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Coffee Consumption Patterns and Anemia Risk: A Cross-Sectional Study of Female University Students in Surakarta

Arifa Sofia Mahra[1], Adi Magna Patriadi Nuhriawangsa[1,2]*, Yulia Sari[1,3]

[1] Department of Nutrition Science, Postgraduate School, Sebelas Maret University, Surakarta, Indonesia
[2] Department of Animal Science, Faculty of Animal Husbandry, Sebelas Maret University, Surakarta, Indonesia
[3] Department of Parasitology, Faculty of Medicine, Sebelas Maret University, Surakarta, Indonesia

Corresponding Author Email: adimagna@staff.uns.ac.id

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ABSTRACT

Iron deficiency anemia in women of childbearing age is a public health problem. This can be caused by a lack of iron intake from protein sources and impaired iron absorption by inhibitors such as coffee. This study aimed to analyze the relationship between coffee consumption habits and the proportion of protein intake types on the incidence of anemia and menstrual cycle disorders in female university students in Surakarta. This study used a quantitative method with a cross-sectional design. A total of 110 samples were selected through purposive and consecutive sampling. Data collection on coffee consumption habits, protein intake, and menstrual cycle was conducted using questionnaires and SQ-FFQ, while hemoglobin levels were measured using a hematology autoanalyzer; then, it was analyzed using Spearman's Rank or contingency coefficient test and binary logistic regression. The results showed that 39.1% respondents had anemia and 53.6% respondents had menstrual cycle disorders. Based on multivariate test, the only variable related to the incidence of anemia was the habit of consuming ready-to-drink coffee type (p=0.019; r=3.092). Meanwhile, general coffee consumption habits, specific consumption habits based on frequency and other types, and the proportion of protein intake types were not related to the incidence of anemia (p>0,05). Then, there were no variables of coffee consumption habits and proportion of protein intake types related to menstrual cycle disorders (p>0.05). In conclusion, only the habit of consuming ready-to-drink coffee type significantly increased the risk of anemia.

Key Messages:

- Female university students were included in the women of childbearing age group who are vulnerable to anemia and malnutrition.
- Fulfilling good nutritional intake since preconception is one effective way to overcome nutritional problems during pregnancy.

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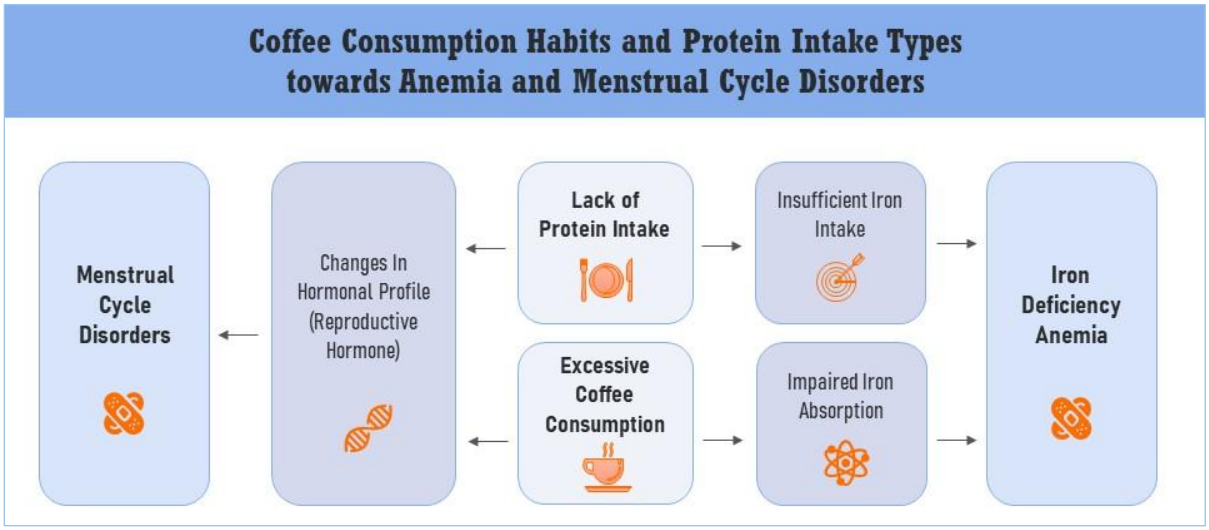
GRAPHICAL ABSTRACT



INTRODUCTION

Iron deficiency anemia is a condition of decreased red blood cell count, hemoglobin (Hb) levels, or red blood cell volume as a result of greater iron storage requirements than the normal supply (1). Cases of anemia in women of childbearing age (15-49 years) are a public health problem in many countries. The global prevalence rate in 2021 was 33.7% (2), while in South and Southeast Asia, the prevalence even reached 50.17% (3). Meanwhile, in Indonesia, the prevalence in 2023 was 26.7% (4).

Iron deficiency anemia in women generally occurs due to several factors, such as insufficient iron intake and impaired iron absorption (5). Iron absorption from plant protein (nonheme) is much lower than from animal protein (heme). The presence of inhibitor and enhancer factors significantly affects the absorption of nonheme iron (6). Women with low levels of heme iron intake and enhancer factors but high levels of inhibitor intake (such as coffee) are at risk of iron deficiency anemia (7).

Coffee contains polyphenols (tannins and chlorogenic acid) and caffeine. They can bind iron in the intestinal lumen by forming insoluble complexes, thereby reducing the availability of iron absorption (7,8). Consuming a cup of black coffee (150 mL) along with iron-rich foods can reduce iron absorption by around 39-90% (9). Another research has shown that drinks containing 100-400 mg of polyphenols can reduce iron absorption by 60-90% (10).

The caffeine content in various coffee preparations can vary significantly, with black coffee usually having a higher concentration than that mixed with other additional ingredients (11). The addition of other ingredients to coffee drinks, one of which is milk, can mediate changes in the total content and functionality (bioaccessibility and bioactivity) of coffee phenolic compounds due to interference between milk components (eg, protein and fat) and coffee constituents (eg, chlorogenic acid and caffeine) (12).

Consuming coffee more than three times a day results in lower Hb levels compared to consuming it less frequently (11). In the formation of Hb, there is a bond between apoferritin and iron ions in the digestive tract, as well as a bond between transferrin and iron ions in the circulatory system. Polyphenol compounds in coffee that have bound to iron ions cause it to be excreted from the body because it is considered a useless compound (13).

Coffee consumption and insufficient protein intake can also contribute to menstrual cycle disorders. In women, caffeine also has side effects on the menstrual cycle. It has the ability to inhibit the cyclic hydrolysis of 3',5'-adenosine monophosphate and 3',5'-guanosine monophosphate and shows adenosine antagonism, causing changes in the hormonal profile (14). Meanwhile, insufficient protein intake can indirectly affect reproductive hormone levels such as estrogen, which causes Follicle Stimulating Hormone (FSH) levels to not reach the peak. This has an impact on the cessation of follicle growth, so that ovulation will not occur and the menstrual cycle will be prolonged (15).

Female students have the habit of consuming coffee as a lifestyle (16) and usually have an irregular

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and less nutritious diet (17), so they are susceptible to anemia and malnutrition. Presence of anemia can reduce individual well-being, cause fatigue, disrupt physical conditions, and reduce work productivity. The effects of anemia will persist until pregnancy, like increasing the risk of infection, preeclampsia, postpartum hemorrhage, and a higher chance of death during childbirth. In addition, severe anemia can also have an impact on premature birth, low birth weight (LBW), and even neonatal death (18). Meanwhile menstrual cycle disorders are known to be associated with the risk of various diseases and medical conditions, such as anemia, psychological problems, impacts on quality of life, infertility, and pregnancy disorders (19).

Previous studies only examined the association between adequacy of iron intake and frequency of general inhibitor consumption with anemia (20) or the association between consumption of total heme iron, Meat-Fish-Poultry (MFP), and nonheme iron, as well as whether there was coffee consumption with anemia (21). There were also previous studies that only examined the relationship between the frequency of overall caffeine consumption with the menstrual cycle (22) or the adequacy of protein intake with the menstrual cycle (15). However, this study specifically examined coffee consumption as one of the iron inhibitors, seen from the aspect of consumption habits such as type and frequency, as well as the proportion of animal and plant protein intake, then looking at its impact on both anemia and menstrual cycle disorders. This was because we hypothesized that higher frequency and specific types of coffee consumption (e.g., those with higher polyphenol content) and higher proportion of plant protein (nonheme iron) intake would be positively associated with the incidence of anemia and menstrual cycle disorders.

Based on the description of the background of the problem and the research gaps, this study was conducted to analyze the relationship between coffee consumption habits and the proportion of protein intake types on the incidence of anemia and menstrual cycle disorders in female university students in Surakarta City.

METHODS

This study was an analytical observational study with a cross-sectional design, where data collection was carried out at one time. This study was conducted in January – February 2025. The population in this study was all female, aged 20-24 years, in Surakarta. While the sample was active female university students who were visiting one of the predetermined coffee shops and had met the specified sample criteria.

Respondents were recruited at 4 coffee shops in Banjarsari and Jebres Districts, namely CB, HS, AM, and ON. The location selection technique used the purposive sampling method (23) because those sub-districts are areas with the largest number of universities in Surakarta, namely 15 and 18 universities (24) and the selected coffee shops are favorite local coffee shops with large capacities and are often visited by university students. Meanwhile, the sampling technique used the consecutive sampling method (25), where all respondents who came and met the selection criteria were included in the study until the required number of respondents was met. The minimum sample size in this study was calculated using the Lameshow formula, which was 106 people. The inclusion criteria for this study were: (1) active female university students (all levels) aged 20-24 years who are studying at a university in Surakarta; (2) domiciled or currently living in Surakarta; (3) consuming coffee at least 1-3x/month; (4) having experienced their first menstruation (menarche); and (5) not having donated or had a blood transfusion for at least the last 3 months. Meanwhile, the exclusion criteria were: (1) currently pregnant or breastfeeding; (2) having a history of being diagnosed with abnormal uterine bleeding (AUB), polycystic ovary syndrome (PCOS), thyroid disorders, or hyperprolactinemia; (3) currently or having a history of using hormonal drugs related to the disorders mentioned in point 2; (4) currently or having a history of progestin ± estrogen gonadal steroid treatment; and (5) having a history of leukemia or hemophilia.

After the selection, 110 respondents were obtained who met the criteria and underwent the data collection procedure at the Postgraduate School Building, Sebelas Maret University. The research procedures carried out were: (1) providing an explanation, then requesting permission and approval from respondents by filling out an informed consent form; (2) anthropometric measurements using a digital scale to measure body weight and a microtoise to measure height; (3) exploring coffee consumption habits using a modified questionnaire with total score results that were classified as low, moderate, and high (26).

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More detailed exploration was carried out regarding coffee consumption habits (type and frequency) and the proportion of protein intake types during the last 3 months using the Semi Quantitative Food Frequency Questionnaire (SQ-FFQ) (27); (4) anemia assessment by measuring Hb levels by taking venous blood samples and analyzing them using an hematology autoanalyzer; (5) menstrual cycle assessment using a questionnaire from The International Federation of Gynecology and Obstetrics (FIGO) (28); and (6) conducting a 2 x 24 hour food recall interview.

Coffee consumption habits in the form of coffee types were classified into 4 types: (1) Manual brew and without mixture (WTM); a type of coffee served without using an espresso machine so that the coffee produced was black coffee without powder (manual brew) and espresso based coffee without added sugar or sweetener (without mixture); (2) Espresso based and with mixture (WM); coffee-based drinks that used an espresso machine and were served with hot milk (steam milk), milk foam, and sugar or flavoring syrup; (3) Instant coffee powder; packaged coffee that was consumed by brewing with hot water; and (4) Ready-to-drink coffee; bottled coffee that can be consumed immediately (11,29). Meanwhile, the coffee consumption frequency was classified into rarely (1-4x/month), often (2-6x/week), and very often (1-3x/day) (29,30).

Data processing using Nutrisurvey 2007 (27) and IBM SPSS Statistics 23 software. Univariate data analysis was conducted to see the frequency of respondent characteristics and all variables. Bivariate analysis using the Spearman Rank test (ordinal scale independent variables) and the contingency coefficient test (nominal scale independent variables) were used to test how strong the relationship was between each independent and dependent variable. Meanwhile, multivariate testing using the binary logistic regression was used to know how much influence there was between all independent and dependent variables. The relationship is said to be significant if p-value was <0.05.

CODE OF HEALTH ETHICS

The research was conducted after obtaining ethical clearance from the Health Research Ethics Committee of Dr. Moewardi Hospital with number 2.871/XII/HREC/2024 issued on December 27, 2024.

RESULTS

In Table 1, the average age of respondents was 22 years. The majority of respondents were pursuing undergraduate degrees (68.2%) and the most dominant study program was science and technology (57.3%). The average age of menarche was 12.47 years. Meanwhile, the most common daily physical activity of respondents was light (54.5%). More respondents lived in boarding houses (57.3%) and had an allowance of more than IDR 1,200,000 per month (40.9%). Most respondents had no history of illness or drug consumption for bipolar disorder and epilepsy (96.4%), and they also did not consume iron tablets routinely at least once a week (86.4%). Almost half of the respondents admitted to experiencing stress in the last 3 months due to academic factors. The average nutritional status is normal (57.3%).

Table 1. Respondent Characteristics (n=110)

Characteristics	n	%
Age (years)		
20 – 21	51	46.4
22 – 24	59	53.6
Education Level		
D3	1	0.9
D4	4	3.6
S1	75	68.2
S2	26	23.6
Profession	4	3.6
Study Program		
Science and Technology	63	57.3
Social Sciences and Humanities	47	42.7

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Characteristics	n	%
Age of Menarche (years)		
<12	27	24.5
12 – 14	77	70
>14	6	5.5
Physical Activity		
Light	60	54.5
Moderate	48	43.6
Heavy	2	1.8
Residence		
House	47	42.7
Boarding House	63	57.3
Allowance		
< IDR 800.000	29	26.4
IDR 800.000 – IDR 1.200.000	36	32.7
> IDR 1.200.000	45	40.9
Medical History (Bipolar & Epilepsy)		
None	106	96.4
Yes	4	3.6
Medication History (Antidepressant & Epilepsy)		
None	106	96.4
Yes	4	3.6
Regular Consumption of Iron Tablets		
No	95	86.4
Yes	15	13.6
Experiencing Academic Stress		
No	56	50.9
Yes	54	49.1
Nutritional Status		
Very Thin	4	3.6
Thin	9	8.2
Normal	63	57.3
Overweight	9	8.2
Obesity	25	22.7

Table 2 shows the distribution of respondents' adequate intake obtained from 2 x 24 hours of food recall data. Most respondents had inadequate intake of energy, protein, fat, carbohydrate, vitamin C, and iron. All respondents lack carbohydrate and iron intake (100%).

Table 2. Respondents Intake Characteristics (n=110)

Respondents' Intake	n	%
Energy Intake		
Less (<80% RDA)	107	97.3
Sufficient (80-120% RDA)	3	2.7
Protein Intake		
Less (<80% RDA)	78	70.9
Sufficient (80-120% RDA)	28	25.5
More (>120% RDA)	4	3.6
Fat Intake		
Less (<80% RDA)	74	67.3
Sufficient (80-120% RDA)	26	23.6

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Respondents' Intake	n	%
More (>120% RDA)	10	9.1
Carbohydrate Intake		
Less (<80% RDA)	110	100
Vitamin C Intake		
Less (<77% RDA)	105	95.5
Sufficient (≥77% RDA)	5	4.5
Iron Intake		
Less (<77% RDA)	110	100

In Table 3, the number of respondents who did not have anemia was 67 people, while those who did were 43 people. In the anemic group, their coffee consumption habits were almost the same between low and moderate (20% and 19.1%). If differentiated based on the coffee type, respondents mostly consumed espresso-based and WM types (86.4%) and instant coffee powder (79.1%), of which 30% and 31.8%, respectively, had anemia (Figure 1). Meanwhile, if differentiated based on frequency, the respondents who most experienced anemia were those who rarely consumed coffee (33.6%). Then, if viewed from the protein intake types, more respondents consumed higher animal than plant protein (56.4% and 33.6%).

The statistical tests result in Table 3 stated that when viewed by the type, the habit of consuming espresso-based and WM coffee had a significant relationship with the incidence of anemia ($p<0.05$). Although weak, this correlation was positive ($r = 0.219$), which means that consuming this type increased the incidence of anemia. In addition, the habit of consuming ready-to-drink coffee also had a significant relationship with the incidence of anemia ($p<0.05$). Although weak, this correlation was also positive ($r = 0.209$), which means that consuming this type also increased the incidence of anemia. Meanwhile, the habit of consuming coffee in general and specifically distinguished by frequency as well as the proportion of protein types did not have a significant relationship with the incidence of anemia ($p>0.05$).

Table 3. Coffee Consumption Habits and Proportion of Protein Intake Types with Anemia Incidence

Variables	Anemia Incidence				Total		r	p-value
	Non-anemic		Anemic					
	n	%	n	%	n	%		
Coffee Consumption Habits[a]							-0.107	0.267
Low (score 9-14)	27	24.5	22	20.0	49	44.5		
Moderate (score 15-20)	40	36.4	21	19.1	61	55.5		
High (score 21-27)	0	-	0	-	0			
Coffee Types[b]								
Manual Brew & Without Mixture (WTM)	37	33.6	16	14.5	53	48.2	0.173	0.065
Espresso Based & With Mixture (WM)	62	56.4	33	30	95	86.4	0.219	**0.019***
Instant Coffee Powder	52	47.3	35	31.8	87	79.1	0.045	0.634
Ready-to-Drink Coffee	20	18.2	22	20	42	38.2	0.209	**0.025***
Drinking Frequency[a]							-0.031	0.749
Rarely (1-4x/month)	56	50.9	37	33.6	93	84.5		
Often (2-6x/week)	10	9.1	5	4.5	15	13.6		
Very Often (1-3x/day)	1	0.9	1	0.9	2	1.8		
Proportion of Protein Intake Types[b]							0.105	0.268
Higher Animal Protein	62	56.4	37	33.6	99	90		
Higher Plant Protein	5	4.5	6	5.5	11	10		

Note: *significant ($p<0.05$); a = using Spearman Rank statistical test; b = using Contingency Coefficient statistical test.

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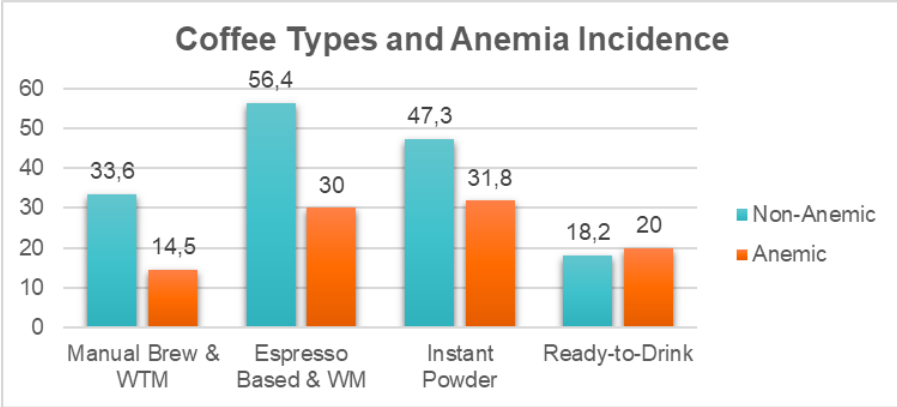

Figure 1. Percentage of individuals with and without anemia grouped by coffee types.

Furthermore, in Table 4, the number of respondents who did not experience menstrual cycle disorders was 51 people, while those who did were 59 people. In both groups, respondents mostly had moderate coffee consumption habits (23.6% and 31.8%). If differentiated based on coffee type, most respondents who experienced menstrual cycle disorders also consumed espresso-based and WM types (48.2%) and instant coffee powder (41.8%). Meanwhile, if differentiated based on frequency, the respondents who most experienced menstrual cycle disorders were those who also rarely consumed coffee (33.6%). Then, if viewed from the proportion of protein intake types in both groups, more respondents consumed higher animal than plant protein (40% and 50%). The statistical test results show that both general and specific coffee consumption habits differentiated by type and frequency, and also the proportion of protein types, did not have a significant relationship to menstrual cycle disorders (p>0.05).

Table 4. Coffee Consumption Habits and Proportion of Protein Intake Types with Menstrual Cycle Disorders

Variables	Menstrual Cycle Disorders				Total		r	p-value
	No		Yes					
	n	%	n	%	n	%		
Coffee Consumption Habits[a]								
Low (score 9-14)	25	22.7	24	21.8	49	44.5	0.084	0.385
Moderate (score 15-20)	26	23.6	35	31.8	61	55.5		
High (score 21-27)	0	-	0	-	0	-		
Coffee Type[b]								
Manual Brew & Without Mixture (WTM)	20	18.2	33	30	53	48.2	0.165	0.080
Espresso Based & With Mixture (WM)	42	38.2	53	48.2	95	86.4	0.108	0.254
Instant Coffee Powder	41	37.3	46	41.8	87	79.1	0.030	0.755
Ready-to-Drink Coffee	21	19.1	21	19.1	42	38.2	0.057	0.548
Drinking Frequency[a]								
Rarely (1-4x/month)	42	38.2	51	46.4	93	84.5	-0.048	0.618
Often (2-6x/week)	9	8.2	6	5.5	15	13.6		
Very Often (1-3x/day)	0	-	2	1.8	2	1.8		
Proportion of Protein Intake Type[b]								
Higher Animal Protein	44	40	55	50	99	90	0.115	0.226
Higher Plant Protein	7	6.4	4	3.6	11	10		

Note: a = using Spearman Rank statistical test; b = using Contingency Coefficient statistical test.

Table 5. Bivariate Analysis of Respondent Characteristics (Confounding) with Anemia Incidence

Variables	r	p-value

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Regular Consumption of Iron Tablets[b]	0.062	0.518
Energy Intake[a]	-0.020	0.838
Protein Intake[a]	-0.066	0.494
Fat Intake[a]	-0.192	**0.045***
Vitamin C Intake[a]	0.004	0.966

Note: *significant (p<0.05); a = using Spearman Rank statistical test; b = using Contingency Coefficient statistical test.

Table 6. Bivariate Analysis of Respondent Characteristics (Confounding) with Menstrual Cycle Disorders

Variables	r	p-value
Age[b]	0.157	0.095
Education Level[b]	0.158	0.586
Study Program[b]	0.045	0.640
Age of Menarche[b]	0.106	0.535
Physical Activity[a]	0.005	0.956
Medical History (Bipolar & Epilepsy)[b]	0.178	0.058
Medication History (Antidepressan & Epilepsy)[b]	0.178	0.058
Experiencing Academic Stress[b]	0.146	0.123
Nutritional Status[a]	0.000	0.997
Energy Intake[a]	0.044	0.650
Protein Intake[a]	-0.096	0.316
Fat Intake[a]	-0.015	0.874
Vitamin C Intake[a]	0.115	0.230

Note: a = using Spearman Rank statistical test; b = using Contingency Coefficient statistical test.

In addition, in table 5 dan 6, respondents' characteristic data that may be confounding were also tested. Only fat intake has a significant relationship with the incidence of anemia (p<0.05). Although very weak, this correlation is negative (r= -0.192), meaning that the lower the fat consumption, the higher the risk of anemia.

Based on Table 7, the ability of independent and confounding variables to explain the dependent variable was 0.232 or only 23.2% and there were 76.8% other factors outside the model that explain the dependent variable. Only the consumption of ready-to-drink coffee and the confounding variable fat intake had a p-value of the Wald test <0.05. This means that the consumption of ready-to-drink coffee and fat intake had a significant partial effect on the incidence of anemia in the model. It can be concluded that respondents who had a habit of consuming ready-to-drink coffee have a risk of experiencing anemia by 3.092 times compared to respondents who did not consume this type of coffee. Then, respondents who had sufficient fat intake can reduce the risk of anemia by 0.217 times compared to respondents who had insufficient fat intake.

Table 7. Multivariate Analysis of Coffee Consumption Habits and Proportion of Protein Intake Types with Anemia Incidence

Variables	*p-value*	OR	95% C.I.		*Nagelkerke R Square*
			Lower	Upper	
Independent Variables:					
Coffee Consumption Habits	0.811	1.131	0.412	3.105	0.232
Coffee Types					
Manual Brew & WTM	0.078	0.400	0.144	1.109	
Espresso Based & WM	0.156	0.377	0.098	1.452	
Instant Coffee Powder	0.897	0.926	0.291	2.945	
Ready-to-Drink Coffee	**0.019***	3.092	1.204	7.937	
Drinking Frequency	0.821				
Often	0.855	1.150	0.255	5.181	

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Variables	*p-value*	OR	95% C.I.		*Nagelkerke R Square*
			Lower	Upper	
Very Often	0.535	2.681	0.119	60.263	
Proportion of Protein Intake Types	0.502	1.735	0.347	8.662	
Confounding Variables:					
Regular Consumption of Iron Tablets	0.543	1.493	0.411	5.415	
Energy Intake	0.829	0.688	0.023	20.720	
Protein Intake	0.961				
Sufficient	0.895	1.083	0.334	3.509	
More	0.781	1.632	0.051	51.815	
Fat Intake	**0.044***				
Sufficient	**0.014***	0.217	0.064	0.731	
More	0.396	0.385	0.043	3.483	
Vitamin C Intake	0.950	0.938	0.126	6.993	
Constant	0.489	1.818			

The results of the statistical test analysis in table 8 showed that the ability of independent and confounding variables to explain the dependent variable was 0.343 or only 34.3% and there were 65.7% other factors outside the model that explain the dependent variable. It can also be seen that there were absolutely no variables that had a Wald test p-value <0.05, which means that there were no independent or confounding variables that had a significant partial effect on menstrual disorders in the model.

Table 8. Multivariate Analysis of Coffee Consumption Habits and Proportion of Protein Intake Types with Menstrual Cycle Disorders

Variables	p-value	OR	95% C.I.		Nagelkerke R Square
			Lower	Upper	
Independent Variables:					
Coffee Consumption Habits	0.339	1.711	0.569	5.148	0.343
Coffee Types					
Manual Brew & WTM	0.575	1.375	0.452	4.186	
Espresso Based & WM	0.879	0.890	0.199	3.974	
Instant Coffee Powder	0.307	0.538	0.164	1.768	
Ready-to-Drink Coffee	0.875	0.916	0.309	2.721	
Drinking Frequency	0.969	1.029	0.239	4.431	
Proportion of Protein Intake Types	0.083	0.191	0.029	1.243	
Confounding Variables:					
Age	0.303	1.878	0.566	6.232	
Education Level	0.737				
D4	1.000	0.000	0.000	-	
S1	1.000	0.000	0.000	-	
S2	1.000	0.000	0.000	-	
Profession	1.000	0.000	0.000	-	
Study Program	0.749	1.206	0.383	3.791	
Age of Menarche	0.134				
12 – 14	0.071	0.340	0.105	1.095	
>14	0.771	1.426	0.131	15.566	
Physical Activity	0.948				
Moderate	0.743	1.174	0.450	3.067	
Heavy	0.999	0.000	0.000	-	
Medical History	0.999	4.311	0.000	-	
Experiencing Academic Stress	0.389	1.557	0.569	4.259	

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Variables	p-value	OR	95% C.I.		Nagelkerke R Square
			Lower	Upper	
Nutritional Status	0.188				
Thin	0.310	5.211	0.215	126.33	
Normal	0.484	0.432	0.041	4.532	
Overweight	0.277	0.198	0.011	3.683	
Obesity	0.829	0.768	0.070	8.462	
Protein Intake	0.365				
Sufficient	0.182	0.444	0.135	1.464	
More	0.427	0.244	0.008	7.935	
Fat Intake	0.897				
Sufficient	0.642	1.316	0.414	4.177	
More	0.963	1.056	0.110	10.174	
Vitamin C Intake	0.340	3.603	0.259	50.194	
Constant	1.000	1826129246			

DISCUSSION

In this study, the average age of respondents was 22 years, with most respondents currently pursuing undergraduate degrees, with the dominant study program being science and technology. This was in line with previous research, where female undergraduate students reported higher caffeine intake, mainly from coffee (31). The availability of money also strengthens the consumptive behavior of contemporary coffee drinks (32). Even though the nutritional status of the majority of respondents was normal, the respondents' food intake was still less than adequate. Students who lived in boarding houses tended to have irregular eating habits and were far from healthy compared to students who lived in their own homes (17).

Coffee Consumption Habits and Anemia

The prevalence of female university students with anemia in this study was 39.1%. This was higher than the prevalence of anemia in Indonesia, which was 26.7% (4). The result of this study indicated that coffee consumption habits in general was not significantly related to the incidence of anemia, which was in line with two previous studies (33,34). However, this result was in contrast to a research in 2025 that showed the significant effect of caffeine consumption habits on Hb levels in adolescent girls (35). The difference in result may be due to differences in subject characteristics (high school and college students) and also the examination of caffeine intake was conducted from various sources, not specifically from coffee alone, like this research.

Individual responses to caffeine may vary depending on genetic variations in caffeine metabolism, tolerance, and sensitivity (36). Factors like type, amount, and frequency of coffee consumption also play a role. The caffeine content in black coffee is usually higher than that which has been mixed with other ingredients (11). The addition could mediate changes in the total content and function (bioaccessibility and bioactivity) of phenolic compounds (12). However, the results of this study actually showed a significant relationship between the habit of consuming espresso-based and with mixture (WM) coffee types, not manual brew and without mixture (WTM), with anemia. This may be due to differences in the consumption amount.

In a day, respondents with the habit of consuming espresso-based and WM coffee types consumed an average of 154 ml, while respondents with the habit of consuming manual brew and WTM coffee types consumed an average of only 53 ml. This also caused differences in the polyphenol and caffeine content of coffee that enters the body. Higher consumption volume leading to greater polyphenol intake. The espresso-based and WM coffee variants most consumed by respondents were palm sugar milk coffee, cafe latte, and cappuccino, which contain around 96.2 – 103.3 mg of polyphenols and 74.1 – 159.9 mg of caffeine. Meanwhile, for manual brew and WTM coffee types, respondents mostly consumed americano and manual brew, which contain around 54.1 mg of polyphenols and 29.7 – 34.9 mg of caffeine (37,38). Drinks containing 100-400 mg of polyphenols can reduce iron absorption by 60-90% (10). Thus, the amount of

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espresso-based and WM coffee consumed by respondents was closer to the lower limit of the minimum polyphenol content that could reduce iron absorption, and the caffeine content was also higher compared to the amount of manual brew and WTM coffee consumption.

The results of this study also showed a significant relationship between the habit of consuming ready-to-drink coffee, not instant coffee powder, and the incidence of anemia. The average consumption of ready-to-drink coffee was 26 ml while the consumption of instant coffee powder was 86 ml per day. The polyphenol content of instant coffee powder was around 80.9 mg and caffeine 22.7 mg (black variants) (37,39). Although in terms of quantity, the most consumed was instant coffee powder, its variant was the one that also contains a mixture such as sugar, milk, and creamer, just like ready-to-drink coffee. There are other factors that can affect caffeine content, such as the brewing method used, including time, temperature, amount of coffee and water, and the degree of coffee bean roasting. In instant coffee powder, there was a possibility of greater caffeine loss due to the roasting process which was certainly different from ready-to-drink coffee which had a final preparation in liquid form. In addition, the ratio of the amount of coffee and water used in the production of ready-to-drink coffee may also had an effect on caffeine content (40,41). However, in this study, it was not possible to find out details about these things because the two types of coffee came from different brands. This also could be because 95.2% of respondents who consumed ready-to-drink coffee also consumed other types of coffee, so the results of the multivariate analysis showed significant results for the consumption of this type of coffee only. As many as 37.3% of respondents consumed 2 different types of coffee, 32.7% of respondents consumed 3 different types of coffee, and 16.4% consumed all types of coffee. This will certainly also affect the amount of polyphenol content that enters the body more than respondents who consume fewer types of coffee.

Furthermore, the habit of coffee consumption, when viewed according to frequency, shows no significant relationship with anemia. This was in contrast to a previous research in 2021 (42). This difference may occur because in that study, respondents had a higher coffee-drinking intensity, between 4-6 times a week, whereas in this study, most respondents consumed it less frequently (1-4x/month).

Coffee Consumption Habits and Menstrual Cycle Disorders

The results of this study also indicated that coffee consumption habits in general were not significantly related to menstrual cycle disorders. These results were in line with two previous studies in 2022 (22,43). However, this study contradicted the two researches in 2020 and 2025 (44,45). The difference in the results of this study compared to previous studies may be due to differences in the types of caffeine sources consumed (this study only examined caffeine from coffee) and the lower amount and frequency of consumption. In addition, there were also factors such as differences in sensitivity to caffeine and related genetic variants that affect the adenosine system (46). Irregular and longer menstrual cycles are more likely to occur in younger women and those who experience menarche at a later age (43) and who also engage in excessive physical activity (47).

In all types of coffee, the amount of daily consumption still contains caffeine below the recommended daily caffeine intake for women of childbearing age, so it may affect why the results show no relationship with menstrual cycle disorders. The recommended caffeine intake to avoid reproductive problems was not to exceed 300 mg per day (48). The amount of daily coffee intake in this study was only 154 ml at most, which was much lower than previous studies that reached 500 ml per day. Furthermore, when viewed according to frequency, the result also did not have a significant correlation with menstrual cycle disorders, perhaps because the majority of respondents consumed it rarely (1-4x/month). This frequency is much lower from the previous study that could reach 4x/week (45).

Proportion of Protein Intake Type and Anemia

In this study, the results showed that the proportion of types of protein intake was not significantly related to the incidence of anemia. This was in line with a previous study in 2024, although the types of protein intake were not distinguished (49). But, this was not in line with a previous study in 2021, which showed that iron deficiency anemia had a greater relationship with lower consumption of animal foods (21). This difference may be because the study also explained that there was only a significant correlation between heme iron and Meat, Fish, and Poultry (MFP) with Hb, but not with nonheme iron. However, another study stated that the average intake of heme iron from food was not related to Hb concentration,

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while the intake of total iron and nonheme iron from food was related to Hb concentration (50).

Although the results of this study indicate that as many as 73.6% of respondents actually have insufficient protein intake (average total intake = 43.1 g/day), most respondents (90%) consume more types of animal protein (average animal protein intake = 29.4 g/day, plant protein = 13.8 g/day). Non-heme iron in plant foods had a lower absorption rate than heme iron in animal foods and depended on the balance between inhibitors or enhancers of iron absorption and the individual's iron status (51). In this study, although the intake of coffee (inhibitor) was close to the recommended amount that could reduce iron absorption, the intake of heme iron from animal protein was more dominant. Research showed that the effect of reduced iron absorption by coffee was more pronounced when consumed together with non-heme iron sources (plant protein), but had very little effect on heme iron from animal foods (21,52). Then, although the intake of vitamin C as an enhancer factor of the majority of respondents (95.5%) was still relatively low, the absorption of heme iron has been regulated by the body's iron status (52).

In addition, overall individual diet and sleep patterns can also affect anemia status (50). Research stated that in addition to consuming foods that inhibit iron absorption such as tea and coffee, irregular eating patterns are potential factors contributing to the high prevalence of anemia among female students (51). This is in line with what happened in this study where most female students only ate 1-2 large meals a day, resulting in most of their nutritional intake being lacking. Nutrition education for subjects is necessary because it can have a significant positive impact on the subject's knowledge so that they can consume food according to their needs (53) (54).

This study also showed that the incidence of anemia was also significantly related to fat intake as a confounding variable, where the lower the fat consumption, the greater the risk of anemia. Increasing the percentage of energy fulfillment for the body from carbohydrate sources to fat has been shown to increase the use of protein from food. This can affect the optimization of Hb synthesis because amino acids are needed for intra-erythroblast protein synthesis (55).

Proportion of Protein Intake Type and Menstrual Cycle Disorders

The results of this study indicated that the proportion of protein intake types also had no significant relationship to menstrual cycle disorders. This was in line with a previous study in 2020, although the types of protein intake were not distinguished (56). However, the findings of this study also had differences and similarities with the results of another study, which showed that lower plant protein intake was associated with changes in reproductive hormone concentrations and an increased risk of sporadic anovulation. However, total and animal protein intake were not associated with ovulatory function (57). Another study stated that among premenopausal women with adequate total protein intake, reduced consumption of plant protein, compared to animal protein, was associated with impaired ovulatory function (58).

The difference in the results of this study compared with other studies may be due to the adequacy of the average protein intake of respondents was only 71.9% (less). The average total protein intake was 43.1 g/day; with the average intake of animal protein was 29.4 g/day and plant protein was 13.8 g/day. In addition, the intake of other nutrients was also predominantly lacking, and they also were not taking iron tablets regularly. Based on the Recommended Dietary Allowances (RDA) guidelines, in a day, women aged 20-24 years have an energy requirement of 2250 kcal, 60 grams of protein, 65 grams of fat, 360 grams of carbohydrates, 75 mg of vitamin C, and 18 mg of iron (59). The role of balanced nutrition in maintaining physiological homeostasis is very important. Energy imbalance and nutritional status are mainly felt by the Hypothalamic-Pituitary-Gonadal Axis (HPG) and affect GnRH secretion (60). Lack of iron entering the body will also interfere with the production of estrogen, progesterone, and Gonadotropin-Releasing Hormone (GnRH) so that it can inhibit the menstrual cycle (61). Normally, the hypothalamus stimulates the pituitary gland to release GnRH through small blood vessels in the portal system of the anterior pituitary gland. Then, gonadotropins-pituitary stimulate the synthesis and release of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) (62). FSH is responsible for the maturation of the egg and the cells surrounding the egg that produce estrogen, while LH controls the duration and development of a woman's menstrual cycle, including ovulation, preparation of the uterus for implantation of a fertilized egg, and the production of estrogen and progesterone by the ovaries (63). In addition, there are other complex causes that affect

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reproductive health and fertility, one of which is stress. However, in this study, the majority of respondents had no history of mental disorders or epilepsy, and most were only exposed to stress from academic factors (60).

CONCLUSION

There was no relationship between general and specific coffee consumption habits based on frequency and the incidence of anemia. But, when viewed from the coffee type, there was a significant relationship between the consumption of ready-to-drink coffee types with the incidence of anemia in female university students. Although weak, this correlation was positive, meaning that consuming these types increased the risk of anemia. Meanwhile, there was no relationship between the proportion of protein intake types and the incidence of anemia. This study also proved that there was no relationship between coffee consumption habits and the proportion of protein intake types with menstrual cycle disorders in female university students.

These finding highlights the need for female university students to be vigilant in consuming ready-to-drink coffee to avoid the risk of iron deficiency anemia. Further research is also needed using experimental or cohort methods to determine the more accurate effect of coffee consumption habits and the proportion of protein intake types on the incidence of anemia (with serum ferritin parameters) and menstrual disorders in female students so as to minimize bias.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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