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Comparative of Moringa (Moringa oleifera) Cookies and Capsules on Hemoglobin Levels in Adolescent Girls with Iron Deficiency Anemia

Perbandingan Pemberian Cookies dan Kapsul Daun Kelor (Moringa oleifera) dalam Upaya Meningkatkan Kadar Hemoglobin pada Remaja Putri Anemia Defisiensi Zat Besi

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ABSTRACT

Background: Iron Deficiency Anemia (IDA) during adolescence can have serious long-term consequences, not only compromising individual health but also increasing the risk of complications during future pregnancies. Local food sources such as moringa oleifera leaves offer a promising strategy to address this issue, given their high iron content. Developing practical, acceptable forms such as cookies and capsules may provide holistic solutions for improving hemoglobin levels. Although both preparations have been shown to significantly enhance hemoglobin levels within the same intervention period, differences in their composition, production methods, and potential iron bioavailability warrant further comparison.
Objectives: This study aimed to compare the effectiveness of moringa-based cookies and capsules in improving hemoglobin levels among adolescent girls diagnosed with iron deficiency anemia.
Method: A quasi-experimental study was conducted in 2024 among 53 female high school students selected through purposive sampling. Hemoglobin concentrations were measured using the Easy Touch GCHb device. Paired t-tests were used to assess changes within each group, and independent t-tests were applied to compare outcomes between groups.
Results: The study proved that the mean hemoglobin level in the moringa cookies group increased to 12.52 g/dL (p=0.002), while the capsule group showed an increase to 12.20 g/dL (p=0.001). However, no significant difference was observed between the two interventions (p=0.412).
Conclusion: Both moringa cookies and capsules effectively improved hemoglobin levels in adolescent girls with iron deficiency anemia. Nevertheless, there was no significant difference in the extent of improvement between the two forms of supplementation.

Keywords: Adolescent girls, Hemoglobin levels, Iron deficiency anemia, Moringa capsules, Moringa cookies

ABSTRAK

Latar Belakang: *Masalah anemia defisiensi zat besi pada remaja yang memilik dampak berkepanjangan dan tidak hanya dirasakan oleh individu remaja tersebut melainkan akan meningkatkan risiko kesehatan ketika hamil. Salah satu langkah untuk mengatasi masalah tersebut dengan memanfaatkan pangan lokal yaitu daun kelor (Moringa oleifera). Pendekatan strategis dalam penanggulangannya dilakukan melalui kombinasi cookies dan kapsul kelor berbahan kaya zat besi dan keduanya mudah dikonsumsi serta berpotensi meningkatkan kadar hemoglobin secara holistik. Perbandingan antara cookies dan kapsul kelor perlu dilakukan*

karena keduanya telah terbukti memberikan pengaruh signifikan terhadap peningkatan kadar hemoglobin pada remaja putri dengan anemia defisiensi zat besi dalam durasi intervensi yang sama, namun memiliki karakteristik yang berbeda dalam hal komposisi, proses pembuatan, serta potensi bioavailabilitas zat besi.
Tujuan: *Penelitian ini adalah untuk membandingkan pemberian dari cookies dan kapsul kelor dalam upaya meningkatkan kadar Hemoglobin remaja putri anemia defisiensi zat besi.*
Metode: *Penelitian kuantitatif menggunakan desain quasy eksperimen pada siswi Sekolah Menengah Atas pada tahun 2024 dengan sampel remaja putri sebanyak 53 orang. Sampel diambil dengan menggunakan teknik purposive sampling, sedangkan sampel kadar hemoglobin remaja purti menggunakan Easy Touch GCHb. Variabel yang diteliti pada. Analisis bivariat menggunakan uji paired t test untuk mengetahui pengaruh dari masing-masing produk dan uji indenpendent t test untuk mengetahui perbandingan pemberian dari kedua produk tersebut.*
Hasil: *Penelitian membuktikan bahwa rerata pada kelompok cookies kelor terjadi peningkatan kadar Hemoglobin menjadi 12.52 g/dl dengan nilai signifikansi yaitu 0.002 (p-value<0.05). Begitu juga peningkatan pada kelompok kapsul kelor 12.20 g/dl dengan nilai signifikasi yaitu 0.000 (p-value<0.05). Sedangkan perbandingan antar kelompok yaitu tidak ada perbandingan yang signifikan 0.412 (p-value>0.05).*
Kesimpulan: *Pemberian Cookies kelor dapat meningkatkan kadar hemoglobin remaja putri anemia defisiensi zat besi dan begitu pula kapsul daun kelor namun tidak ada perbedaan yang signifikan atas pemberian cookies dan kapsul kelor.*

Kata kunci: *Anemia defisiensi zat besi, Cookies kelor, Kadar hemoglobin, Kapsul kelor, Remaja putri*

INTRODUCTION

Iron deficiency anemia is characterized by decreased hemoglobin levels, hematocrit, and red blood cell counts below normal values, specifically with hemoglobin levels <12.0 g/dL (Fitriany and Saputri, 2018). Adolescent girls are particularly vulnerable to iron deficiency anemia due to menstrual blood loss, which leads to significant iron depletion (Balkis *et al.*, 2023). The incidence of iron deficiency anemia among adolescent girls aged 15 to 24 years has increased markedly over the past 15 years, rising from 9.40% in 2007 to 26.40% in 2013, and slightly increasing again to 26.80% in 2018 (Kemenkes RI, 2018). According to the SKI report (2023), the prevalence among adolescents aged 15–24 years is currently 15.5% (Kemenkes, 2023).

Despite the expansion of iron supplementation programs, iron deficiency anemia remains a persistent public health issue. Although these programs are considered successful in reaching adolescents, the current strategy primarily providing iron-folic acid tablets (IFA) has not effectively reduced anemia rates. The success of supplementation programs largely depends on adolescents' adherence to iron tablet consumption, which is often compromised due to side effects such as nausea, vomiting, and dizziness (Widiastuti and Rusmini, 2019). The consequences of untreated iron deficiency anemia are serious, affecting not only adolescents' daily functioning, such as causing fatigue and poor concentration, but also increasing the risk of complications during future pregnancies, including maternal mortality, preterm births, and low birth weight (Kemenkes RI, 2014). This is because mothers who experience iron deficiency anemia do not have enough healthy red blood cells to transport oxygen to the mother's tissues or to the fetus (Nurrahman *et al.*, 2021). Therefore, alternative approaches, particularly those utilizing local food sources, are urgently needed.

Moringa oleifera leaves have emerged as a promising local food intervention, with proven success in combating iron deficiency anemia. Numerous moringa-based products have been developed, including dry noodles (Sari and Ismawati, 2023), moringa leaf brownies (Nugroho *et al.*, 2023), capsule extract, jelly, meatballs, dry noodles, cookies, tea and sorbet. Moringa cookies have shown a significant increase in hemoglobin levels among adolescent girls after just 14 days of intervention (Khofifah and Mardiana, 2023). Likewise, moringa capsules are able to provide a significant effect on hemoglobin levels in adolescent girls with iron deficiency anemia within 14 days (Hastuty and Khodijah, 2017).

This study focuses on moringa cookies and capsules because their production processes maintain the iron content despite heating. Moreover, 100 grams of moringa cookies can meet approximately 39.6% of the daily iron requirement (Pratiwi *et al.*, 2023). Both interventions have shown positive outcomes over similar durations, and an additional advantage of the cookies is that the flour used is fortified with iron. A direct comparison between cookies and capsules is important, as they

differ in composition, manufacturing processes (Prasetyo, Farapti and Isaura, 2022), and potential iron bioavailability (Pambudi, 2019). However, few studies have directly compared these two forms of intervention within the same study design. Therefore, study is needed that compares these two forms of intervention to determine a more optimal product as an alternative treatment for iron deficiency anemia. Based on this background, this study aims to compare the administration of moringa cookies and capsules in an effort to increase hemoglobin levels in female adolescents with iron deficiency anemia.

METHOD

The research method used is a quasi-experiment with a two-group pretest-posttest design. The location of this study was several high schools/equivalents in Baubau City in July-August 2024. Before determining the population, iron deficiency anemia screening was carried out in several high schools/equivalent in Baubau City depending on the response and willingness of the school, as many as five schools. The screening was carried out by taking blood samples and testing using Easy Touch GCHb. The population of this study was all female students who had been screened at the school. The sample in this study was female adolescents taken from three schools who were willing to participate, as many as 60 people but seven dropped out for several reasons, namely not getting permission from their parents, feeling nauseous or dizzy, while several schools were not involved because this research activity coincided with the August 17 activities involving female students at the school. The number of samples in this study was 53 respondents, in the moringa cookies group as many as 30 respondents and 23 respondents in the moringa capsule group. The sampling technique was purposive sampling, with inclusion criteria, namely (1) present at the time of iron deficiency anemia screening, (2) female adolescents with hemoglobin levels <12 g/dl, (3) willing to be respondents by signing an informed consent while the exclusion criteria were that respondents stopped consuming cookies or moringa capsules.

Moringa cookies and capsules were given after iron deficiency anemia screening and met the sample criteria, namely having Hb levels <12 g/dl. Moringa cookies were consumed for 14 days with four pieces (10 g/piece) consumed per day as a snack. When cookies were given, respondents would be given 20 pieces to be consumed for five days. This was done so that there was a face-to-face meeting between respondents and researchers, as well as asking about things they felt while consuming moringa cookies. Moringa capsules were consumed by respondents for 14 days with a dose of 2 capsules per day @500 mg. Capsules were given every five days. Monitoring of the consumption of cookies and moringa capsules was carried out by reminding the WhatsApp group that had been created during screening or by contacting them personally.

After the intervention, the female adolescents with iron deficiency anemia had their hemoglobin levels re-measured by the screening team using Easy Touch GCHb, carried out in the morning or afternoon following the respondents' free time or rest time. The purpose of measuring Hb levels is to see changes in hemoglobin levels in both groups and to measure the comparison of changes between the two groups. Data analysis used a paired t-test to determine the effect of each product and an independent t-test to determine the comparison of the administration of the two products. This study has received approval from the Health Research Ethics Commission, Faculty of Medicine, Tadulako University No. 3651/UN28.10/KL/2024.

RESULTS AND DISCUSSION

Univariate analysis provides the distribution of respondent characteristics in the form of age and nutritional status. In Table 1, the majority of respondents in the moringa cookies and moringa capsule groups were 15 years old, where in the moringa cookies group there were 25 people (83.3%) and in the moringa capsule group there were 17 people (74%). The characteristics of nutritional status in the distribution of the largest respondents in both groups were normal nutritional status, where in the moringa cookies group there were 16 people (53.3%) and in the moringa capsule group there were 12 people (52.2%).

Table 1. Distribution of Respondent Characteristics

Characteristics	Moringa Cookies Group		Moringa Capsule Group	
	n	%	n	%
Age				
14 years old	2	6.7	4	17.4
15 years old	25	83.3	17	74.0
16 years old	3	10.0	2	8.6
Total	**30**	**100.0**	**23**	**100.0**
Nutritional Status				
Malnutrition	12	40	10	43.5
Normal	16	53.3	12	52.2
Overweight	2	6.7	1	4.3
Total	**30**	**100,0**	**23**	**100.0**

Moringa Cookies

The moringa cookies intervention was given for 14 days to 30 female adolescents with iron deficiency anemia by giving four pieces a day @10 g per piece. Table 2 shows that there was an increase in the hemoglobin levels of female adolescents with iron deficiency anemia before and after giving moringa cookies. The average hemoglobin level before being given moringa leaf cookies was 11.43 g/dl and after giving moringa cookies the average hemoglobin level increased to 12.52 g/dl with a difference of 1.09 g/dl. The results of this analysis illustrate that the hemoglobin levels of female adolescents with iron deficiency anemia increased with the administration of moringa cookies ($p<0.05$).

Changes in the hemoglobin levels of female adolescents with iron deficiency anemia were influenced by the addition of moringa leaf powder and wheat flour that had been fortified with several micronutrients such as iron. Novitaroh *et al.* (2022) stated that the more moringa leaves are added, the higher the levels of substances in moringa cookies. Likewise, research conducted by Dewi (2018) stated that adding 150 g of moringa powder to 100 g of wheat flour can increase the Fe content in cookies by up to 31.52%.

The increase in hemoglobin due to the administration of moringa cookies is in line with research conducted by Khofifah and Mardiana (2023) which found that there was an increase with an average difference of 2.1 g/dl, where the average Hb level before administration of moringa cookies was 10.8 g/dl and increased to 12.9 g/dl after administration of moringa cookies. In addition, research conducted by Nua, Adesta and Conterius (2021) proved that by administering Bikelor to a group of pregnant women, a p-value of 0.000 was obtained, this indicates a significant change in the hemoglobin levels of pregnant women. These findings collectively support the effectiveness of moringa-based interventions in improving hemoglobin levels among vulnerable populations.

Table 2. Changes in Hemoglobin Levels in Adolescent Girls with Iron Deficiency Anemia in the Moringa Cookies Group

Hemoglobin Levels	Min-Max (g/dl)	Median (g/dl)	Mean ±SD (g/dl)	Δ (g/dl)	p-value
Moringa Cookies Group					
Pre-test	9.9-11.3	11.8	11.43 g/dl±0.925	1.09± 1.81	0.002[a]
Post-test	9.0-15.7		12.52 g/dl ±1.525		

[a]Paired T-Test

Moringa Capsule

Table 3. Hemoglobin Levels of Adolescent Girls with Iron Deficiency Anemia Before and After Intervention in the Moringa Capsule Group

Hemoglobin Levels	Min-Max (g/dl)	Median (g/dl)	Mean ±SD (g/dl)	Δ (g/dl)	p-value
Moringa Capsule Group					
Pre-test	9.0-11.9	12,3	10.63 ±0.984	1.56±1.26	0.000[a]
Post-test	9.7-13.9		12.20±1.239		

[a]Paired T-test

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Moringa capsule intervention was given for 14 days to 30 female adolescents with iron deficiency anemia by giving two capsules per day weighing 500 mg per capsule. Table 3 shows a significant increase with a p-value of 0.000. Before giving moringa capsules, the average hemoglobin level of female adolescents before giving moringa capsules was 10.63 g/dl and increased after giving moringa capsules by 12.20 g/dl, so the difference obtained was 1.56 g/dl.

The effect of moringa capsules on hemoglobin in female adolescents with iron deficiency anemia has been proven by many previous studies, including research conducted by Hastuty and Nitia (2022) which found that the largest increase in hemoglobin levels was 2.9 g/dl with a significance value of 0.001 (p<0.05). The intervention in the study was for 14 consecutive days with a dose of two capsules per day (morning and evening) where one capsule contained 500g of moringa powder. Research conducted by Ernawati (2023) proved that there was an increase in hemoglobin levels in the study of 4.273 g/dl by administering moringa capsules at a dose of two capsules a day for 14 days; the significance value in the study was 0.000 (p <0.05).

During the intervention, several respondents experienced symptoms of dizziness at the beginning of consumption, but these symptoms disappeared on the second day. Most respondents did not experience any symptoms during the intervention period. This shows that the body's initial reaction to consumption varies, but generally does not continue or worsen. In the group, respondents dropped out because their parents/guardians forbade it due to lack of knowledge regarding the benefits of moringa leaves and the impact of iron deficiency anemia.

Comparative of Moringa Cookies and Capsules

The intervention of cookies and moringa capsules was given for 14 days. Based on the paired t-test, it was found that in the cookies group there was an increase of 1.09 g/dl with a significance value of 0.002 (p<0.05), while in the moringa capsule group there was an increase of 1.57 g/dl with a significance value of 0.000 (p<0.05). To determine the comparison between groups, an independent t-test was carried out, as in Table 3, and it was found that the significance value of hemoglobin levels before the intervention was 0.004 (p<0.05) with an average in the moringa cookies group of 11.43 g/dl while the moringa capsule group was 10.63 g/dl. From these results, it can be concluded that there was a significant difference in the two groups with a difference of 0.8 g/dl.

Table 4. Comparison of Hemoglobin Levels in Adolescent Girls with Iron Deficiency Anemia in the Moringa Cookies Group and the Moringa Capsule Group

Hemoglobin Levels	Moringa Cookies Group *(mean ±SD)*	Moringa Capsule Group *(mean ±SD)*	*p-value*
Pre-test	11.43±0.925	10.63±0.984	0.004[b]
Post-test	12.52±1.525	12.20±1.239	0.412[b]

[b]Independent T-test

The average change in hemoglobin levels after intervention in the cookies group was 12.52 g/dl, while in the moringa capsule group it was 12.20 g/dl with a significance value of 0.421 (p>0.05), the difference between the two groups was 0.32 g/dl. These results indicate that there is no significant difference in the two groups, where both products can be used as an effort to increase hemoglobin levels in female adolescents with iron deficiency anemia. Differences in changes in hemoglobin levels in the cookies group (1.09 g/dl) and moringa capsules (1.57 g/dl) are caused by several factors, namely the level of compliance with consumption, respondent diet, and differences in iron bioavailability. In addition, the product processing process can be a factor, where the method of cooking or processing food can also affect the nutritional content of the food. In particular, exposure to food to heat, light, and/or oxygen will cause a significant nutrient deficit (Sundari, Almasyhuri and Lamid, 2015), as iron is a mineral that is not resistant to heating processes either directly by the sun or 50oC but lasts a long time (Irwan, 2020).

The difference in processing in the two products can affect the levels of Fe contained, thereby affecting their level of effectiveness. In the moringa cookies product, it goes through three stages of processing, namely drying moringa, the refining process, and finally the cooking or baking process. In the drying process, moringa will be heated at a temperature of 50^0C for 48 hours, because at that temperature Fe can tolerate the level of heat (Murdiana, Rawar and Kurniawaty, 2022). The second process is the refining process which is carried out to produce moringa powder. The third stage is cooking using the baking method; the temperature used is 1000C for ±30 minutes. In this third process, the Fe content in moringa cookies is largely lost due to the temperature exceeding 50^0C. However, in moringa cookies, the source of Fe does not only come from moringa powder but also wheat flour that has been fortified with Fe±8-10 g / kg. In capsule products, only two processing processes are carried out, namely drying and refining. The drying process carried out on capsule products is the same as moringa cookies, namely at a temperature of 50^0C

for 48 hours. Likewise in the refining process, the dried moringa will be ground. The difference in the processes carried out on the two products can affect the Fe content, thereby affecting the effectiveness of the product.

The digestive process can also affect the effectiveness of the product, where capsules (especially gelatin or liquid) are digested faster because the ingredients are easily dissolved in gastric fluid, while in the form of cookies it requires enzymatic breakdown and is more complex to release the nutrients contained in it (Zebua, 2022). Thus it can be proven that the moringa capsule group was higher in increasing the hemoglobin levels of adolescent girls (1.57g/dl) compared to the moringa cookies group (1.09g/dl). Significant differences in both groups were not seen because the p-value after the intervention was 0.412.

The strength of this study is the innovation in processing moringa leaves, which are local food in Baubau City, into cookies and capsules as an alternative iron supplement that is more acceptable to adolescent girls. However, this study has limitations, such as the lack of monitoring of respondents' daily consumption, which can affect the validity of the results due to possible variations in consumption compliance. In addition, the lack of approach to parents/guardians caused some respondents to drop out, which can affect the final sample size and the generalization of the study results.

CONCLUSION

Innovations utilizing moringa oleifera leaves, in the form of cookies and capsules, can serve as effective strategies to improve hemoglobin levels among adolescent girls with iron deficiency anemia. Both moringa cookies and capsules significantly increased hemoglobin concentrations; however, no significant difference was found between the two groups (p=0.412), suggesting that both products have potential as alternative iron supplementation options. Further research is recommended to develop moringa-based products with enhanced iron bioavailability, while also exploring factors such as adherence to consumption and adolescent preferences. Additionally, attention should be given to the daily dietary patterns of adolescent girls, emphasizing iron-rich foods, and schools are encouraged to collaborate with health agencies to strengthen nutrition education and awareness related to iron deficiency and other nutritional issues.

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Author Contributions

JA: funding acquisition, conceptualization, writing-original draft; BD: Screening, data curation; MSI: writing–review and editing, validation; AF: project administration; RA: Screening; H: Screening.

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