

Article

# Frequency And Amount Of Animal And Plant Protein Consumption In Relation To Hemoglobin Levels In Adolescent Girls

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## Abstract

**Background:** Anemia remains a major nutritional problem among adolescent girls and can adversely affect health, academic performance, and the quality of human resources. Protein intake, derived from both animal and plant sources, plays an important role in hemoglobin synthesis. **Objectives:** This study aimed to analyze the relationship between the frequency and amount of animal-based and plant-based protein consumption and hemoglobin levels among adolescent girls at SMAN 1 Kartasura. **Method:** This study employed an observational cross-sectional design. A total of 90 female students from grades X and XI were selected using simple random sampling. Protein intake data were collected through interviews using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), while hemoglobin levels were measured using the cyanmethemoglobin method. Data were analyzed using univariate and bivariate analyses with the Chi-square test. **Results:** The results showed that most respondents had normal hemoglobin levels (66.7%). Higher frequencies of animal and plant protein consumption tended to be associated with normal hemoglobin levels; however, no significant association was found between the amount of animal protein intake ( $p = 0.134$ ) or plant protein intake ( $p = 0.266$ ) and hemoglobin levels. **Conclusion:** This study concludes that protein consumption contributes to maintaining normal hemoglobin levels, although hemoglobin status in adolescent girls is influenced by multiple factors, including food quality, iron bioavailability, and overall dietary patterns.

Academic Editor: Soleman Landi

Received: 16 March 2026

Revised: 30 March 2025

Accepted: 05 April 2026

Published: 30 April 2026

Citation: Vancouver Style

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**Keywords:** Animal Protein, Plant Protein, Hemoglobin, Adolescent Girls, Anemia

## 1. Introduction

Adolescence is a crucial developmental phase in an individual's life, marked by significant changes in physical, physiological, and psychological aspects. During this period, there is accelerated physical growth, maturation of organ functions, and intensive cognitive and social development (Astuti, 2021). The health of adolescents is greatly influenced by adequate intake of nutrients, particularly protein and iron, which play an important role in the formation of hemoglobin as the main component of red blood cells (Kurniawan, 2023).

One of the health problems that is still commonly found in adolescents is anemia. Globally, anemia remains a dominant public health problem, especially in developing countries (WHO, 2021). Anemia is defined as a condition in which the hemoglobin level

in the blood is below normal, i.e., less than 12 g/dL, thereby reducing the blood's ability to transport oxygen to all tissues in the body. Hemoglobin, as the main protein in erythrocytes, functions to transport oxygen from the lungs to body tissues and carry carbon dioxide back to the lungs. A decrease in the number of red blood cells or hemoglobin levels can interfere with the supply of oxygen to organs and cause symptoms such as fatigue, dizziness, weakness, and paleness (Almatsier, 2020).

Epidemiological data shows that anemia is still prevalent among women of reproductive age. Approximately 30% of women aged 15–49 years worldwide are reported to have anemia. In Indonesia, the prevalence of anemia among adolescent girls is still relatively high. The Ministry of Health reported that in 2021, the prevalence of anemia in the 15–24 age group reached 48.9%. However, the 2023 Indonesian Health Survey recorded a prevalence of anemia in the 15–25 age group of 15.5% (Kemenkes, 2023b). At the regional level, the 2023 Central Java Health Profile shows that of the female adolescents in grades 7 and 10 who underwent hemoglobin screening, 30.45% were identified as having anemia (Dinkes Jateng, 2023).

In Sukoharjo Regency, the prevalence of anemia among adolescent girls shows an increasing trend. In 2022, the prevalence of anemia was recorded at 29.4%, a relatively higher figure compared to several other regions in Central Java (Sukoharjo Health Office, 2022). Furthermore, in 2023, Sukoharjo Regency was included in the top ten regencies/cities with the highest prevalence of anemia among adolescent girls in Central Java Province. Of the 91.6% of adolescent girls who underwent screening, 36.9% were identified as having anemia (Central Java Health Office, 2023). Among the twelve subdistricts, Kartasura Subdistrict recorded the highest prevalence of anemia among adolescent girls, at 6.7% (Sukoharjo, 2024).

Anemia in adolescent girls is caused by various factors, including iron, folic acid, vitamin B12, and protein deficiencies (Thamaria et al., 2017). Iron deficiency is often related to dietary patterns suboptimal lifestyle and food consumption habits (Setiawati et al., 2025). Low protein intake, especially animal protein rich in iron, is one of the main factors causing iron deficiency, which leads to anemia (Waspadji, 2023). Iron from animal food sources (heme iron), such as liver, meat, poultry, and fish, has a higher absorption rate of around 20–30%, while iron from plant-based food sources (non-heme iron), such as green vegetables and nuts, is only absorbed by the body at a rate of about 1–10% (Kemenkes, 2023a; Thamaria et al., 2017).

Protein is an essential macronutrient that plays an important role in hemoglobin synthesis because it provides the essential amino acids needed for globin formation. Essential amino acids determine the biological value of protein and cannot be synthesized by the body, so they must be obtained through food intake (Rahman, 2022; A. R. Putri et al., 2023). Meanwhile, non-essential amino acids can be produced endogenously by the body (Damongilala, 2021). Therefore, protein consumption from animal and plant sources is important to support physical growth and replace iron loss that can potentially trigger anemia (Rahmawati & Abdullah, 2021). This is in line with Hartono's (2021) findings, which state that protein deficiency can inhibit red blood cell production, thereby reducing hemoglobin levels and increasing the risk of anemia, especially in adolescent girls.

Adolescent girls have a higher risk of anemia than adolescent boys, mainly due to blood loss during the menstrual cycle. This condition will further increase the risk of anemia if not balanced with adequate iron and protein intake (Nurjanah, 2016). Research by Darma et al. (2019) shows that adolescent girls with higher intake of animal protein, sourced from fish, chicken, eggs, pork, and cow's milk, have better hemoglobin levels. As many as 80.7% of adolescent girls with higher protein intake were reported to not have anemia. Similar results were also shown by the study by Sari et al. (2022), which found that consuming animal protein more than three times per week was associated with a reduced risk of anemia.

In addition to animal protein, plant-based protein also plays an important role in meeting daily protein requirements. Adequate consumption of plant-based protein can provide the essential amino acids needed by the body. Several studies have reported that adolescent girls who consume plant-based protein sources, such as nuts and seeds, show an increase in hemoglobin levels (Susanti et al., 2020). Research by Eniwati et al. (2019) also proves a significant relationship between plant-based protein intake and the incidence of anemia. Tempeh, a traditional soy-based food, has been proven to increase hemoglobin levels in various age groups (Pinasti et al., 2020).

The absorption of non-heme iron from plant-based foods can be increased when consumed together with heme iron from animal-based foods or with foods containing vitamin C (Kemenkes, 2020). Widodo and Lestari (2022) showed that a diet combining animal and plant proteins can increase iron absorption and help maintain optimal hemoglobin levels in adolescent girls. Similar findings were reported by Wati and Handayani (2023) and Lestari et al. (2023), who confirmed that combining plant-based protein with iron and vitamin C sources has the potential to increase hemoglobin levels. The combination of animal and plant protein consumption has also been reported to provide broader health benefits, including improved iron status, immune system function, and cognitive development in adolescent girls (Yunita, 2022; Kartika et al., 2023).

State Senior High School 1 Kartasura is one of the state senior high schools in Sukoharjo Regency that routinely provides adolescent health services through collaboration with the Kartasura Community Health Center. Based on anemia screening data collected between March and May 2024, it was recorded that out of 18 high schools/equivalent institutions screened, State Senior High School 1 Kartasura had the highest number of adolescent girls with anemia, namely 96 individuals or 26.3%.

Based on this description, it can be concluded that the pattern of animal and plant protein consumption plays an important role in preventing anemia in adolescent girls. The right combination of these two protein sources not only contributes to meeting iron requirements but also supports the overall health and development of adolescents. Therefore, this study aims to analyze the relationship between the frequency and amount of animal and plant protein consumption and hemoglobin levels in female adolescents at SMAN 1 Kartasura.

## 2. Materials and Methods

This study is an observational study with a cross-sectional design that aims to analyze the relationship between the frequency and amount of animal and plant protein consumption and hemoglobin levels in female adolescents at SMA Negeri 1 Kartasura, Sukoharjo Regency. The study was conducted from September 2024 to June 2025 with a population of 470 female students in grades X and XI. The study sample consisted of 91 respondents selected using simple random sampling based on inclusion and exclusion criteria. Data on animal and plant protein consumption were collected through interviews using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) to describe the frequency and amount of consumption during the last three months. Protein intake was calculated in grams per day and categorized based on the percentage of the Nutrient Adequacy Rate. Hemoglobin levels were measured using the Cyanmethemoglobin method and expressed in g/dL. Data were analyzed univariately and bivariate using the Chi-Square test with a significance level of  $p < 0.05$ . All research procedures complied with research ethics principles with the written consent of the respondents.

## 3. Results

### Profile of SMAN 1 Kartasura

SMAN 1 Kartasura is one of the public high schools located in Kartasura District, Sukoharjo Regency, Central Java. The school was established on April 1, 1978, and is under the auspices of the Ministry of Education and Culture. Based on the latest

accreditation issued by the National Accreditation Agency for Schools/Madrasahs, SMAN 1 Kartasura has received an A accreditation status, which reflects the quality of its management, facilities and infrastructure, and learning processes. With a total of 1,164 students, predominantly female, and supported by 66 professional educators, this school is a representative educational environment for adolescent health studies, especially among adolescent girls.

The vision and mission of SMAN 1 Kartasura emphasize the development of innovative, collaborative, reflective, and digitally friendly learning, as well as the formation of excellent, characterful, and environmentally conscious graduates. This orientation is in line with efforts to improve the quality of human resources, including in the aspects of student health and nutrition. The school's commitment to strengthening character, literacy, and student welfare is reflected in various support programs, including the implementation of school health services and regular adolescent health screenings in collaboration with the Kartasura Community Health Center.

Table 1. Respondent Characteristics

Age	Frequency	Percentage (%)
15 years	10	11.1
16 years	44	48.9
17 years	33	36.7
18 years	3	3.3
<b>Total</b>	<b>90</b>	<b>100</b>

Most respondents were 16 years old, totaling 44 people (48.9%), followed by 33 people (36.7%) who were 17 years old. There were 10 respondents aged 15 (11.1%), while those aged 18 were the fewest, at 3 (3.3%). This data shows that the study was dominated by mid-adolescents.

Table 2. Hemoglobin Levels in Adolescent Girls

Hemoglobin Levels	Number	Percentage (%)
Normal	60	66.7
Abnormal	30	33.3
<b>Total</b>	<b>90</b>	<b>100</b>

Based on Table 2, most adolescent girls had normal hemoglobin levels (66.7%), but 33.3% of respondents still had abnormal hemoglobin levels

Table 3. Frequency of Animal Protein Consumption Among Adolescent Girls

Food	Daily Consumption (x/day)	Consumption per Day (x/day)	Food	Consumption per Day (x/day)	Daily Consumption (x/day)
Beef	6.34	0.07	Pomfret	0.71	0.01
Chicken Meat	60.33	0.67	Sardines	5.42	0.06
Duck Meat	8.43	0.09	Patin Fish	4.87	0.05
Goat Meat	1.92	0.02	Tilapia	4.91	0.05
Chicken Eggs	15.83	0.18	Salted Fish	1.58	0.02
Village Domestic Chicken	61.07	0.68	Salted Fish	5.04	0.06
Eggs					
Duck Eggs	2.33	0.03	Anchovies	2.72	0.03
Salted Duck Eggs	8.43	0.09	Eel	3.49	0.04
Quail eggs	11.07	0.12	Shellfish	2.27	0.03
Chicken liver	16.49	0.18	Tripe	0.59	0.01
Beef liver	0.76	0.01	Beef ribs	0.83	0.01
Chicken feet	9.36	0.10	Goat ribs	0.12	0
Shrimp	1.36	0.02	Beef brain	0.19	0

Squid	5.78	0.06	Goat brain	0	0
Tilapia	0.92	0.01	Beef	0.18	0
			Intestines		
Snapper	8.45	0.09	Shredded meat	9.67	0.11
Snakehead fish	0.29	0	Chicken	27.27	0.30
			Nuggets		
Carp	0.54	0.01	Meatball	14.46	0.16
			Noodles		
Catfish	12.59	0.14	Sausage	25.22	0.28
Milkfish	16.42	0.18			

Source: Primary Data, 2025

Based on Table 3, the most frequently consumed animal proteins are chicken eggs and chicken meat, while products such as nuggets and sausages are also consumed quite frequently. Conversely, some foods such as goat brains and snakehead fish are rarely consumed.

Table 4. Frequency of Plant-Based Protein Consumption Among Adolescent Girls

Food Item	Total Daily Consumption (x/day)	Average Consumption per Day (x/day)
Tempe	80.92	0.9
Tofu	74.14	0.82
Tofu Flower	0.76	0.01
Green Beans	5.15	0.06
Red beans	1.17	0.01
Soybeans	3.31	0.04
Peanuts	2.1	0.02
Walnuts	0.04	0
Cashew nuts	2.54	0.03
Oncom	0.72	0.01

Source: Primary Data, 2025

Based on Table 4, tempeh and tofu are the most frequently consumed sources of plant-based protein, while nuts and oncom are consumed less frequently, and walnuts are rarely consumed.

Table 5. Frequency of Animal Protein Consumption Among Adolescent Girls

Food Item	Daily Consumption (grams)	Consumption per Day (grams)	Food	Consumption per Day (grams)	Daily Consumption (grams)
Beef	446.90	4.97	Pomfret	31.86	0.35
Chicken Meat	2697.59	29.97	Sardines	405.67	4.51
Duck Meat	385.14	4.28	Patin Fish	194.56	2.16
Goat Meat	197.46	2.19	Tilapia	179.62	2.00
Free-range chicken eggs	1073.72	11.93	Salted Fish	51.43	0.57
Domestic Chicken Eggs	5032.57	55.92	Salted Fish	12.71	0.14
Duck Eggs	131.91	1.47	Anchovies	7.34	0.08
Salted Duck Eggs	597.84	6.64	Eel	195.29	2.17
Quail eggs	445.71	4.95	Shellfish	174.41	1.94
Chicken liver	709.17	7.88	Tripe	26.22	0.29
Beef Liver	32.78	0.36	Beef ribs	60.57	0.67
Chicken feet	1065.43	11.84	Goat Ribs	7.22	0.08
Shrimp	166.96	1.86	Beef brain	12.17	0.14
Squid	309.29	3.44	Goat brain	0	0
Tilapia	51.68	0.57	Beef	8.81	0.1
			Intestines		
Snapper	380.44	4.23	Shredded meat	191.84	2.13

Snakehead fish	12.50	0.14	Chicken	890.54	9.89
Carp	19.11	0.21	Nuggets		
Catfish	530.10	5.89	Meatball	289.24	3.21
Milkfish	719.07	7.99	Noodles		
			Sausage	1,236.95	13.74
<b>Total</b>				<b>18,981.82</b>	<b>210.91</b>

Source: Primary Data, 2025

Based on Table 5, the highest consumption of animal protein comes from chicken eggs and chicken meat, while some ingredients such as goat brains and anchovies are rarely consumed. The total average consumption of animal protein reaches 210.91 grams per day.

Table 6. Frequency of Plant Protein Consumption Among Adolescent Girls

<b>Ingredient food</b>	<b>Total consumption day</b>	<b>Average consumption per day</b>
Tempe	6949.52	77.22
Tofu	5,171.43	57.46
Fried Tofu	35.87	0.4
Green Beans	101.94	1.13
Red beans	48.84	0.54
Soybeans	110.79	1.23
Peanuts	63.17	0.7
Walnuts	0.89	0
Cashew nuts	82.62	0.92
Oncom	108.7	1.21
<b>Total</b>	<b>12,673.78</b>	<b>140.82</b>

Source: Primary Data, 2025

Based on Table 6, the highest consumption of plant-based protein among adolescent girls comes from tempeh and tofu, while other types of nuts are consumed in low amounts. The total average consumption of plant-based protein is 140.82 grams per day.

Table 7. Relationship between Animal Protein Consumption Frequency and Hemoglobin Levels in Adolescent Girls

<b>Frequency of Animal Protein Consumption</b>	<b>Normal Hemoglobin Levels n(%)</b>	<b>Abnormal Hemoglobin Levels n (%)</b>
Low	18 (56.3)	14 (43.7)
Normal	29 (72.5)	11 (27.5)
High	13 (72.2)	5 (27.8)
<b>Total</b>	<b>60 (66.7)</b>	<b>30 (33.3)</b>

\*Pearson Chi-square test

Based on Table 7, normal hemoglobin levels were more common among adolescents with adequate and high animal protein consumption, although there were still some with abnormal levels.

Table 8. Relationship Between Frequency of Plant Protein Consumption and Hemoglobin Levels in Adolescent Girls

<b>Frequency of Plant Protein Consumption</b>	<b>Normal Hemoglobin Levels n(%)</b>	<b>Abnormal Hemoglobin Levels n (%)</b>
Low	20 (58.8)	14 (41.2)
Normal	28 (70.0)	12 (30.0)
High	12 (75.0)	4 (25.0)
<b>Total</b>	<b>60 (66.7)</b>	<b>30 (33.3)</b>

Based on Table 8, normal hemoglobin levels tend to be higher in adolescents with moderate and high frequency of plant protein consumption, although some are still in the abnormal category.

Table 9. Relationship between Animal Protein Consumption and Hemoglobin Levels in Female Adolescents at SMA 1 Kartasura

Animal protein	Hemoglobin intake P value				
	Normal		Abnormal		
	n%	n	%	n	%
Deficit	5465.9	28	34.1	82	100
Normal	133.3	2	66.7	3	100
More	5100	0	0	5	100
Total	6066.7	30	33.3	90	100

\*Pearson Chi-square test

Based on Table 9, adolescent girls with higher animal protein consumption were more likely to have normal hemoglobin levels, although the difference between categories was not statistically significant ( $p = 0.134$ ).

Table 10. Relationship between Plant Protein Intake and Hemoglobin Levels in Female Adolescents at SMA 1 Kartasura

n	Normal		Abnormal		n	%	P value
	%	n	%	n			
Deficit	55	64.7	30	35.3	85	100	0.266
Normal	4	100	0	0	4	100	
More	1	100	0	0	1	100	
Total	60	66.7	30	33.3	90	100	

Based on Table 10, adolescent girls with normal and higher consumption of plant-based protein showed normal hemoglobin levels, but this relationship was not statistically significant ( $p = 0.266$ ).

#### 4. Discussion

##### 4.1 Hemoglobin Levels in Adolescent Girls

The results of the study show that most female adolescents at SMA N 1 Kartasura have hemoglobin levels in the normal category, namely 60 people (66.7%). The lowest Hb level recorded was 9.11 g/dl and the highest was 14.50 g/dl, with a normal threshold of  $\geq 12$  g/dl according to WHO criteria (2024). These findings indicate that anemia is still a significant problem among adolescent girls.

This study is in line with research conducted by Sari et al. (2022), which found that 20 adolescent girls (21.1%) had anemia and 75 adolescent girls (78.9%) did not have anemia. The results of this study also support the research by Annisa et al. (2024), which found that 25 adolescent girls (32.9%) had anemia and 52 adolescent girls did not have anemia (67.1%).

According to (Hartini et al., 2023), anemia in adolescents is caused by an imbalance between iron requirements and intake, mainly due to increased physiological needs due to menstruation and rapid growth. In addition to consumption factors, regular menstruation is also a major cause of decreased hemoglobin levels in adolescent girls. Each menstrual cycle can cause blood loss of around 30–40 ml, which is equivalent to a loss of 15–20 mg of iron. If this loss is not balanced with the intake of iron-rich foods, there will be a decrease in iron reserves in the body and ultimately a decrease in hemoglobin levels.

Although most respondents had normal Hb levels, one-third still suffered from anemia. According to researchers, low Hb levels in some respondents may be related to irregular consumption of animal protein or limited to certain types. As found in previous consumption analyses, adolescents consume eggs and chicken more often, while

consumption of red meat and liver is still very low. This explains why most cases of anemia are iron deficiency anemia, rather than chronic disease.

#### 4.2 Frequency of Animal Protein Consumption Among Adolescent Girls

Animal protein intake was obtained from interviews using the SQ-FFQ questionnaire, in which respondents were asked to recall and write down their animal protein consumption over the past 3 months. The results of the study show that animal protein consumption among adolescent girls tends to be dominated by easily accessible and processed protein sources, such as local chicken eggs (0.68 times per day) and chicken meat (0.67 times per day). In addition, processed products such as chicken nuggets (0.30 times per day) and sausages (0.28 times per day) also show relatively high consumption levels. These findings show that the eating habits of adolescent girls have shifted from fresh ingredients to more practical ready-to-eat products. This shift may be influenced by changes in lifestyle, limited meal times, and the ease of obtaining fast food.

The Ministry of Health recommends that adolescents consume animal protein sources at least twice a day and increase their consumption of vegetables and fruits containing vitamin C to aid iron absorption (Ministry of Health, 2020). However, in practice, adolescents' eating habits often do not align with these recommendations. In this study, it was found that the frequency of animal protein consumption among adolescent girls varied greatly, with low consumption of red meat such as beef and goat, as well as fish and seafood such as catfish, milkfish, and squid, which were consumed less frequently. Goat brains were a food item that was never consumed at all.

These findings are in line with previous studies showing that protein consumption patterns among adolescents are often dominated by foods that are easily available and preferred, but lack diversity in animal protein sources rich in heme iron and other nutrients important for hemoglobin formation (Atikah et al., 2023). The study found that low animal protein consumption patterns are associated with an increased incidence of anemia in adolescent girls due to a lack of easily absorbed iron (animal protein), indicating a significant relationship between animal protein consumption patterns and the incidence of anemia in some adolescent female populations.

According to the researchers, this limitation in animal protein consumption may be due to limited knowledge about nutrition and the influence of family economic status, leading parents to tend to serve foods that are easily available in the market and relatively affordable. Therefore, Nutrition education is needed in schools and communities to raise awareness about consuming a variety of animal proteins.

#### 4.3 Frequency of Plant-Based Protein Consumption Among Adolescent Girls

Based on the results of the study, it is known that adolescent girls consume various sources of plant-based protein such as tofu, tempeh, peanuts, and soy products at a fairly high frequency. This shows that plant-based foods are still an important component of the daily diet.

According to Putri et al. (2023), plant-based foods such as nuts and their processed products are affordable sources of protein that are easily obtained by Indonesians. In addition, plant-based proteins also provide fiber, vitamins, and minerals that play a role in maintaining the body's metabolic functions. However, plant-based proteins have limitations when compared to animal proteins. According to Almatier (2009), plant-based protein tends to have a lower biological value because it does not contain all essential amino acids in sufficient quantities.

The research data shows that most respondents consume plant-based side dishes such as tofu, tempeh, and nuts at least once or twice a day. According to researchers, adolescents from low-income families tend to consume plant-based protein more often than animal protein. This is influenced by purchasing power, as plant-based protein is cheaper and more affordable. In addition, eating habits and culture also influence the

frequency of plant-based protein consumption among adolescent girls. Families that often serve plant-based side dishes tend to make their family members prefer the food provided.

#### 4.4 Animal Protein Consumption Among Adolescent Girls

Based on the results of the study, the amount of animal protein consumption among adolescent girls at SMAN 1 Kartasura shows that most respondents are in the deficient category, namely 82 respondents (91.1%), while only a small portion are in the normal and above categories. This finding reflects that although the frequency of animal protein consumption varies, the amount consumed is still insufficient to meet the daily protein requirements according to the Nutrient Adequacy Rate (NAR). This condition may be caused by small consumption portions, the selection of animal protein types that are low in iron content, and the tendency to consume processed foods such as nuggets and sausages, which have lower protein quality and micronutrient content compared to fresh animal protein sources. The dominance of processed animal protein intake also has the potential to reduce the contribution of heme iron, which plays an important role in hemoglobin formation. The absence of a significant relationship between the amount of animal protein consumption and hemoglobin levels indicates that sufficient quantity alone is not enough; it must be supported by the quality of intake, a balanced diet, and other factors that support iron absorption.

Theoretically, animal protein plays an important role in hemoglobin status because it contains heme iron, which has a higher bioavailability than non-heme iron. According to Gibney et al. (2019) in *Introduction to Human Nutrition*, heme iron from meat, poultry, and fish is absorbed more efficiently by the body and is relatively unaffected by iron absorption inhibitors, thereby contributing directly to hemoglobin synthesis. However, recent research by Hurrell and Egli (2021) also confirms that the impact of animal protein on hemoglobin status is greatly influenced by adequate consumption, food source variety, and combination with other nutrients such as vitamin C. Therefore, low consumption of animal protein in adolescent girls can limit its physiological benefits for hemoglobin formation even if animal protein is consumed regularly.

#### 4.5 Plant Protein Intake Among Adolescent Girls

Based on the results of the study, the amount of plant protein consumption among female adolescents at SMAN 1 Kartasura was dominated by the deficient category, namely 85 respondents (94.4%), while the normal and higher categories only included a small number of respondents. Statistical tests showed that there was no significant relationship between the amount of plant protein consumption and hemoglobin levels ( $p$  value = 0.266). These findings indicate that although plant protein is consumed in relatively large amounts—especially from tempeh and tofu—its contribution to increasing hemoglobin levels is not yet optimal. This is understandable because plant protein sources generally contain non-heme iron, which has a lower absorption rate than heme iron from animal protein. In addition, plant protein consumption is often accompanied by substances that inhibit iron absorption, such as phytates and polyphenols, which are abundant in nuts and nut products. This condition means that not all of the iron that enters the body can be used for hemoglobin formation, so the risk of anemia remains high even if plant protein intake is sufficient in terms of quantity.

Theoretically, plant-based proteins still play an important role in meeting the nutritional needs of adolescents, including as a source of essential amino acids and minerals, but their effectiveness on hemoglobin status is greatly influenced by the bioavailability of iron and the combination of foods consumed. According to Hallberg and Hulthén (2020), non-heme iron from plant-based foods has a lower absorption rate and is greatly influenced by dietary factors, such as the presence of vitamin C as an enhancer and phytate as an inhibitor. Meanwhile, Gibson (2021) emphasizes that a plant-based diet

without proper food combination management has the potential to cause iron deficiency, especially in adolescent girls who have higher iron requirements due to menstruation. Therefore, although plant-based protein contributes to overall nutritional adequacy, increasing hemoglobin levels requires a more balanced and diverse consumption strategy, including combining plant-based protein with foods that enhance iron absorption.

#### 4.6 Relationship Between Animal Protein Consumption Frequency and Hemoglobin Levels in Adolescent Girls

Based on the results of the study, the relationship between the frequency of animal protein consumption and hemoglobin levels in adolescent girls at SMAN 1 Kartasura showed a positive trend, although it was not entirely linear. The data showed that adolescents with a moderate to high frequency of animal protein consumption had a higher proportion of normal hemoglobin levels compared to those with a low frequency of consumption. In the low consumption group, nearly half of the respondents still fell into the abnormal hemoglobin category. These findings indicate that the more often adolescent girls consume animal protein, the greater their chances of having normal hemoglobin levels. Animal proteins such as meat, eggs, fish, and offal not only serve as high-quality protein sources, but also provide heme iron, which is more easily absorbed by the body. More frequent consumption allows for a more consistent supply of heme iron, thereby supporting the process of erythropoiesis and hemoglobin formation, especially in adolescent girls who lose iron physiologically through menstruation.

Theoretically, the relationship between the frequency of animal protein consumption and hemoglobin levels can be explained through the concept of iron bioavailability. Heme iron derived from animal foods has a higher absorption rate and is relatively unaffected by inhibitory factors from other foods. According to Hurrell and Egli (2019), regular consumption of animal-based foods contributes significantly to improving iron status in the body because heme iron can be directly used in hemoglobin synthesis. This is reinforced by research by Abbaspour, Hurrell, and Kelishadi (2019), which states that the frequency of consumption of heme iron sources is an important determinant in the prevention of anemia in adolescents, especially females. Thus, the results of this study confirm that the frequency of animal protein consumption plays a strategic role in maintaining normal hemoglobin levels, although it still needs to be supported by a balanced diet and adequate intake of other nutrients that play a role in iron metabolism.

#### 4.7 The Relationship Between the Frequency of Plant Protein Consumption and Hemoglobin Levels in Adolescent Girls

Based on the results of the study, the relationship between the frequency of plant protein consumption and hemoglobin levels in adolescent girls at SMAN 1 Kartasura showed a moderate trend. Adolescents with moderate and high frequencies of plant protein consumption had a higher proportion of normal hemoglobin levels compared to the group with low frequencies, although the difference was not very significant. In the low frequency group, there was still a relatively high percentage of adolescents with abnormal hemoglobin levels, while in the high frequency group, the proportion of normal hemoglobin was more dominant. These findings indicate that increasing the frequency of plant protein consumption can contribute positively to hemoglobin status, but the effect is not as strong as that of animal protein. This is understandable because plant protein generally comes from tempeh, tofu, and nuts, which, although frequently consumed, contain mostly non-heme iron, which has lower absorption rates.

Theoretically, the frequency of plant-based protein consumption still plays a role in supporting hemoglobin status through the contribution of supporting nutrients such as protein, folate, and other minerals, but its effectiveness is highly dependent on overall consumption patterns. Beard and Tobin (2020) explain that non-heme iron from plant-based foods has low absorption and is greatly influenced by other dietary components,

including the presence of phytate, which can inhibit iron absorption. Meanwhile, research by Lynch (2021) confirms that high frequency of plant-based food consumption without being balanced with enhancers such as vitamin C or a combination of heme iron sources can lead to suboptimal hemoglobin status, especially in adolescent girls who have higher iron requirements. Thus, the results of this study indicate that the frequency of plant-based protein consumption contributes to hemoglobin levels, but it needs to be supported by dietary variety and appropriate dietary combinations to maximize its benefits in preventing anemia.

#### 4.8 The Relationship Between Animal Protein Consumption and Hemoglobin Levels in Adolescent Girls

The results showed that 54 (65.9%) adolescent girls had normal hemoglobin levels with a deficient intake of animal protein, while 5 (100%) adolescent girls had normal hemoglobin levels with a higher intake of animal protein. The statistical test using Pearson's chi-square yielded a p-value of 0.134, indicating that there was no significant relationship between animal protein intake and hemoglobin levels in female adolescents at SMA N 1 Kartasura.

This study supports the research by Rusyda et al. (2022), which found no significant relationship between protein intake and anemia status in female Islamic boarding school students (p value 0.575). However, the results of this study differ from those of a study conducted by Qurrotunnufus et al. (2025), which found a significant relationship between animal protein intake and hemoglobin levels in adolescent girls at SMAN 27 Jakarta (p value 0.00). In that study, it was found that the animal protein intake consumed by female students was very low, with chicken meat, chicken eggs, and fish being the most commonly consumed.

The quality of food consumption, especially animal protein intake, has a direct effect on hemoglobin levels, because heme iron from meat, liver, and fish is more easily absorbed by the body than non-heme iron from plants (Sirajudin et al., 2018).

#### 4.9 The Relationship Between Plant Protein Intake and Hemoglobin Levels in Adolescent Girls

The results of the study showed that 55 (64.7%) adolescent girls had normal hemoglobin levels with a deficit in plant protein intake, 4 (100%) adolescent girls had normal hemoglobin levels with normal animal protein intake, and 1 (100%) adolescent girl had normal hemoglobin levels with higher plant protein intake. The statistical test using Pearson's chi-square yielded a p-value of 0.266, indicating that there is no significant relationship between plant protein intake and hemoglobin levels in female adolescents at SMA N 1 Kartasura.

Research by Rahfiludin et al. (2021) in Indonesia found similar results. A study on plant-based diets among Sundanese adolescent girls showed no direct relationship between plant-based diets and anemia status, but stated that low consumption of animal protein sources played a greater role in the incidence of anemia due to a lack of highly bioavailable iron. On the other hand, research by Putri et al. (2024) showed that general protein intake, which includes a combination of various food sources, has a significant relationship with hemoglobin levels in adolescent girls in Bekasi Regency, so that adequate and balanced protein consumption from various sources can support hemoglobin synthesis.

Based on the results of interviews using the SQFFQ questionnaire, it was found that although the consumption of plant-based protein was quite high, hemoglobin level measurements showed that many adolescents still did not reach normal levels. This indicates that quantity alone is not sufficient to prevent anemia; rather, the quality and composition of nutrients are more decisive factors. Therefore, efforts to increase plant-based protein consumption need to be accompanied by education on the importance of

combining plant-based and animal-based sources and paying attention to accompanying substances such as vitamin C so that iron absorption is more efficient.

## 5. Conclusions

The results of the study show that most female adolescents at SMAN 1 Kartasura have normal hemoglobin levels (66.7%). Animal protein consumption is dominated by chicken eggs and chicken meat, while certain types of animal-based foods are rarely consumed. For plant-based protein, tempeh and tofu are the most frequently and most consumed sources, while other types of legumes contribute relatively little to daily protein intake.

Based on the analysis of consumption frequency, adolescent girls with higher consumption of animal and plant protein tended to have normal hemoglobin levels, although the differences between groups were not very significant. Statistical tests show that there is no significant relationship between the amount of animal protein consumption and hemoglobin levels ( $p = 0.134$ ) or between the amount of plant protein consumption and hemoglobin levels ( $p = 0.266$ ). These findings indicate that hemoglobin status in adolescent girls is influenced by various factors, not only the amount of protein consumption, but also food quality, nutrient bioavailability, and overall dietary patterns.

## 6. Acknowledgments

The author would like to thank God Almighty for His grace so that this research could be completed successfully. Thanks are also extended to the supervising lecturer and examiner for their guidance and input, to the school and all respondents for their cooperation in data collection, and to parents and friends for their support and motivation during the research process. Hopefully, this research can contribute to the development of science.

## 7. Conflicts of Interest

The authors declare no conflict of interest.

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