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Daily consumption of functional egg increases hemoglobin level of children with anemia

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ABSTRAK

Latar Belakang: *Zat Besi adalah salah satu elemen kunci dalam mengoptimalkan 1000 hari pertama kehidupan, termasuk untuk pencegahan stunting. Telur adalah protein hewan yang kaya zat besi dan terjangkau bagi semua orang, lebih ekonomis, dibandingkan dengan sumber protein hewani lainnya seperti daging.*
Tujuan: *Untuk menentukan efek dari konsumsi telur fungsional terhadap tinggi badan dan kadar hemoglobin pada balita dengan anemia di Yogyakarta.*
Metode: *Metode penelitian menggunakan rancangan double blind randomized controlled trial dengan desain kelompok kontrol pra tes dan pasca tes. Sampel terdiri dari 16 balita anemia yang dibagi menjadi 8 subyek sebagai kelompok intervensi diberikan telur fungsional dan 8 subjek sebagai kelompok plasebo diberikan telur biasa. Pemberian telur ini berlangsung selama 42 hari diberikan terus menerus 1butir/hari dipagi hari untuk sarapan.*
Hasil: *Hasil penelitian menunjukkan terdapat 1 anak stunting pada kelompok perlakuan dan 2 anak k stunting pada kelompok placebo . Rata-rata usia responden yaitu 38 bulan pada perlakuan dan 33 bulan pada placebo. Terdapat peningkatan tinggi badan dan hemoglobin dengan selisih 1,3 cm untuk tinggi badan dan 2,8 gr/dl untuk hemoglobin pada kelompok perlakuan setelah diberikan intervensi selama 42 hari, sedangkan pada kelompok placebo terdapat peningkatan 0,5 cm untuk tinggi badan dan 0,7 gr/dl untuk hemoglobin. Terdapat perbedaan secara signifikan kadar hemoglobin setelah diberikan intervensi antar kelompok (p=0.010), sedangkan tidak pada tinggi badan (p=0,328). Terdapat perbedaan yang signifikan baik pada kelompok perlakuan dan kelompok placebo terdapat perbedaan tinggi badan dan hemoglobin yang signifikan sebelum dan sesudah diberikan intervensi (p<0.05.*
Kesimpulan: *Konsumsi telur fungsional setiap hari selama 42 hari secara positif signifikan dapat meningkatkan kadar hemoglobin pada balita anemia..*

KATA KUNCI*: telur fungsional; balita anemia; kadar hemoglobin; tinggi badan*

ABSTRACT

Background: *Iron is one of the key elements in optimizing the first 1,000 days of life, including stunting prevention. Eggs are animal proteins that are rich in iron and affordable to all, more economically friendly, compared to other animal protein sources like meat.*

Objectives: *This study aims to determine the effect of daily consumption of eggs on height and hemoglobin level of anemic children under five in Yogyakarta.*

Methods: *Double-blind randomized controlled trials were used in the study procedures. The samples included sixteen under-five anemic children, separated into two groups: eight recipients of functional eggs as an intervention group and eight recipients of regular eggs as a placebo group. The intervention was passed during 42 days given continuously1 egg/day in the morning for breakfast.*

Results: *The results showed that there were 1 stunted child in the treatment group and 2 stunted children in the placebo group The average age of recipients was 38 months in treatment and 33 months in placebo. There was an increase in height and hemoglobin with a difference of 1.3 cm for height and 2.8 gr/dl for hemoglobin in the intervention group after being given treatment for 42 days, whereas in the placebo group there was an increase of 0.5 cm for height and 0. 7 gr/dl for hemoglobin. There was a significant difference in hemoglobin levels after the treatment was given between groups (p=0.010), whereas there was not a difference in height (p=0.328). Meanwhile, within intervention group and the placebo group, there were significant differences in height and hemoglobin before and after being given intervention treatment (p<0.05).*

Conclusions: *Daily Consumption of Functional eggs for 42 days can significantly increase hemoglobin levels in children with anemia.*

KEYWORD*:* *functional egg; anemia children; hemoglobin;height*

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INTRODUCTION

Malnutrition is still a significant public health issue in Indonesia, with stunting and anemia representing the two most common nutritional issues affecting newborns and young children (1). Anemia is more common in children under five, according to Indonesia's 2018 National Health survey was 38,5%, in comparison to that in the 2013 survey, which was 28,1% (2). The majority of undernutrition, including iron deficiency, is caused by poverty. The most prevalent micronutrient deficiency worldwide and the leading cause of anemia is iron deficiency (ID). Because they consume less iron and eat less food that contains bioavailable iron, children and adolescents from lower socioeconomic backgrounds are more likely to experience iron deficiency (3). Because it is going through a period of rapid growth, children under five is one of the groups that is more susceptible to anemia due to the increased need for iron. If anemia occurs, it needs to be treated right away because it can interfere with children's growth and development, which can have serious long-term effects (4). Anemia that occurs due to stunting can also be a contributor to morbidity and mortality in toddlers. According to a previous study, severely stunted toddlers have lower average hemoglobin levels than toddlers who are not (1).

To prevent the risk of anemia, adequate intake of iron should be encouraged. Food consumption is the principal determinant for adequate intake of iron. Dietary iron comes in two forms non-heme iron (NHI), which is absorbed from the intestine more effectively than heme iron (HI) (5,6). Legumes, cereals, pulses, fruits, and vegetables are sources of nonheme iron, while meat, fish, and poultry are sources of heme iron (7,8). A few intervention studies have been performed, eggs have a lot of potential to enhance children's nutrition (9). Egg is a high-nutrient food

that may help ensure that young children's diets are adequate in a variety of nutrients. The chicken egg yolk contains 56,8 ppm/serving of the iron. Eggs contain both heme and non-heme iron. Heme iron can contribute 40% or more to the total iron absorbed by the body, meanwhile, non-heme iron is less efficiently absorbed (5).

Recently, some researchers have tried to improve the eggs' functionality by adding other ingredients, like vitamins, trace minerals, polyunsaturated fatty acids, and biocatalysts (10–12). Eggs are designed not only to fulfill daily nutrient requirements but also to promote health and prevent certain diseases (13). One of the functional eggs that has been developed is an egg high in iron (Fe) content . The eggs were obtained from laying hens fed a ration with a high Fe content (14,15). Functional eggs have higher Fe levels than ordinary eggs (65,7 ppm on fungtional egg and 56,8 ppm on regular egg) so it is hoped that it has potential as a nutrient to increase blood hemoglobin and growth in anemic children There was a lack of reaseach regarding the effect of high Fe eggs on anemic toddlers. The purpose of this study is to ascertain the impact of daily egg consumption on height and hemoglobin levels of anemic toddlers in Yogyakarta, Indonesia.

MATERIALS AND METHODS

Subject and study Design

A randomized controlled trial with double blinds was the study design with a pretest-posttest design. A group of 16 subjects was split into two groups: one for the intervention and the other for a placebo. This research used simple randomization, which means that all subjects that come and meet the inclusion criteria will be randomly selected until the required number of samples is met. Randomization is performed to determine which subject belongs to the intervention group or placebo group (16). The research was carried out at Posyandu Toino-Jetakan, Pendowoharjo Village, Sleman, Yogyakarta, Indonesia, from July to November 2023. Hypothesis testing for differences in two proportions between two independent groups was used to determine the sample size.

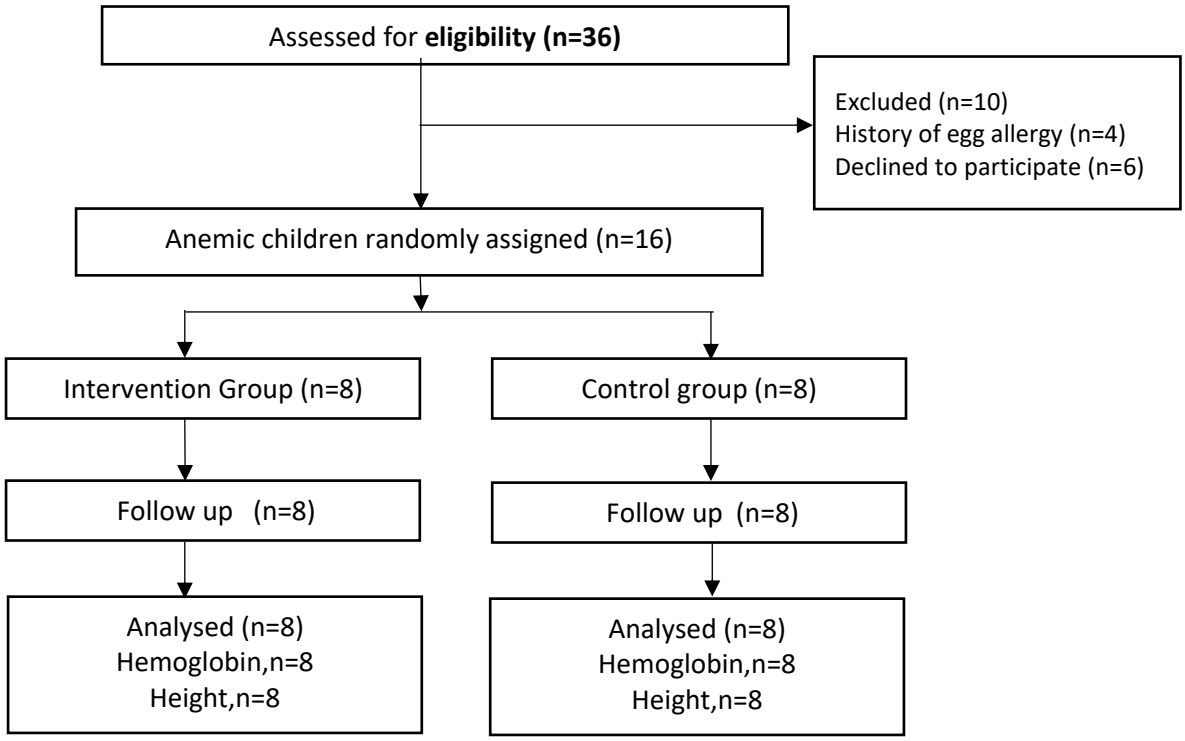

Figure 1. Flow diagram of the progress through the phases of a parallel randomized trial of two group

The minimal number of subjects required, with 95% confidence interval and 80% power. The inclusion criteria of the subject covered having a hemoglobin level below 11 g/dl, has no allergy to eggs, and they were between the ages of 6-59 months. Children were excluded based on history of egg allergy.

Intervention

The study took place over a 42-day period. It was ensured that all respondents consumed eggs by monitoring them every day from whatsapp group.. One functioning egg per day for breakfast was provided to the intervention group during the trial period (17), while placebo group was given 1 broiler chicken egg/day. The average weight of eggs, both functional eggs and broiler chicken egg, is 50 grams. Functional eggs (Telur Ayam Bahagia® provided by PT Agromix Lestari Group, Yogyakarta, Indonesia) have 11% higher albumin than ordinary eggs. An increase in the amount of protein indicates that the portions of the protein containing the bioactive compound are increasing. In addition, Each partisipant's was asked to fill compliance form to ensure the egg was consumed daily functional eggs contain higher Fe content than control egg. On the other hand, the cholesterol content of the functional egg yolk is 45% lower than the control eggs. Analysis for protein, fat and cholesterol levels was carried out in Laboratory of Nutritional Biochemistry, Faculty of Animal Science Universitas Gadjah Mada, while analysis for Fe and Zn was carried out in Animal Science Learning Center, Faculty of Animal Science, Universitas Gadjah Mada. Comparison of the nutritional composition of control eggs with functional eggs based on laboratory result is presented in **Table 1**.

Hemoglobin sample collection

Hemoglobin levels were collected using the finger test stick method (Capillary blood) using the Easy Touch Strip hemoglobin, which is in line with a study that says that the finger testing stick method is considered a useful predictor for measuring the level of haemoglobin (18). In terms of age-appropriate hemoglobin values, the WHO defines iron deficiency anemia as follows: Child age 6-59 months: Hb < 11 g/dL (19). Hemoglobin was measured before and after the intervention.

Table 1. Nutritional comparasion of placebo and intervention

Component	Placebo (Control egg)*	Intervention (Functional egg)*
Protein (g/100g)	19.4	21.7
Fat (g/100g)	8.8	6.2
Cholesterol (mg/100g)	616.2	403.3
Fe (ppm)	56.8	65.7
Zn (ppm)	33.3	33.5

Antropometric Measurement

Height was taken using length board for children under five and microtoise for over 2 years. Meanwhile weight was taken using a standardized digital scale. Body weight was measured before the intervention while height was measured before and after the intervention. Recumbent child length and weight were converted to z-scores based on the WHO Growth Standards applicable to each age and sex. The anthropometric z-score distribution curve figures were created using the WHO Anthro Survey Analyzer (20)

Data Analysis

Descriptive analysis was used to describe baseline characteristics, and independent sample t-test and cross-tabulation/chi-square analysis were used to compare the study groups for categorical and continuous variables, respectively. Paired and unpaired t-test were performed to compare mean value within and between group. Kolmogorov-Smirnov analysis indicates that the data have a normal distribution. Statistical significance was defined as a P value of less than 0.05.

Ethical Consideration

Given that the subjects were minors, parents were fully informed of the study's purpose and provided a signed informed consent form, if not both. The Ethical Committee Faculty of Health Sciences, Universitas Respati Yogyakarta,

authorized the protocol (The approval date July 7th 2023, No 0139.3/FIKES/PL/VII/2023).

RESULTS AND DISCUSSIONS

This study included 16 anemic children under the age of five; Table 2 list the characteristics of the subjects. It was possible to establish that the subjects' baseline characteristics were the same since the intervention group and the placebo group did not significantly differ from one another (p>0.05) **(Table 2**). There was a significant within group on height and hemoglobin before and after intervention and there was a significant between group on hemoglobin after intervention (**Table 3**)

Table Table 2. The Subject's Baseline Characteristic

Characteristics	Intervention (n=8)	Placebo (n=8)	*P* value
Sex			
Male	4	5	1,00[a]
Female	4	3	
Age, month	38±9,9	33±13,9	0,44[b]
Nutritional Status, HAZ			
Stunted	1	2	1,00[a]
Normal	7	6	
Weight, kg	13,1±2,2	12,8±3,4	0,84[b]

[a]Chi-Square Analysis, [b]Independent t-test, significant if p-value less than 0.05, Mean±SD is displayed in the data

The purpose of this study was to evaluate on how anemic children's height and hemoglobin levels were affected by consuming functional eggs every day. The functional egg may improve the height of toddler through promoting the hemoglobin level. The amount of iron consumed by the treatment group was greater (65.7 ppm) than the placebo group (56.8 ppm). The intervention of functional egg showed the children's height increased by 1,3 cm while in the control group increased by 0,5 cm at 42 days of intervention and statistically significant in both groups. Furthermore, there was a difference in hemoglobin levels between the functional egg and the placebo (2.8 g/dl vs 0.7 g/dl). It is suggested that Functional eggs consumption that can make anemic children become non-anemic. Globally, the most common micronutrient shortage is iron deficiency, and young children are especially vulnerable because of their high iron needs duet to their fast growth (21). Iron is regarded as a vital dietary element that is required for growth and well-being.

Table 3. The difference between and within groups on height and hemoglobin level

	Before	After	Δ	p-value**
Height (cm)				
Intervention Group	91.8±7.23	93.1±7.25	1.3±0.02	0,000***
Placebo Group	88.1±9.25	88.6±9,23	0.5±0.02	0,000***
p-value*	0,425	0,328		
Hemoglobin level (g/dl)				
Intervention Group	9.3±1,03	12.1±0.90	2.8±0.13	0,000***
Placebo Group	9.6±1.30	10.3±1.30	0.7±0.00	0.027***
p-value*	0,565	0,010***		

Iron is needed for Erythropoiesis, which is the process that produces red blood cells that carry oxygen (22). Transporting and delivering oxygen to tissues is the main role of hemoglobin. (22). There are two ways to treat late infantile anemia trough dietary intervention, first with iron supplementation and iron fortification (23). The recommended daily allowance (mg/d) for total iron consumption in infants is 0.27 mg for 0–6 months of age,11 mg for 7–12 months of age, 7 mg for 24-36 months of age, and 10 mg for over 36 months of age (24).

Dietary iron can be absorbed in two forms, heme and non-heme iron. Heme iron, which is derived from the hemoglobin and myoglobin of animal dietary sources (egg, meat, fish, and poultry), is the most readily absorbed form of iron (from 15% to 35%), at least 10% of our total iron absorption comes from it (25). Dietary iron absorption is primarily performed through enterocyte on duodenum and upper jejunum of the small intestinal. While in this study was not designed to directly assess iron bioavailability, its important that eggs has positively impact iron status on anemic toddlers. Egg are a nutrient-dense food with potential to improve the dietary adequacy of many nutriens for toddlers. In eggs, iron is primarily concentrated in the yolk. There was a study from Australia and Malawi has shown some potential for eggs to increase hemoglobin among infants non-anemic, after providing 4 egg yolk/week to 6 months old infants for 6 months (26). The other studies from Southeren Ethiopia stated eggs have nutrients to boost hemoglobin levels, and recommended in settings where anemia is high and animal-source food intake is low (27).

In addition, based on lab result functional egg also has a higher protein content (21.7 g/100g) than control eggs (19.4 g/100g). This indicates that toddlers who consume functional eggs get more protein supply than control eggs. Development, neurogenesis, and enduring well-being are significantly impacted by the amount and quality of protein consumed in the first two years of life. (30). Infants that consume optimal amounts of protein will grow taller (32). Eggs are regarded as the ideal source of protein since they have a profile of amino acids that can be used to compare other proteins (31).

Based on the results of the research, it shows that there is significant correlation between total protein intake and animal protein with hemoglobin levels in toddlers. This shows the important role of proteins in formation of hemoglobin. Proteins in foodstuffs derived from animals such as meat and egg apart from being a source of protein also a source of heme iron which forms blood hemoglobin. Proteins in the human body play a role in forming blood droplets (hemopoiesis) that is, formation erythrocytes with hemoglobin in them. In order to establish nitrogen balance across various age groups, foods are evaluated using reference patterns of necessary or required amino acids using the protein-digestibility-corrected amino acid score (PDCAAS). A PDCAAS of less than one (or 100% when converted to percentile) indicates that at least one amino acid is limiting, even while a score above one exceeds the requirements for all nine essential amino acids.

The PDCAAS for eggs is 118% for kids between the ages of six months and five years, but it is 92–94% for meat and fish, 90–93% for soy, and 35–57% for rice, wheat, and maize (32). Chicken eggs are widely available and enjoyed by nearly all people, even young children. The potential for peak bone mass arises when amino acids in proteins work to modulate the secretion and osteotropic activity of the IGF-I hormone, which in turn builds bone matrix and influences bone growth (33). Based on the researcher's direct experience in the research process Currently, there are several limitations experienced such as inadequate sample size and the presence of unmeasured confounding variables such as food intake during the intervention.

CONCLUSIONS AND RECOMMENDATIONS

The results of this research can be concluded that providing 1 functional egg/day for 42 days continuously significantly affected on increase in hemoglobin levels among anemic children. Functional eggs rich iron and protein are one of the strategies used to reduce anemia among children. These results suggested that children who receive 1 functional egg/day had significantly reduced anemia. This study was supported by Internal research grants from Universitas Respati Yogyakarta and PT Agromix Lestari Group, Yogyakarta, Indonesia for supplying fungtional eggs (Telur Bahagia®).

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