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Moringa Oleifera Leaves Cookies as New Supplementary Food Enhancing Concentration Ability among Adolescents

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ABSTRACT

Background: *Moringa oleifera* is the plant with high antioxidative, anti-inflammatory and neuroprotective effects. The concentration capability is important component of cognitive function development on adolescents. This study aimed to assess *M. oleifera* leaf cookies for enhancing concentration capability on adolescents.

Methods: A randomized controlled trial was conducted in 53 adolescents aged 13-15 years assigned into 3 groups receiving *M. oleifera* cookies at dose of 5 g, 10 g and the control group. The administration was during 14 days. Concentration ability was measured by Kraeplin test performed by ULAPSI Sebelas Maret University, physical activity was measured by physical activity questionnaire, anxiety by Hamilton anxiety rating scale (HARS), and food intake by food recall 24-hours.

Results: The concentration ability slightly decreased among the control group (P=0.65). The concentration ability among both *M. oleifera* groups receiving doses of 5 and 10 g increased after 14 days treatment (P=0.001). There was no difference score of concentration ability between *M. oleifera* cookies at dose of 5 g and 10 g and control in 7th day (P=0.92) and 14th day (P=0.23). Only cookies consumption and age showed association with concentration ability, while BMI, physical activity, and food intake did not reveal any correlation.

Conclusion: The administration of *M. oleifera* cookies at doses of 5 and 10 g during 14 days can improve the concentration ability of male adolescents aged 13-15 years.

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Introduction

Adolescence is a transitions period between childhood and adulthood. During this phase, an adolescents will experience physiological and behavioral changes, including eating behavior (1). An adolescent is more likely to eat snacks such as cookies and chips, meals outside the home, and eats larger portion sizes of meal at restaurants and fast food takeaways, and increased consumption of soft drinks instead of healthy meals (2). The prevalence of snacking among adolescents was highly prevalent. In America, around 87% of 12-18

years adolescents consume at least one snack per day and contributed approximately 25% of their daily energy intake (3).

In European countries, 5-15 years old people consume an average of 1.5-2.8 snacks per day (4). In Asian countries, snacking rate among 2-19 years old subjects is at least one snack per day providing 18% of their total daily energy (5). These conditions are likely to be associated with imbalance nutrition intake, energy regulation and obesity among adolescents. Imbalance nutrition intake occurring in childhood and early adolescents are associated with cognitive impairment, such as attention span, memory, and concentration ability. The impairment is closely related with poor school performance and productivity in later adulthood (6).

These functional problems can be traced to neurochemical deficiencies, which affect dendritic development in brain areas such as prefrontal cortex and hippocampal (7). An effective alternative possible for long-term repairing treatment for this situation is by using food-based treatments. Commonly snacks are not nutritionally optimal and do not include several nutrients that are important for cognitive health. The innovation for ready-to-use supplementary food and fortified blended foods that are important for cognitive health was needed.

Concentration ability is one of cognition aspects, besides intelligence quotient and academic achievement (8). Concentration ability is the capability to hold attention in a certain period of time. It involves attention and short term memory. Concentration ability is consists of speed, accuracy, constancy and endurance in doing something, for example learning (9). *Moringa oleifera,* a plant include family of Moringaceae, is a popular plant which has been used both as food and herbal medicine in many Asian countries including Indonesia (10-12).

The leaves of this plant had been reported to be rich source of antioxidants such as vitamin C, vitamin E, and flavonoids. In addition, rich potassium, calcium, iron and essential amino acid contents were also observed (10-12). The *M. oleifera* leaf also possesses nutritropic and neuroprotective effects (13). The scientific evidence, concerning the effect of *M. oleifera* leaves on cognitive function, especially on concentration capability, is still limited until now. Therefore, this study aimed to create innovation and investigate the effect of new supplementary snack based *M. oleifera* leaves on concentration capability of adolescents aged 13-15 years old.

Materials and Methods

This Randomized Control Trial (RCT) study with pre- and post-test control group design was conducted in two junior high schools in Surakarta from October to December 2019. Population of this study was all male students in two junior high schools. Subjects were chosen randomly and divided into three groups, 19 subjects in the control group received daily 100 g of cookies without *M. oleifera* leaf flour, 19 subjects in the treatment group 1 received daily 100 g of cookies with 5 g *M. oleifera* leaf flour, and 19 subjects in the treatment group 2 received daily 100 g of cookies with 10 g *M. oleifera* leaf flour.

Both control and treatment groups consumed the cookies during 14 days. Subjects who did not eat the cookies for three days were excluded from the study. The cookies were given to control group containing protein of 7.8 g, fat of 28.1 g, carbohydrate of 46.6 g, Fe of 1.3 mg, and vitamin C of 3.1 mg, with a total energy of 467.5 Kcal. The cookies were given to treatment group 1 contained protein of 8.9 g, fat of 28.3 g, carbohydrate of 49.6 g, Fe of 2.4 mg, and vitamin C of 7.9 mg, with a total energy of 485.9 Kcal. The cookies were given to treatment group 2 contained protein of 10.1 g, fat of 28.5 g, carbohydrate of 52.5 g, Fe of 3.5 mg, and vitamin C of 12.6 mg. with a total energy of 504.3 kcal.

The ingredients of the cookies in *M. oleifera* leaf flour were wheat flour, egg, milk powder, sugar, and margarine butter. These ingredients were mixed and kneaded until the dough was smooth for 5 minute. The dough was flattened, molded and roasted at 180ºC for 11 minutes. This preparation method was carried out by CV Syafa Indonesia. The concentration ability was measured by Kraepelin test performed before, and after 7th and 14th days by a psychologist of ULAPSI Sebelas Maret University who was blind to the study.

Food intake that contained energy, carbohydrate, protein, fat, folic acid, zinc, vitamin C, and vitamin E was measured by food recall 24-hours questionnaire and conducted before, after 7th day and 14th day by trained enumerators. Collected data of food consumptions were then converted into g/day using a nutrisurvey 2007 software (http://www.nutrisurvey.de/). Body mass index (BMI per age) was measured before, after 7th and 14th days by weight scale and microtoice with 0.5 g accuracy level. Physical activity was measured before, after 7th and 14th days by physical activity questionnaire, anxiety before treatment by Hamilton Anxiety Rating Scale (HARS).

Numeric data were presented as mean±standard deviation (SD), while categoric data were presented as absolute number and percentage. The baseline characteristics of research subjects consisted of age, body weight, body height and Body Mass Index

(BMI), daily intake, physical activity, concentration ability (before treatment), and anxiety level. For statistical analysis of baseline nutritional status and daily intake, Chi Square test was used. Friedman test and Kruskal Wallis test were for statistical analysis, because the data were non-homogenous. Multiple Regression test was also performed to analyze other confounding variables in the study. The significant value was set up P<0.05. The protocol of this study was approved by Health Research Ethics Committee of Dr. Moewardi General Hospital with number of 1.029/VIII/HREC/2019.

Results

In the present study, we evaluated administration of *M. oleifera* leaf cookies on concentration ability of male adolescents. Two subjects were excluded on 7th day due to low compliment level, while 2 subjects were excluded on 14th day, because they did not attend on the post-test measurement. Totally, data of 53 subjects were analyzed. Table 1 indicated baseline characteristics of adolescents either in control group or treatment groups. In general, the control group had similar characteristics to the treatment groups in terms of age, weight, BMI, vitamin E intake, physical activity, concentration ability, and anxiety level (Table 1).

After 7th and 14th days, there was a statistical difference regarding concentration ability among subjects. Table 2 indicated that in control group, there was decreased score of concentration ability on 7th day and 14th day, but it was not significant (P=0.65). In treatment group 1, there was a significant increase of 0.20±0.21 on 7th day and 0.34±0.46 on 14th day and (P=0.001); while in treatment group 2, there was a significant increase of 0.26±0.17 on 7th day and 0.56±0.48 on the 14th day (P<0.001). On the 7th and 14th days, there were no difference between concentration score between control and treatment groups (P=0.92, P=0.23) (Table 2).

This randomized study evaluated a new nutritional food for making healthier snack, which contributed to cognitive health and improved brain function. The results indicated the administration of *M. oleifera*

Table 1: Baseline characteristic of subjects demonstrated in CG and TG groups

Variable	Group			P value*
	Control (n=17)	TG1 (n=18)	TG2 (n=18)	
	Mean±SD	Mean±SD	Mean±SD	
Age (years)	13.94±0.66	13.77±0.55	13.77±0.55	0.680
Weight (kg)	65.06±22.30	58.87±19.06	55.22±14.78	0.134
Height (cm)	164.17±7.80	159.94±8.73	156.50±7.98	0.030*
Body Mass Index (kg/m^2)	23.94±6.75	22.99±7.04	22.26±5.49	0.747
Daily intake				
Energy (Kkal)	1565.64±738.98	1796.80±131.06	1291.64±412.72	0.002*
Carbohydrate (g)	182.29±9142	234.13±42.41	166.09±69.67	0.020*
Fat (g)	67.96±37.47	61.85±17.44	46.10±21.85	0.031*
Protein (g)	52.62±20.15	66.34±11.10	44.20±13.16	<0.001*
Folic acid (mcg)	152.74±57.31	194.91±48.93	167.57±139.26	0.026*
Vitamin C (mg)	87.81±59.50	110.83±46.06	65.57±25.65	0.009*
Zinc (mg)	5.36±2.34	7.78±2.81	4.74±1.96	0.002*
Vitamin E (mg)	4.32±2.74	3.77±1.01	5.87±3.55	0.061
Physical Activity	3.18±0.58	2.87±0.58	2.74±0.62	0.110
Concentration capability	2.72±0.49	2.55±0.67	2.42±0.45	0.190
Anxiety	6.23±2.71	6.53±3.20	6.46±3.99	0.969

CG=control group, TG1=treatment group 1 who were given dose of 5 g of *M. oleifera* leaf flour, TG2=treatment group 2 who were given dose of 10 g of *M. oleifera* leaf flour. *P value using Kruskal Wallis test to be significant as P<0.05

Table 2: Changes of concentration ability in subjects who were given *M. oleifera* leaf cookies

Variable	Group			P value[b]
	Control (n=17) Mean±SD	TG1 (n=18) Mean±SD	TG2 (n=18) Mean±SD	
Pre-test	2.72±0.51	2.56±0.67	2.42±0.45	0.190
After 7th day	2.67±0.51	2.76±0.55	2.68±0.51	0.919
Post-test (after 14th day)	2.64±0.63	2.90±0.54	2.98±0.53	0.230
P[a]	0.651	0.001*	<0.001*	

CG=control group, TG1=treatment group 1 who were given dose of 5 g of *M. oleifera* leaf flour, TG2=treatment group 2 who were given dose of 10 g of *M. oleifera* leaf flour. *P value[a] using Friedman test; p value[b] using Kruskall Wallis test to be significant at P<0.05

leaf cookies at doses of 5 g and 10 g that significantly improved the score of concentration ability after 7th and 14th days of treatment, when compared with the control group. Formula of *M. oleifera* generally met WHO nutrient target for nourishing adolescents, including specific target for energy, protein, vitamin and mineral. *M. oleifera* contained 497 Kcal, 51.4 g carbohydrate, 9.6 g protein, 28.4 g fat, and 3.1 mg Fe. In addition, *M. oleifera* contained phytochemical nutrient such as flavonoid, polyphenols that have potentially beneficial neurological effects in adolescent population.

Discussion

The results of this study showed that the administration of *M. oleifera* at doses of 5 g and 10 g increased concentration score during 14 days. This finding was supported by the preliminary finding of an association of supplement consumption that improved memory, long-term cognitive development and academic achievement among children (14). Naturally, *M. oleifera* leaf contained polyphenols that were able to decrease oxidative damage in tissue by indirect enhancement of cell by free radicals (15). The *M. oleifera* leaf was demonstrated for antioxidant activity due to the high amount of polyphenols (16, 17).

Chlorogenic acid (CGA) is one of the most abundant materials of polyphenols in the *M. oleifera* leaf. It acts to decrease the activity of acetylcholine esterase enzymes. It makes neuron inter-communication to be increased due to increase in acetylcholine level of synapses. By this mechanism, cholinergic function of brain memory system increased and affected concentration ability (18). Highly antioxidant activity of *M. oleifera* leaf was also closely related with ability to reduce cell damage due to stress oxidative (20).

High antioxidant activity of *M. oleifera* leaf such as flavonoid, vitamin C and vitamin E were able to decrease lipid peroxidase (LPO) and nitric oxide (NO) in brain by increasing the super oxide dismutase (SOD) and catalase (CAT) levels. These conditions advantage reducing stress oxidative states in brain and prevent neurodegeneration, so in the end, the concentration ability increases (19). A previous study also showed that highly antioxidant diets or supplements increased hippocampus-dependent memory of rats (20).

Carbohydrate content in *M. oleifera* also affects by increasing score of concentration ability via mechanisms providing source of energy for nervous system. Energy management in neurons influences synaptic plasticity 32 (ARA 2) and is related to cognitive function (21). *M. oleifera* also contains thiamin, which has a role as coenzyme in carbohydrate metabolism (22). Caffeoylquinic acid content in *M. oleifera* also increases the ATP production to provide the energy for nervous system. The providing source of energy is needed and is very important for speed and concentration endurance (23).

Conclusion

This study focused on assessing a new innovative supplementary snack to improve cognitive function, especially the concentration ability. The results of this study suggested that *M. oleifera* was the promising supplementary snack to improve the concentration ability among male adolescents aged 13-15 years old. The results are preliminary, but it gives potential documents needed to be replicated in a more powerful trial during a longer duration and larger population.

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Conflict of Interest

None declared.

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