent of their recommended daily allowance. The treatment also significantly ($p < 0.05$) reduces the number of subjects at risk of CED from 93.94% to 60.61% and those who are very thin from 42.42% to 24.24%.* ***Conclusions:*** *The administration of snakehead fish-based snacks appears to be a successful strategy in promoting the consumption of macronutrients, MUAC, and BMI of female adolescents at risk of CED.*

KEYWORDS: *adolescence female; BMI; CED; MUAC; snakehead fish snacks*

INTRODUCTION

The prevalence of chronic energy deficiency CED among non-pregnant adolescence female aged 15-19 years old in Indonesia is 36.3% which is the highest as compared to other age groups [1]. This number is 2-5 times higher compared to the CED prevalence across four countries of Malawi, Gabon, Kenya, and Nigeria in sub-Saharan Africa [2]. The CED has been a major government concern as women of reproductive age who are experiencing CED have a higher risk of giving birth to children which also likely to develop CED in their future life. In addition, malnutrition leads to health problems such as morbidity, mortality, and disability, and reduces the quality of human resources in a nation. On a broader perspective, malnutrition could pose a threat to a nation resilience and survival [3].

The incidence of CED is related to many factors. As reported by previous studies risk factors for CED is socio demographics variables and health related condition. These include age, education, occupation, access to information, family income, and anemia [2,4,5]. The qualities of diet is important direct factors

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which determine CED. Imbalance macronutrient intakes including energy, protein, and fat for prolonged time may have significant contribution to CED development [6].

The use of snakehead fish *(Channa striata)* as the basic ingredient in snacks development may improve nutrient intake and nutritional status in adolescents. Fresh snakehead fish contains high protein ranging from 16.2% to 21.87% [7,8]. Snakehead fish also contains important immune-nutrients, including albumin, essential amino acids, zinc and iron, which stimulate appetite, help repair damaged body cells, improve nutritional status, and enhance immunity [9]. Albumin content of snakehead fish is between 13.95 % and 19.61 % [10]. The use of fish as source of protein has been reported to positively improve nutrition children outcome [11,12]. Snakehead fish also finds important use in clinical setting as it offers affordable albumin extract alternative for hypoalbuminemia patients [13]. However, the effect of snakehead-based snacks on adolescence female at risk of CED has not been studied elsewhere. This current study was therefore aimed to determine the effect of snakehead fish formulation in form of snacks on the nutrition outcome of the high school students at risk of CED.

METHODS

Study design and participants

This study is part of a larger project which was conducted to determine the effect of local protein rich food products developed using fish as ingredient on nutrient outcomes on female at risk of CED [14]. The detailed method is explained in the respective study. In brief, three types of local snack foods; named Ekado, Siomay, and Nuggets; were developed in food laboratory using snakehead fish as the main ingredient and administered to 33 senior high school female students aged 16 years old twice a week every Tuesday and Friday for 8 weeks. The anthropometric data, daily nutrient intakes were collected before and after the snacks administration.

Measures

The snacks and other food consumption were collected using 24-hour food recall method. The data was collected at the commencement of the study, at each day when the snacks were administered, and at the end of the study. The amount of energy and nutrients from the consumed food and drinks were estimated based on the Indonesian food database using NutriSurvey software [15]. The obtained data was then compared to the national recommended dietary allowance and classified as the following: very low (<70%), low (70 - 100%), adequate (100 - <130%), slightly excessive (≥130%) [16,17].

The MUAC data was measured using a non-stretchable flexible measuring tape to the nearest 0.1cm. The measurement point was approximated to the midpoint between the acromion and olecranon processes on the shoulder blade and the ulna of the subjects arm [18]. The height was measured using a high stature meter to the nearest 0.1cm. The body weights of the subjects were collected using digital scale measured to the nearest 0.1kg. The BMI or Quételet index was used to determine the nutritional status and defined as weight (kg) divided by squared height (in meters). The anthropometric data were presented descriptively based on the nutrition outcome respective grouping criteria. The obtained MUAC data was used to identify adolescence female at risk of CED using cut off point of <23.5 cm [19,20]. The BMI data were further classified to very thin (<17.0 kg/m^2), thin (17 – 18.5 kg/m^2), normal (18.5 – 25.0 kg/m^2), overweight (>25.0 – 27.0 kg/m^2), obese (>27.0 kg/m^2) [21]. Anthropometric and food consumption data were collected by trained enumerator.

Data analysis

The difference values before and after treatments was examined using statistical paired t-test and Wilcoxon test. Pearson's correlation coefficient was run to assess the relationship between the MUAC and BMI. All statistical analysis was performed using statistical software JASP version 0.19.2 [22] at 95% confidence level. The graph was drawn using Gnuplot software version 6.0 [23]. This research complies with ethical standards approved by the Health Research Ethics Committee of the Polytechnic of Health Ministry of Health Malang. All participants received informed consent prior to data collection, and their confidentiality and anonymity were maintained throughout the study.

RESULTS

The subject is this study is adolescence female at school age. This specific group is unique due to the high CED prevalence among them as compared to other such as 20-24 yrs and 25-29 yrs groups with CED of 23.3% and 13.5% respectively [1]. Also, based on education the highest CED prevalence among non-pregnant adolescence female is in fact those who has completed junior high school, thus selecting senior high school students as subject would be most appropriate. The results also confirm that based on MUAC, 93.94% of the subjects are CED. At the beginning of the study, the majority of the subjects suffered from low energy and macro nutrients intakes. According to the national nutrition guidelines, the recommended daily allowance (RDA) for energy for 16 years old female group is 2,100 kcal [8]. The average of the energy intake before the study commencement was only 61.06% RDA. Most of the subjects fell under category very low or low intakes and none of them cold satisfied energy intake. This almost true for other nutrients intake, except for protein in which small number (21.21%) of the subjects have met their recommended value. At the end of the study, the energy intakes increased slightly to 73.01% RDA or subtle improve from very low to low based on the RDA category. The energy and macro nutrients intake are presented in **Table 1**.

The iron and vitamin C intakes of the subjects mostly fall below adequate categories. None of the subject have sufficient iron intakes and only 3.04% of them obtain adequate vitamin C. At the end of the study, the number of subjects who suffer from very low or low of iron and vitamin C intakes decreased significantly ($p<0.05$). The changes in the number of subjects in each category of intakes is presented in **Table 2**.

Within every day of snack administration, the subjects consumed the all provided snack completely. As reported earlier [14], the serving size for Ekado is 60 g per (3 pieces) containing energy of 216.4 kcal, 7.8 g protein, 13.3 g fat, and 17.1 g carbohydrates. The Siomay is served at 75 g per portion (5 pieces) with nutritional content of 214.8 kcal, 13.7 g protein, 4.2 g fat, and 29.3 g carbohydrates. The Nuggets is provided at 60 g per portion (3 pieces) with nutritional content of 216.1 kcal, 8 g protein, 14.1 g fat, and 14.9 g carbohydrates. The total of energy and nutrient intakes at the days when the snacks were administered is presented in **Figure 1**. The figure shows that based on the type of the snacks provided the energy and macro nutrients intakes of the subjects vary.

Table 1. Nutrient intakes (%RDA) and anthropometric data

	Before treatment	After treatment	Significant difference (p-value)
Energy	61.06 ±16.71	73.01± 18.80	p<0.05*
Total fat	61.55 ± 27.06	77.03 ± 30.90	p<0.05*
Carbohydrates	55.87 ±17.63	67.78 ± 20.45	p<0.05*
Fe	44.46 ± 24.09	79.55 ± 100.16	p<0.05**
Vitamin C	19.17 ± 28.98	31.84 ± 34.83	p<0.05**
MUAC	21.33 ± 1.44	22.36 ± 1.49	p<0.05**
BMI	17.32 ± 1.40	17.64 ± 1.17	p<0.05*

*paired t-test; **Wilcoxon signed-rank test

Tabel 2. Nutritional outcome before and after intervention

Nutritional outcome	Before treatment		After treatment	
	n	%	n	%
Energy intake*)				
Very low	25	75.76	14	42.42
Low	8	24.24	17	51.52
Adequate	0	0	2	6.00
Protein intake*)				
Very low	15	45.45	7	21.21
Low	11	33.33	16	48.48
Adequate	7	21.21	6	18.18
Slightly excessive	0	0	4	12.12
Iron intake*)				
Very low	27	81.82	22	66.67
Low	6	18.18	5	15.15
Adequate	0	0	3	9.09
Slightly excessive	0	0	3	9.09
Vitamin C intake*)				
Very low	31	93.94	27	81.82
Low	1	3.03	3	9.09
Adequate	1	3.03	3	9.09
MUAC (cm)*)				
< 23.5	31	93.94	20	60.61
≥ 23.5	2	6.06	13	39.39
BMI (kg/m^2)				
Very thin (< 17.0)	14	42.42	8	24.24
Thin (17-18.5)	13	39.39	16	48.48
Normal (18.5-25.0)	6	18.18	9	27.27

*) Wilcoxon, p<0.05

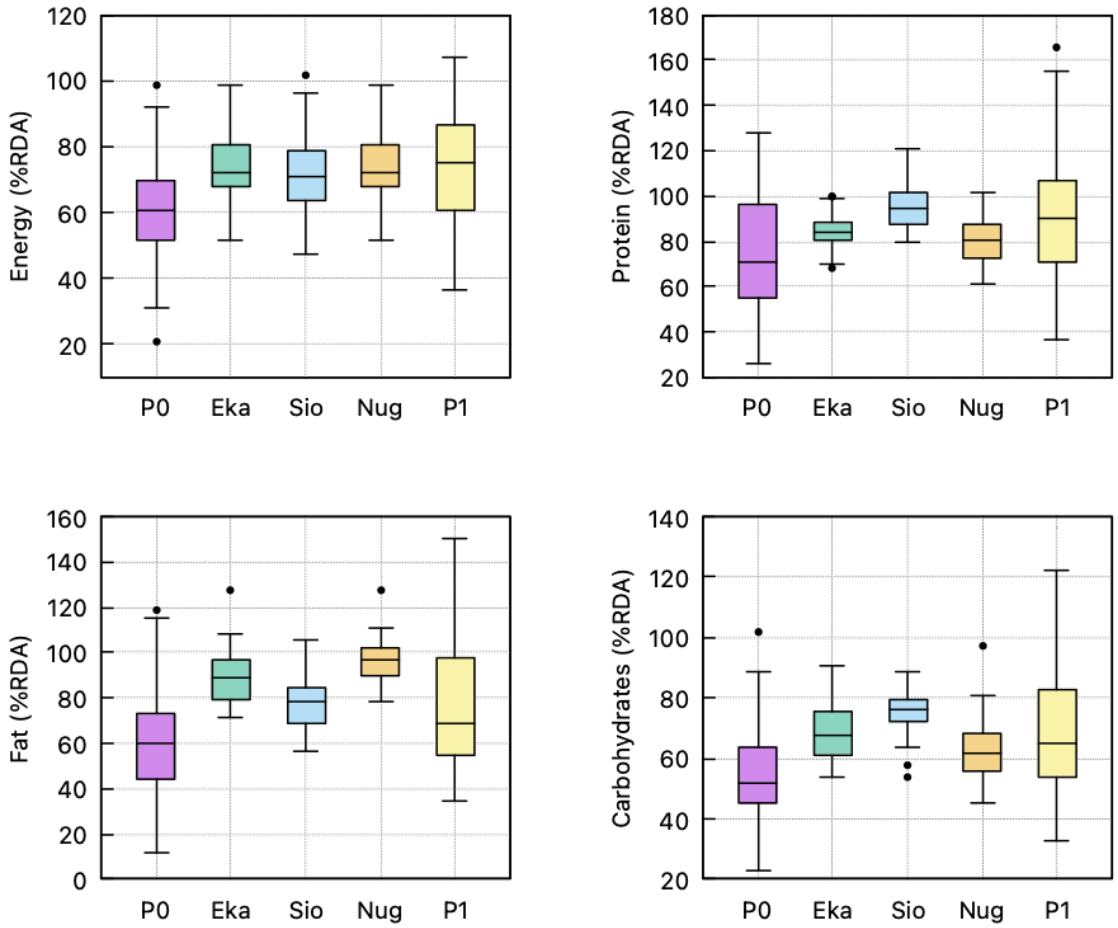

Figure 1. Total energy and nutrient intakes during snack administration

Note: *Eka, Sio, and Nug represent average of energy and nutrients intakes of the subjects at the days when Ekado, Siomay, and Nuggets respectively were administered. All values were calculated from five separate measurements. P0 and P1 are data at the pre-tests and post-tests respectively.*

The variation is clear for intakes of protein, fats, and carbohydrates. At the day of Ekado administration, the energy intake of the subjects is slightly higher compared to the data from Nugget and Siomay groups. However, this not the case for macro nutrients intakes where higher protein intakes is observed when administration of Siomay.

As with the nutrient intakes, the anthropometric data shows that most the subjects before study exhibited both a low MUAC and BMI indicating high risk of CED. However, as the study progress this data revealed significant improvements. The average of the MUAC increased significantly ($p<0.005$) from 21.33 in the beginning of the study to 22.36 cm at the study completion. Prior to the treatment, 93.94% of the students were classified as thin (MUAC <23.5 cm), this percentage decreased to 39.22% after treatment. The number of students with normal MUAC increased more than sixfold after treatment. Similarly, the average BMI was 17.32, while at the post-test, it had increased to 17.64. The proportion of students were very thin decreased from 42.42% to 24.24%. The MUAC dan BMI shows positive strong Pearson's correlation of 0.64 ($p<0.01$).

DISCUSSION

The low energy and protein intakes of the subject at the pre-test may be attributed to poor dietary habits they practiced. Most respondents rarely consumed breakfast due to their concerns about being late for school. This

resulted in only two meals per day. Furthermore, the quantity or portion of food consumed per meal was insufficient to meet their nutritional requirements, and there was a lack of food variety. Prolonged insufficient energy intake can lead to decrease in nutritional status. The energy intake directly impacts a person's nutritional status. Low energy intake may lead to poor nutritional status, and for women of reproductive age, the sustained insufficient intake result in chronic energy deficiency [24]. Study shows that respondents consuming less than 80% of the RDA energy requirement had a 2.1 times higher risk of CED compared to those consuming energy within the recommended range (80-120% of RDA) [25]. The increase in energy intake observed in the students after the intervention is consistent with similar study which reports a significant increase in energy intake after providing instant fish-based porridge with pumpkin over 14 days as complementary food, resulting in an average energy intake increase of 183.19±85.42 kcal [26]. This is also supported by other report which found a significant difference in energy intake before and after giving Snakehead fish-based biscuits, with a p-value of 0.01. This suggests that consuming biscuits can increase children's appetite [27].

The increase of energy and macro nutrients intake during the study indicates that the provision of snakehead fish snacks could help improve the intake of energy, protein, fat, and carbohydrates of the subjects. The snack which contributed the highest amounts of protein and carbohydrates during the intervention was Siomay. The protein and carbohydrate content in 100 grams of fresh snakehead fish is 16.2 g and 2.6 g, respectively [8]. The protein and carbohydrate intake of the respondents during the snack intervention showed continuous improvement. However, despite the increase, their intake still remained below the recommended levels. According to the 2019 RDA guidelines, the protein requirement for a 16-year-old female is 65 g [18]. This could be due to a lack of variety in the respondents' protein sources. They often consume only eggs and chicken as protein sources. The respondents reported not liking fish due to its unappealing taste. Fish consumption in Indonesia is still relatively low, leading to nutritional problems such as CED, especially among adolescents [28]. The reason for underweight adolescents is probably due to infrequent consumption of protein-rich foods like fish, meat, and legumes, resulting in inadequate protein intake. The provision of snakehead fish-based snacks could serve as a model which motivates respondents to consume more high protein foods.

Snakehead fish also contains important immune nutrients, such as albumin protein, essential amino acids, and minerals like Zn and Fe, which stimulate appetite, repair damaged body tissues, improve nutritional status, and boost immune function [9]. A study reported a significant difference in protein intake before and after administration of instant fish-based complimentary food in form of porridge with pumpkin over 14 days, resulting in a protein intake increase of 7.78 g [26].

According to the national recommended dietary standard, the carbohydrate requirement for a 16-year-old female is 300 g [18]. The low carbohydrates intakes among the female students is very likely related to a lack of consumption of high-carbohydrate foods in their daily diet. On average, the respondents consumed only 2-3 servings of rice per day. They preferred eating instant noodles or fast food. Furthermore, the lack of variation and portion control in the respondents' meals also influenced their daily carbohydrate intake. The busy school activities could also affect their eating behavior, leading to irregular meal times, which in turn has negative impact on their macro nutrients intakes. In fact, adolescents typically eat during free time between activities, making it difficult to maintain an adequate daily intake due to busy schedules, peer influences, concerns about body weight, and easy access to fast food [29].

The increase in carbohydrate intake among the students after the intervention is consistent with a study which shows a significant difference in carbohydrate intake before and after providing instant complementary food in form of porridge made of snakehead fish and pumpkin over 14 days. The treatment results in an average carbohydrate intake increase of approximately 30.21g [26]. Carbohydrate serves as main energy for the human body, hence one should have adequate intake in order to have normal physiological functions. Study on pregnant women shows that pregnant women who consume inadequate carbohydrate tend to experience CED as compared to those who have sufficient intakes [30].

The snack that contributed the most fat during the intervention was Nugget. The fat content in 100 grams of snakehead fish is 0.5 g [8]. The fat intake of the subject at time of Nugget administration is higher as compared to the other two snacks. However, the average fat intake remains slightly below the recommended value. The recommended daily fat intake for the subjects is 70 g [18]. This low fat intake is probably attributable to infrequent consumption of fat-rich foods such as beef, goat meat, fish, legumes, and dairy products. Additionally, the menstrual phase in adolescent females can reduce appetite due to pain. Discomfort in the lower abdomen which sometimes accompanied by nausea, is caused by increased uterine contractions leading to decreased appetite that would further affect fat intake in women [31]. It is recommended that women consume foods rich in omega-3 fatty acids obtained from fish oil, fish, soy, eggs, meat, shrimp, and fruits [32]. These foods can help alleviate pain as a result of dysmenorrhea, rheumatoid arthritis, intestinal diseases, and neuropathy [33]. The increase in fat intake observed in the students after the intervention is consistent with a study which indicates a significant difference in fat intake before and after providing instant complimentary food in form of porridge made from Snakehead fish and pumpkin for 14 days, with an average increase in fat intake of 3.49 g [26].

The MUAC and BMI are commonly used to assess the nutritional status of adolescent female and to determine the risk of CED. MUAC is a representative measure as the is closely related to their BMI, increase in MUAC is accompanied by increased BMI [34]. This current study also shows strong positive correlation, ie 0.6 between the two measures. A person is diagnosed with the risk of CED when their MUAC is less than 23.5 cm [19]. The measurement of the MUAC before and after the intervention showed a tendency for improvement (Table 1). MUAC in adolescent females might serve as good an indicator for the maturation of reproductive organs as it reflects the body's protein and fat status. Protein and fat play key roles in the formation and function of steroid hormones that affect the reproductive organs [35]. This can be seen in the relationship between a adolescence female age at menarche and MUAC measurements. The increase in energy intake after the intervention also positively impacted the respondents' MUAC values. This is supported other study which found a significant positive correlation ($r=0.428$, $p<0.05$) between energy intake and nutritional status based on MUAC measurements in female prisoners [36].

The measurement of BMI before and after the intervention showed an improvement. Result from other study also shows similar trend. Significant increase in nutritional status based on weight-for-age (W/A) and height-for-age (H/A) indices before and after provision of snakehead fish-based food supplements ($p<0.05$) in toddlers is reported earlier [37]. Snakehead fish extract combined with vitamin C also indicated significant improvement in BMI, with an increase from 22.5 kg/m² to 24.6 kg/m² [38]. Improvements in nutritional status (W/A and weight-for-height) has also been reported after providing biscuits made of snakehead fish and red rice flour for 90 days [27].

CONCLUSIONS

Snakehead fish has promising potential as source of high protein food with good level of acceptance. The intervention of snakehead fish-based snacks to adolescence female at risk of CED improves energy and macro nutrients intakes significantly. The improvements in nutritional status as indicated by BMI and MUAC in this study, further highlights the potential benefits of incorporating nutrient-dense of fish-based foods in adolescent female diets. It is also confirmed that BMI and MUAC are positively correlated. The finding in this current study is in line with previous studies on the positive impact of fish consumption on nutritional outcomes. The nutrients intakes of the female adolescence to meet their recommendation is still required. Therefore, it is suggested that maintaining variety and frequency consumption of high-energy and nutrient-rich foods, particularly staple foods such as rice as part of daily healthy diet is encouraged. Education on the specific topic related nutritional problem in adolescents would also benefit to help overcome typical female adolescence difficulties related to diet.

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Declaration of conflicting interests

The authors declare that there are no conflicts of interest related to this study.

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