International Journal of Nutrology
(Official Journal of the ABRAN - Brazilian Association of Nutrology)

ORIGINAL ARTICLE

DOI: 10.54448/ijn26215

# Prevalence of Iron Deficiency Anemia (IDA) and Its Associated Risk Factors among University Students in Kampar, Malaysia

**Hong Yen Chin**[1], **Sivanesan Rajeswaran** [2,*]

[1] Dietetics Programme, Department of Allied Health Sciences, Faculty of Science, Universiti Tunku Abdul Rahman, Perak, Malaysia.
[2] Lecturer, Dietetics Programme, Department of Allied Health Sciences, Faculty of Science, Universiti Tunku Abdul Rahman, Perak, Malaysia.

*Corresponding author: Sivanesan Rajeswaran.
Lecturer, Dietetics Programme, Department of Allied Health Sciences, Faculty of Science, Universiti Tunku Abdul Rahman, Perak, Malaysi.
E-mail: sivanesan@utar.edu.my
DOI: https://doi.org/10.54448/ijn26215
Received: 09-05-2025; Revised: 12-05-2026; Accepted: 04-02-2026; Published: 05-06-2026; IJN-id: 26215

**Editor:** Dr. Maria Eloisa Garcia Velasquez, MD, MPH.

## Abstract

Iron deficiency anemia (IDA), a condition caused by inadequate iron stores, is a widespread health issue across all age groups. In university students, prevalence rates have been reported between 7.8% and 59.4%, highlighting substantial regional variation. Therefore, a crosssectional study was conducted to investigate the prevalence of iron deficiency anemia and its relationship with anthropometric measurements and dietary intake among 95 university students aged between 18 to 25 years old through convenient sampling. Anthropometric measurement and hemoglobin concentration of study participants were obtained. A selfadministered Food Frequency Questionnaire (FFQ) was distributed physically to participants. The data analysis was conducted via Statistical Package for Social Science (SPSS), version 29.0 software. The prevalence of IDA among university students was 25.2%. There was no significant association, with a weak relationship found between body mass index (BMI) and body fat percentage (BFP), with IDA ($p>0.05$). Moreover, no significant differences were found between the intake of non-heme iron, vitamin C, coffee, tea, as well as milk and milk products with IDA among students ($p>0.05$). However, significant differences were found between breakfast intake and heme-iron intake among students ($p=0.002$, $p=0.020$) on IDA respectively, with 2 times/week of median breakfast intake and 4.49 g/day of median hemeiron intake were more likely to suffer from IDA. Therefore, proper health education, health management, and administration are required to improve knowledge and awareness towards IDA, as well as increase healthy food availability to prevent further development of IDA effectively.

**Keywords:** Iron deficiency anemia. Anthropometry. Dietary intake. Students.

## Introduction

Iron deficiency anemia (IDA) is a hypochromic, microcytic nutritional-deficiency anemia caused by insufficient iron stores in the body where the hemoglobin (Hb) concentration is below the recommended value, or there is a reduction in the red blood cell (RBC) number in the body, which gives rise to a significant global health problem **[1]**. The global anemia prevalence is 24.3%, where IDA was one of the most common anemias estimated causes, which contribute to approximately 66% of anemia cases **[2]**. In Malaysia, the prevalence of anemia is 21.3%, to which IDA contributed 14.06% as reported by the National Health Morbidity Survey (NHMS) in 2019, where females (30.4%) have a higher prevalence compared to males (12.6%) **[3]**. Among international university students, the prevalence of IDA has been reported between 7.8% and 20.8% **[4,5]**, whereas a considerably higher prevalence of 59.4% has been reported in Malaysia **[6]**.

According to the Ministry of Health Malaysia, IDA

is caused by prolonged negative iron balance, primarily caused insufficient dietary iron intake or reduced iron absorption, increase iron demand and prolonged blood loss [3]. Other non-nutritional factors such as age, gender, body mass index (BMI), body fat status and many other causes contribute to the occurrence [5,7,8]. However, the impact of IDA varies across different populations due to different factors. Common signs and symptoms that can be suspected during iron deficiency stage such as fatigue, loss of appetite, glossitis and sleep disorder [9]. However, the more severe signs and symptoms can be observed when IDA progresses. Among that, pale appearance or pallor is the most significant feature presented [10]. In mild to moderate IDA, individuals may experience a reduction in work performance, exercise intolerance, lethargy and dizziness. In addition, tachycardia, shortness of breath, cardiac murmur, and heart failure may be noticeable when IDA proceeds to the severe stage [9,10].

According to local Ministry of Health, the local public anemia prevalence was still inadequate as existing studies only focused the significant prevalence of IDA and its association between various factors among infants, children, pregnant women, and non-pregnant women. [11-14]. The only two local studies investigating the IDA prevalence among tertiary studies students were outdated and limited in scope. Furthermore, both local studies investigating the association between IDA and its related factors were also sparse [15,16]. Limited studies specified iron intake into heme iron and non-heme iron. Moreover, most studies analyzed nutrient intake categorically, yet studies on the exact serving size of nutrients associated with IDA status were limited. In terms of anthropometric measurements, numerous studies predominantly focus on height, weight, and BMI.

Insufficient attention was given to the association of IDA with body fat status. Because of these gaps, this study aimed to assess the IDA prevalence and its relationship with associated factors particularly on anthropometric data and dietary habits among university students which served as a guideline and understanding on how different dietary habits affect iron levels in the body and eventually offered a foundation for students in making informed dietary choices, consequently improving dietary practices and physical health.

## Methodology

### Study Design and Population

Cross-sectional study was performed in June 2024, and the minimum required sample size was calculated using the Daniel formula [17] with an initial sample of 97 students based on expected prevalence of 5.6% [16], a 95% confidence level, and a 5% margin of error. This yielded the minimum required sample of 81 participants. To account for an anticipated 20% non-response rate, the target sample size increased to 97 respondents. After excluding invalid responses, a total of 95 participants aged between 18 and 25 years and those enrolled to study at Universiti Tunku Abdul Rahman (UTAR) Kampar, Perak campus at the time of recruitment were involved in the final analysis. The study sample excluded students who reported to be pregnant, had experienced chronic illness, injury, or accident, those who were breastfeeding, taking medication regularly, taking iron, zinc, vitamins A, C, and D, and calcium supplements regularly, those who were diagnosed with chronic blood disease such as haemoglobinopathies, and genetically inherited anemia, smoking and female students who reported to experience heavy and clotted menstrual cycles.

### Data Collection

At the baseline, body composition analysis and hematological data (blood sample) were collected. After completing the wet laboratory data collection, standardized self-administered questionnaires were distributed to all participants to determine the prevalence of IDA and its associated factors. Participants were required to complete the questionnaires on the same day.

The questionnaires consisted of 4 sections with 94 questions, which required approximately 20-30 minutes to complete. Section A involved seven questions on sociodemographic information, Section B consisted of 2 parts regarding breakfast intake and the Food Frequency Questionnaire (FFQ), Section C involved four questions on anthropometrics data and Section D was related to blood analysis.

### Sociodemographic Data Collection

Each participant was given to complete the structured questionnaire which was used to obtain the general information of participants. Multiple-choice, open-ended and closed-ended questions were included. For instance, name, age, gender, year of study, faculty, and ethnicity. The name, age, year of study, and faculty in this section were in short answer form, whereas the gender and ethnicity were multiple choice questions. Participants must fill in the six questions by filling in space or choosing the most relevant answer.

### Dietary Intake Data Collection

Each participant was required to provide their dietary habit. The questionnaire was divided into two parts. Part 1 investigated the participants' breakfast intake. A multiple-choice question regarding breakfast intake was included. The frequency of the weekly breakfast intake was taken for breakfast intake. The breakfast timeline was set from 7.00 a.m. to 10.30 a.m., and seven options were provided. Participants who did not eat breakfast weekly must write an '0' beside the question. Part 2 was the modified FFQ, which required participants to recall their food and beverage intake over the past three months. Referring to the Malaysian Adult Nutrition Survey (MANS) 2014, only certain food groups, with a total of 99 items, were extracted **[18]**. The food groups involved were cereals and cereals product, meat and meat product, fish and seafoods, eggs, legumes and legumes product, milk and milk products, vegetables, fruits, and drinks were used to determine the iron source intake, particularly heme-iron intake, non-heme iron intake, iron enhancers such as fruits intake, as well as iron inhibitors like coffee, tea, as well as milk and milk products intake. Components in the FFQ included the list of food items, frequency of intake by day, week, month, year, or not eaten at all, each food item serving size, as well as the number of servings consumed each time the food item was consumed.

### Anthropometric Data Collection

Each participants' height, weight and body fat percentage (BFP) were measured using the portable stadiometer (Charder HM202P) and Karada Scan (OMRON Body Composition Monitors HBF-375). The body mass index (BMI) was classified according to Malaysian Clinical Practice Guideline Management of Obesity, 2023 **[19]**, while the body fat percentage (BFP) was classified according to Omron Healthcare Asia (2024).

### Blood Sample Collection

On the same day, a few drops of blood sample were collected and analyzed in the hemoglobin analyzer (HemoCue Hb 201). The reference range for hemoglobin concentrations were based on the Institute of Public Health (IPH) (2015), males and females who have a hemoglobin concentration <12.0 g/dL and <13.0 g/dL, respectively, were labelled as IDA, otherwise, the participants were labelled as non-IDA **[20]**.

### Data Analysis

The collected data were analyzed using SPSS version 29 with a significance level set at 0.05. Descriptive data such as the prevalence of IDA, anthropometrics data, dietary intake, and sociodemographic information were presented in frequency (n), percentage (%), or median. The continuous data such as dietary intake (heme iron, non-heme iron, vitamin C, coffee and tea, milk, and milk products intake) were presented in mean rank, median, and interquartile range. The chi-square test was implemented to determine the association between anthropometrics data (BMI and BFP) with IDA status among UTAR students. Comparison between groups of IDA status and the mean frequency of dietary intake was performed by using Mann-Whitney U Test

### Ethical Consideration

Ethical approval for the research was sought and obtained from the UTAR Scientific and Ethical Review Committee (U/SERC/78-396/2024). Before the data collection, all respondents were informed about the study objectives and procedure, including blood sampling and anthropometrics data collection procedures. A written informed consent form was obtained from the participants before the data collection begins, and they were allowed to withdraw from the study at any time.

## Results

### Participants Characteristics

Among participants aged from 18 to 25 years, the median age was 20. Most respondents were Chinese (96.8%), followed by Indian (2.1%) and Siamese (1.1%). Besides that, the gender of the participants was likely distributed equally, with a slightly higher prevalence of female students (55.8%). Furthermore, 47.4% of year 1 students joined this study, followed by year 3, year 2 and year 4 (31.6%, 20.0% and 1.1% respectively). In addition, a total of 6 faculties in UTAR Kampar were involved in this study, with most of the study population being from Faculty of Science (36.8%) as reported in Table 1.

Table 1. Sociodemographic characteristics of respondents.

| **Characteristics** | **Respondents (N = 95)** | |
|---|---|---|
| | | **Median (years)** |
| Age | | 20.00 |
| | **Distribution** | **n (%)** |
| Gender | Female | 53 (55.8) |
| | Male | 42 (44.2) |
| Year of Study | Year 1 | 45 (47.4) |
| | Year 2 | 19 (20.0) |
| | Year 3 | 30 (31.6) |
| | Year 4 | 1 (1.1) |

| | | |
|---|---|---|
| Faculty | Center of Foundation Studies | 20 (21.1) |
| | Faculty of Art and Social Science | 8 (8.4) |
| | Faculty of Business and Finance | 21 (22.1) |
| | Faculty of Engineering and Green Technology | 3 (3.2) |
| | Faculty of Information and Communication Technology | 8 (8.4) |
| | Faculty of Science | 35 (36.8) |
| Ethnicity | Chinese | 92 (96.8) |
| | Indian | 2 (2.1) |
| | Siamese | 1 (1.1) |

Note: n = number of subjects; % = percentage. Source: Own authorship.

## Prevalence of IDA

Among 95 respondents, approximately a quarter (25.3%) experienced IDA, while others (71%) remained healthy as reported in Table 2.

Table 2. Prevalence of IDA among UTAR students

| IDA status | n | % |
|---|---|---|
| IDA | 24 | 25.3 |
| n-IDA | 71 | 74.7 |
| Total | 95 | 100.0 |

Note: IDA = iron deficiency anemia; n = number of subjects; % = percentage. Source: Own authorship.

## Association of BMI and BFP with IDA

According to Table 3, more than half of the respondents had normal BMI (53.7%), where 14 (27.5%) were having IDA, while 37 (72.5%) were non-IDA. Besides that, the percentage of underweight and overweight or obese students were the same, which was 23.2%. Furthermore, 4 of the 22 overweight or obese students had IDA, whereas others did not experience IDA. In addition, there were 27.3% of IDA students and 72.7% of non-IDA students among the 22 underweight students. The prevalence of non-IDA students was higher in each nutritional status than IDA students. However, no statistical association exists, with a weak relationship between BMI and IDA status among UTAR students ($X^2$ = 0.761, p = 0.684). Moreover, 77.9% of students had a standard or low body fat percentage, where 20 were IDA students, while 54 were non-IDA students. The frequency of high or very high body fat percentage was 22.1%, with 4 students (19.0%) experienced IDA. The results revealed that body fat percentage was also not statistically associated with IDA status among UTAR students, with a p = 0.458.

Table 3. Association between BMI with IDA status among UTAR students

| Variable | Distribution | IDA status | | Total n = 95 n (%) | p-value |
|---|---|---|---|---|---|
| | | IDA N = 24 n (%) | n-IDA N = 71 n (%) | | |
| BMI | Underweight | 6 (27.3) | 16 (72.7) | 22 (23.2) | 0.761, p = 0.684[a] |
| | Normal | 14 (27.5) | 37 (72.5) | 51 (53.7) | |
| | OW/Ob | 4 (18.2) | 18 (81.8) | 22 (23.2) | |
| BFP | Non-elevated | 20 (27.0) | 54 (73.0) | 74 (77.9) | 0.552, p = 0.458[a] |
| | Elevated | 4 (19.0) | 17 (81.0) | 21 (22.1) | |

Note: IDA = iron deficiency anemia; n = number of subjects; % = percentage; OW = Overweight, Ob = Obese; $X^2$=Chi-square Test; [a] Pearson's Chi-Square test. Source: Own authorship.

## Dietary Intake and IDA

The median breakfast intake among IDA students was 2 times per week, while among non-IDA students the median breakfast intake was 4 times per week. The lower median as presented in Table 4 showed that IDA students generally consume less breakfast weekly than non-IDA students. The average heme iron intake among IDA students was lower (3.99 g/day) compared to non-IDA students (6.22 g/day). However, it was observed that there was a minimal difference in non-heme iron consumption between groups. Besides, the median intake of vitamin C consumption among IDA group (2.88g/day) was higher than non-IDA group (2.39g/day). This indicates that IDA students consumed more vitamin C from fruits. On the contrary, caffeine intake, particularly coffee, was significantly lower among the IDA group (3.34g/day) than the non-IDA group (28.57g/day). In contrast, the tea, and milk and milk product intake showed an opposite result. The median tea, and milk and milk product intake among IDA groups was higher (51.91g/day and 10.80g/day respectively) than non-IDA group (28.57g/day and 9.36g/day respectively).

Table 4. Dietary intake among UTAR students.

| Variable | IDA status | n | Mean Rank | Median | IQR (Q1 – Q3) |
|---|---|---|---|---|---|
| Breakfast intake | IDA | 24 | 32.85 | 2.00 | 2.00 (1.00 – 3.00) |
| | n-IDA | 71 | 53.12 | 4.00 | 5.00 (2.00 – 7.00) |
| Heme iron intake | IDA | 24 | 36.67 | 3.99 | 4.83 (2.68 – 7.51) |
| | n-IDA | 71 | 51.83 | 6.22 | 4.95 (4.28 – 9.23) |
| Non-heme iron intake | IDA n-IDA | 24 | 45.79 | 21.42 | 14.57 (13.25 – 27.82) |
| | | 71 | 48.75 | 21.17 | 19.15 (13.83 – 32.98) |
| Vitamin C intake | IDA | 24 | 51.02 | 2.88 | 5.41 (1.46 – 6.63) |
| | n-IDA | 71 | 46.98 | 2.39 | 5.81 (0.55 – 6.16) |
| Coffee intake | IDA n-IDA | 24 | 40.92 | 3.34 | 71.46 (0.00 – 71.46) |
| | | 71 | 50.39 | 28.57 | 142.86 (0.00 – 142.86) |
| Tea intake | IDA | 24 | 48.29 | 51.91 | 57.14 (0.00 – 57.14) |
| | n-IDA | 71 | 47.90 | 28.57 | 85.71 (0.00 – 85.71) |
| Milk and milk products intake | IDA n-IDA | 24 | 48.67 | 10.80 | 19.18 (2.13 – 21.48) |
| | | 71 | 47.77 | 9.36 | 33.00 (0.33 – 33.33) |

Note: IDA = iron deficiency anemia; n-IDA = non-iron deficiency anemia; n = number of subjects; IQR = interquartile range; Q1 = 25th percentile; Q3 = 75th percentile. Source: Own authorship.

## Association between Dietary Intake and IDA

Based on Table 5, there were significant differences between breakfast intake and IDA group (p=0.002), as well as between heme iron intake and IDA group (p=0.020). On the other hand, no significant differences were found between non-heme iron, vitamin C, coffee, tea, and milk and milk product intake non-IDA group.

Table 5. Association between dietary intake with IDA status among UTAR students.

| Variable | U | p-value |
|---|---|---|
| Breakfast intake | 488.500 | 0.002* |
| Heme iron intake | 580.000 | 0.020* |
| Non-heme iron intake | 799.000 | 0.650 |
| Vitamin C intake | 779.500 | 0.534 |
| Coffee intake | 682.000 | 0.134 |
| Tea intake | 845.000 | 0.951 |
| Milk and milk products intake | 836.000 | 0.891 |

Note: U = Mann-Whitney U value; * p-value < 0.05 = indicate significant differences. Source: Own authorship.

## Discussion

In this study, we identified the prevalence of IDA among undergraduate students at UTAR Kampar. With the mean age of 20 and likely equal gender distribution among UTAR students, the prevalence of IDA was 25.3%, which was considered a quarter of the respondents. This result showed a similar prevalence of IDA among university students from Bangladesh (22%) and two studies from Jazan, Saudi Arabia (27.6% and 29.11% respectively) **[21-23]**. In contrast with previous local study, the IDA prevalence among students varied (3.5%, 5.6% and 59.4% respectively). The studies focused only among medical students, medical laboratory technology (MLT) students and female university students, which may not indicate adequate generalizability of IDA prevalence among students **[6,15,16]**. Based on Relacion et al., students aged 18 to 25 years continued to practice unhealthy or improper lifestyle habits such as drinking tea, coffee, or cocoa after meals, and rarely exercise and consume breakfast despite having sufficient knowledge and awareness of IDA **[24]**. Therefore, this explained the high IDA prevalence among UTAR students. The knowledge, attitude, and awareness of IDA might be considered adequate, yet the effective way to prevent IDA might be insufficient.

In the present study, reported no significant association between BMI and IDA status (p = 0.684) which was similar to study conducted in Mid-Western Nepal and Thailand (p = 0.423 and p = 1.000 respectively) **[4,5]**. In contrast, Mohammed, Chaudhry et al. and Qasrawi et al. reported that a significant association between BMI and IDA among university students (p = 0.001, p = 0.0302 and p = 0.03 respectively) **[8,25,26]**. This might be because of different categorizations of IDA status, causing different subgroups to be created. For instance, Chaudhry et al. divided IDA status into 'non-anemia,' 'mild anemia,' 'moderate anemia,' and 'severe anemia' **[8]**. Moreover, most IDA and non-IDA students in the present study were in the normal BMI category. Among the 24 IDA respondents, 14 (27.5%) had normal BMI. This result aligned with a study from Mid-Western Nepal, where students with normal nutritional status (75%) were found to be more likely to be IDA **[5]**. In contrast, studies from South Africa (52.78%), Pakistan (80%), and Palestine (52.2%) reported that underweight students had the highest prevalence among the IDA subgroups **[8,25,26]**. Therefore, current research indicated that an individual's nutritional status may not be the primary cause of IDA development. Other factors such as family income, living status, stress, dietary intake, choices, and patterns may also affect the IDA status **[4,25-27]**.

The current study reported only 22.1% of the students were in the elevated BFP category but found no significant association between these two variables (p = 0.458). According to Rajalakshmy and Raji, BFP was associated with IDA among adolescent males aged 15 to 19 years (p = 0.001), with non-anemic students had a higher BFP (36.5%) **[28]**. Moreover, another study in United Arab Emirates (UAE) reported a significant relationship between BFP and IDA (p = 0.03) **[29]**. Sabbah also reported that the majority (38.9%) of the female university students who were in the obese (≥ 37%) category had IDA contributing to the inhibition of dietary iron absorption in the duodenum that arise from obesity **[29]**. Chen et al. reported no significant association between BFP and IDA and found that students with increased BFP had reduced hemoglobin and a higher anemia prevalence **[30]**. This may be due to the large sample size and longer timeline for research to be conducted, which improved the result's reliability, validity, and generalizability.

Individuals skipping breakfast or irregular breakfast intake worsens their nutritional status **[31]** by increasing the risk of obesity, cardiometabolic disease, anemia, and many other diseases **[21,32]**. Based on current study findings, the breakfast intake showed a statistically significant difference in IDA status among UTAR students (p = 0.002). Students with adequate breakfast consumption were less likely to have IDA. This result aligned with the findings from Saudi Arabia and Bangladesh, where a statistical association was also found between breakfast consumption and IDA (p = 0.03 and p = 0.04 respectively) **[21,33]**. The latest study from Indonesia also reported a similar association value between breakfast intake and IDA status among adolescents aged between 12 and 18 years (p = 0.003) **[34]**. This finding emboldened the effect of breakfast intake on daily energy and nutrition achievement for boosting iron levels in the blood to prevent IDA.

Haldar et al. [31] also reported that long-term skipping breakfast particularly exceeding two times weekly affects an individual's nutritional status. Students who consume breakfast five times or less a week have a greater chance of suffering from diseases, such as iron deficiency anemia. Current findings reported that UTAR students generally had a median breakfast intake of 2 times per week among IDA groups. University students usually spend most of their time conceptualizing and completing assignments, managing club activities, studying, and doing revision to achieve academic goals [4,35] resulting in breakfast skipping.

The consumption of iron, typically heme iron and non-heme iron, is crucial for Hb formation. Animal products like fish, eggs, meat, and internal organs are the primary heme iron sources with higher bioavailability than non-heme iron sources [21,36]. Current study found a significant difference between heme iron consumption and IDA status among UTAR students ($p = 0.020$) indicating that students who consume less heme iron were prone to have IDA. This result was in line with findings from university students in Jazan, and Savar of Bangladesh [21,22]. Furthermore, Chaudhry et al. and Zafenkey found a negative linear relationship between consumption of heme-iron-rich food and IDA, typically beef, chicken, mutton, fish, and egg [8,36]. These findings proved heme iron's effectiveness in preventing IDA. However, non-heme iron consumption among UTAR students showed no significant association in IDA status ($p=0.650$). Chaudhry et al. has also revealed an insignificant relationship between IDA and rice, chapatti, paratha, naan, as well as vegetable intake [8]. However, a study from Iraq reported a highly significant association between vegetable intake and IDA, but legume intake reported no association [36]. Likewise, Duncan also found that non-heme iron-rich foods, such as vegetables, whole grains and cereals, legumes, nuts and seeds, were not associated with IDA status among students, except for okra [37]. Okra is known for its richness in vitamin C which aids in iron absorption and thus prevents anemia.

Vitamin C, particularly fruits intake among UTAR students, showed no significant association with IDA status ($p = 0.534$), which was consistent with the findings reported by AlAyoubi et al., Zafenkey and Chaudhry et al. [7,8,36]. However, fruit intake was significantly associated with IDA status among students from Bangladesh [21]. A study from Palestine found that lower vitamin C intake was associated with higher IDA risk among university female students ($p = 0.011$) [26]. The absence of significant difference between vitamin C intake and IDA status among students might be due to several factors. For instance, low fruit availability, poor dietary patterns, busy lifestyle and taste preference [38]. In UTAR Kampar, there are a total of 20 food stalls operating with only one stall selling fruit. This led to the demand for fruit exceeding the supply as there were more than 10,000 students on campus resulting in low fruit consumption among students.

The present research has also determined the association between caffeine intake (coffee and tea) and IDA status. Coffee intake showed significant difference with IDA status among UTAR students ($p=0.134$) which aligned with studies conducted among university students in Yemen, Indonesia and Ethiopia aged 17 to 25 years [39-41]. The higher coffee consumption among students might be because of academic stress, cultural factors, dietary patterns and personal preferences. Tea, such as black and green tea, has significant polyphenols and phytate-rich products which inhibit iron absorption even more than coffee after a meal [42]. This was supported by several studies who reported significant association between tea intake and IDA status among university students [33,36,39]. However, the current study showed no significant association between tea intake and IDA status among UTAR students ($p = 0.951$) despite the high tea consumption among IDA students. This was consistent with the results of Al-alimi et al., Al-Jamea et al. and Zafenkey, the trend of tea intake among IDA students were high, although no significant association was found [33,36,39].

Milk and milk product consumption among UTAR students showed no significant association with IDA status ($p=0.891$). This was supported by a West African study which also revealed no significant association between dairy and dairy products intake (evaporated milk, pasteurized yoghurt, dairy cheese, and dairy ice cream), and IDA status among students [37].

In addition, a study from Palestine also revealed no significant differences between calcium intake and IDA status among female university students [26]. Furthermore, Chaudhry et al. also reported similar results, where no significant association was found between yoghurt, cheese, and milk consumption among students [8]. However, a strong correlation revealed that students who consumed more significant amounts of milk and milk products were more prone to having IDA [8,21].

## Limitations

The present study has several limitations which include a relatively limited duration, resources and cost were implemented to collect the population in this

study. This research could not reveal the generalizability and characterization of university students in Malaysia since only UTAR Kampar students were included. To ensure the sample represents the population, a random sampling method such as stratified random sampling ensures the involvement of students from different regions of Malaysia. Although the association between various factors of IDA was determined, multiple relationships between these variables were not studied. Therefore, it is recommended that complex statistical analysis methods, such as multiple linear regression, be implemented. Despite these limitations, our study has notable strengths. This study focused on region-specific university setting (UTAR Kampar, Perak) to provide localized data of prevalence of IDA and its relationship between different variables. Moreover, the data collection was conducted through physical questionnaires. The study subjects were supervised by dietetics students, which increased the validity and reliability of the results which could minimize the potential for misunderstandings. In addition, this study also investigated the strength of the relationship between IDA and anthropometric data. Due to the lack of research on IDA in Malaysia, this study provides the potential for further investigation, awareness and implementation of prevention and treatment.

## Conclusion

The present study reported IDA prevalence of 25.2% with a significant association between breakfast intake and consumption of heme iron with IDA, although mostly showed non significance. This indicates that the government, other health agencies, and even students should pay more attention to developing prevention strategies. Government and university administrators are encouraged to increase the availability of healthy food around the campus. Some reinforcement strategies are recommended, such as iron-rich meal labelling campaigns, iron tracker website or apps, health carnival or flea market, as well as increasing ready-to-eat iron rich food stalls.

## CrediT

**Author contributions**: Sivanesan Rajeswaran designed this study and study protocol. Hong Yen Chin was responsible for the fieldwork, data analyses and the drafting of the manuscript. Both authors contributed to the interpretation of the results and approved the final manuscript.


## Acknowledgment

The authors of this study would like to thank all the students who participated in the research for agreeing to do so.


## Ethical Approval

The present study was approved by the UTAR Scientific and Ethical Review Committee (U/SERC/78-396/2024) and informed consent was applied.

## Informed Consent

It was applicable.


## Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.


## Data Sharing Statement

No additional data is available.

## Conflict of Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Similarity Check

It was applied by Ithenticate[@].

## Application of Artificial Intelligence (AI)

Not applicable.

## Peer Review Process

It was performed.



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