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The Effect of Spirulina Platensis Extract (*Arthrospira platensis*) on Enhancing Hemoglobin Levels in Pregnant Women

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A B S T R A C T

The prevalence of anemia is still relatively high in the world. The impacts of this case are abortion, premature birth, premature rupture of membranes, histitis, postpartum hemorrhage, low birth weight (LBW), risk of congenital defects, infection in babies, and even death. The objective of this research was to assess how the use of spirulina platensis extract influences the elevation of hemoglobin levels in expectant mothers. In this case, the method used is Quasi-Experiment through a pretest and posttest control group design with a sample of 60 participants, consisting of 30 participants and a control group of 30 participants. Furthermore, the group subjected to the intervention was provided with a remedy, which involved administering Spirulina platensis extract in the form of one 300 mg capsule once a day for 30 days and standard care, while the control group received standard care only. In addition, the sampling technique used is simple side random. The results of the Paired Sample T-test analysis in the intervention group during the pretest obtained a mean hemoglobin level of 9.63 with a standard deviation of 0.490, while during the post-test, obtained mean score of 10.93 with a standard deviation of 0.907 with a p-value of 0.000. Meanwhile, the analysis of the control group during the pretest obtained mean hemoglobin levels of 9.60 with a standard deviation of 0.498, while during the posttest, the mean score obtained was 9.70 with a standard deviation of 0.535 and p-value of 0.083. The difference between the mean hemoglobin levels during the posttest in the experimental and control groups showed m= 10.93; SD= 0.907 vs. m= 9.70; SD= 0.535, with a p-value of 0.000. Therefore, it is summed up that there was an increase in hemoglobin levels in pregnant women after the administration of Spirulina platensis extract. As input for the health workers, especially midwives, it is suggested to offer alternative therapeutic approaches for pregnant women suffering from anemia by applying Spirulina platensis.

Introduction

In 2019, the World Health Organization (2021) reported that 29.9% of women between the ages of 15 and 49 worldwide were diagnosed with anemia. The prevalence of pregnant women, at 36.5%, was higher than that of non-pregnant women, which was 29.6%. Moreover, anemia remained the most widespread in Southeast Asia (World Health Organization, 2022). In Indonesia, 48.9% of pregnant women suffer from anemia, however, in East Java, the prevalence of anemia is 5.8%. According to data provided by the Kediri District Health Service in 2022, the prevalence of anemia is 23.3%. According to the Kediri District Health Office (2022), the Sambi Community Health Center had the most significant anemia cases among pregnant women, totaling 300 instances. The Ngasem Community Health Center came second, with 185 cases of anemia among pregnant women.

Anemia with a hemoglobin concentration of no less than ten g/dL at term occurs in most pregnancies and primarily reflects physiological processes rather than an underlying hematological deficiency or disorder. In this case, approximately 2% to 26% of pregnant women have significant anemia (Hb values <11 g/dL in the first trimester or <10 g/dL in the second and third trimesters) (Means et al., 2020). Anemia and Iron Deficiency Anemia is more common among pregnant women who are older than 35, non-native English speakers, carrying more than one child, underweight before pregnancy, or had severe nausea and vomiting while pregnant (Tan et al., 2020). Therefore, specific implications are necessary for mother and child health, both immediate and long-term, for the anemia during pregnancy (Jung et al., 2019). Fast-metabolizing cells need more iron and are more likely to malfunction if they do not get sufficient iron. Due to the limits of widely used indicators like hemoglobin and ferritin levels, iron deficiency during pregnancy may be difficult to identify (Georgieff et al., 2020).

Anemia is linked to several forms of illness and exacerbates some conditions, necessitating heightened critical care for both mothers and neonates. Anemic women not only experience a greater burden of disease, but they also have elevated incidence of prenatal conditions such as pre-eclampsia (Yadav et al., 2021). The prevalence of infectious illnesses before and after birth is much greater in anemic women, and anemia is linked to a higher risk of induction of labor, cesarean section, and blood transfusion. Preterm delivery, worse scores on the subjective global evaluation, and an increased risk of perinatal death and morbidity are all linked to moderate and severe anemia during pregnancy (Smith et al., 2019).

Anemia can also lead to complications during childbirth, including a threefold increase in the likelihood of incontinentia pigmenti, the need for a cesarean section, pre-eclampsia, premature birth, fetal death, and even excessive bleeding after delivery. Preterm birth has a heightened risk for long-term problems, including cerebral palsy and heart disease (Jung et al., 2019). Anemia during the puerperium can lead to several risks, including uterine sub-involution resulting in postpartum hemorrhage, cardiac decompensation immediately after delivery, infection during the puerperium, decreased breast milk production, anemia during the pure perineum, or an increased risk of breast infection (Sunuwar et al., 2019). Iron Deficiency Anemia is associated with increased rates of maternal and perinatal mortality, including stillbirth, early delivery, and low birth weight. Furthermore, anemia can result in death and disability (Rabe et al., 2021). Interventions to address nutritional needs and combat anemia during pregnancy may involve the administration of iron pills and the use of alternative therapies like seaweed. Additional therapies that elevate hemoglobin (Hb) levels include purple sweet potato, guava, red spinach, green beans, and moringa leaves. Spirulina platensis is abundant in protein and is considered to have a high protein content with significant biological significance due to its composition of amino acids (Batool et al., 2022).

Similar research that has been carried out is giving spirulina to pregnant women. The intervention given was less effective because, in this study, pregnant women still experienced anemia due to lack of rest or mothers experienced insomnia. In this study, researchers attempted to provide education about getting enough rest and not sleeping late at night. Researchers also provide information about foods that are good for increasing hemoglobin levels so that increasing hemoglobin levels in pregnant women is more effective.

Spirulina, also known as Spirulina platensis, is a kind of blue-green algae with a single spiral cell. Chlorophyll, beta carotene, phycocyanin, and minerals abound in plenty. Maternal serum retinol and hemoglobin levels concerning spirulina consumption during pregnancy have been researched, but no other prenatal outcomes have been examined. Previous researchers gave spirulina platensis capsules to pregnant women only to increase hemoglobin levels, whereas, in this study, researchers also looked at improving the nutritional status of pregnant women. The research results showed that the vitamin A status of both mothers and infants might be improved by supplementation with a modest physiological daily dosage of beta carotene from spirulina. Serum protein, serum iron, and blood hemoglobin levels also rose somewhat. However, spirulina supplementation was associated with a statistically significant increase in oligohydramnios in multiparous women (Yusof et al., 2016).

Spirulina has been designated as the World Health Organization's most promising future food due to its abundant natural protein and vitamin content. Spirulina has just been designated as Generally Recognized as Safe (GRAS) by the US Food and Drug Administration (FDA) (Othoo et al., 2021). Furthermore, Spirulina was awarded a "Class A" certification by the USP DSI-EC following a thorough examination of reports. When grown under controlled conditions and based on clinical case studies, animal toxicity data, and reports of adverse effects, it has been determined that it is safe for human consumption (Trotta et al., 2022).

A separate study discovered that administering 300 mg capsules of seaweed spirulina once a day for 30 days resulted in an increase in hemoglobin levels. Notably, only 5% of participants did not experience an increase in Hb levels. Specific instances of anemia endured due to inadequate rest or maternal sleeplessness (Stang et al., 2021). In another study, women in their second trimester of pregnancy were administered 56 capsules of spirulina, each containing 300 mg. The initial hemoglobin concentrations ranged from 8 to 11 gr/dL, with an average of 10.16 gr/dL. After consuming spirulina for eight weeks, the hemoglobin levels significantly increased to 13.35 gr/dL, resulting in a difference of 3.19 gr/dL (Marlina & Nurhayati, 2020).

Previous researchers gave spirulina platensis capsules to pregnant women only to increase hemoglobin levels, whereas, in this study, researchers also looked at improving the nutritional status of pregnant women. Related to this matter, current research was carried out to determine whether pregnant women with anemia may benefit from the provision of the blue-green algae Spirulina platensis (*Arthrospira platensis*) extract.

Method

The study employed a quasi-experimental approach, utilizing a pre-and post-test control group analysis of variance to collect and analyze quantitative data. This study employed a two-group design, consisting of an intervention group of 30 individuals and a control group comprising 30 participants. The intervention group received treatment by administering spirulina platensis extract in the form of 30 capsules, each containing 300 mg, once daily for 30 consecutive days. Additionally, they were provided standard care in the form of iron pills from healthcare facilities. Meanwhile, the control group exclusively received conventional care in the form of iron tablets from healthcare providers. For this experiment, we employed a simple random sample technique derived from the field of probability sampling. The study included a sample of 60 people, with 30 participants assigned to the intervention group and 30 participants assigned to the control group. The measurements were conducted using G-Power software version 3.1.6, explicitly using the F test with assumptions set at a significance level of 0.05, an effect size of 0.30, and a power level of 0.80. The study involved two groups. The minimal sample estimate achieved is 45, assuming an attrition rate of 30%. Therefore, a sample of 60 respondents was chosen.

This research was conducted from June to July in the work area of the Sambi Health Center and Ngasem Health Center, Kediri Regency. The inclusion criteria in this study were pregnant women willing to be respondents. These pregnant women had a history of anemia and CED and were pregnant women in the second trimester and third trimester. Meanwhile, the exclusion criteria in this study were pregnant women who had drug allergies and pregnant women who did not want to take part in the intervention provided.

The intervention provided was Spirulina platensis extract, which contained as many as 30 capsules containing 300 mg, once daily for 30 consecutive days. Participants continued to receive standard care when consuming Fe tablets. Spirulina platensis extract was consumed in the morning between 07.00-08.00 am after breakfast, and the group continued to receive standard care by consuming Fe tablets. Daily observation of compliance with drinking spirulina platensis extract was carried out by asking pregnant women to record on the observation sheet every time they consumed spirulina platensis extract.

The instrument used in this study is the Quik-Check brand digital Hb device, which measures hemoglobin levels. The examination of hemoglobin levels in pregnant women was carried out twice during the pre-test and post-test. In the pretest, the examination was carried out on the first day before the intervention of spirulina platensis extract for 30 days was given. Meanwhile, in the Posttest, the examination was carried out on the 30th day after the intervention of spirulina platensis extract for 30 days was done. The results of the examination were recorded on the observation sheet. Researchers monitored the group daily by conducting home visits and chats on WhatsApp. The monitoring aimed to know whether the pregnant women experienced side effects and reactions when receiving the intervention.

The analysis data used in hemoglobin levels is ratio data, so the paired sample t-test was used with the condition that the data must be normally distributed. Furthermore, the difference between the experimental and control groups before and after the intervention on hemoglobin levels was also measured using the Independent T-Test. Data was tested using the SPSS application/software program version 22 for Windows.

The ethical considerations of the study were approved by the Poltekkes Kemenkes Malang ethics committee with No.DP.04.03/F.XXI.31/910/2023.

Results

Table 1. Characteristics of Respondents in the Experimental Group and Control Group

Characteristics	Experiment Group (n=30)		Control Group (n=30)		*p-value*
	F/M	%/SD	F/M	%/SD	
Age	27.87	6.678	32	7.149	0.024[b]
Education					
1. Basic (elementary. junior high)	4	(13%)	7	(23%)	0.365[a]
2. Secondary (senior high school)	17	(17%)	19	(63%)	
3. Higher (S1)	9	(9%)	4	(13%)	
Parity					
1. ≤ 2	25	(83.33%)	17	(56.67%)	0.024[a]
2. > 2	5	(16.67%)	13	(43.33%)	
Pregnancy Spacing					
1. < 2 year	18	(60%)	8	(26.67%)	0.009[a]
2. ≥ 2 year	12	(40%)	22	(73.33%)	
Hemoglobin level	9.63	0.490	9.60	0.498	0.000[b]

Description = a: Chi Quadrat test, b: Levene test

Table 1 displays the respondents' mean age and standard deviation in the experimental and control groups. The experimental group had a mean age of 27.87 years with a standard deviation of 6.678, while the control group had a mean age of 32 years with a standard deviation of 7.149. This indicates that anemia was higher among individuals aged 20-35 years. This discovery is consistent with a prior investigation indicating that anemia is more widespread among individuals aged 20-35 (De Sá et al., 2015). In the most recent education data, the majority of participants from the experimental and control groups had completed secondary education (SMA), with 36 individuals (60%). This finding aligns with prior studies that have demonstrated a correlation between the educational attainment of mothers and their blood iron levels. There is a positive correlation between the mother's education level and the amount of information she receives (ElFar et al., 2022). During the parity assessment, most participants from both the experimental and control groups reported having a maximum of two deliveries, with 42 individuals (70%) falling into this category. Consistent with prior research, Sharma et al. (2020) found that pregnant women with a parity of more than three have a similar relative risk of having anemia compared to pregnant women with a parity of less than three.

In addition, the majority of participants in the experimental group had a pregnancy interval of less than two years, namely 18 individuals (60%), while the majority of participants in the control group had a pregnancy interval of two years or more, precisely 22 individuals (73.33%). Additional research indicates that both excessively long and excessively short intervals between pregnancies might have detrimental effects on the well-being of both the mother and the fetus. This is because such intervals may also be associated with abnormal levels of hemoglobin in pregnant women (Ampofo et al., 2018). Before the intervention, the mean hemoglobin level of the experimental group was 9.63 g/dL, with a standard deviation of 0.490. By comparison, the control group had an average hemoglobin level of 9.60 g/dL, with a standard deviation of 0.498. This indicates that the hemoglobin levels of the experimental and control groups were comparable prior to the administration of spirulina extract, with all pregnant women being anemic. In order to assess the normality of the data, the Shapiro-Wilk test was used. If the data adheres to a normal distribution, employing the Paired Sample T-Test is appropriate.

Table 2. Hemoglobin Levels Before and After Giving Spirulina Platensis Extract (*Arthrospira platensis*) to Pregnant Women in the Experimental Group

Variables	**Experiment Group(n=30)**		***P-Value***
	PreTest	***PostTest***	
	Mean±SD	**Mean±SD**	
Hemoglobin level	9.63±0.490	10.93±0.907	0.000

Description = Paired Sample T-Test

Table 2 displays the analytical findings of hemoglobin levels in the experimental group. The data indicates that the mean hemoglobin concentration before the test is 9.63 grams per deciliter, while the mean concentration after the test is 10.93 grams per deciliter. In this instance, the control group had a 1.3 g/dL greater increase in hemoglobin levels compared to the experimental group. The experimental group demonstrates a rise in hemoglobin levels when comparing the findings before and after the test. In addition, the Paired Sample T-Test conducted on the hemoglobin levels of the experimental group yielded very significant results, as evidenced by a p-value of 0.000. Therefore, it can be inferred that administering spirulina platensis extract to pregnant women in the experimental group resulted in elevated hemoglobin levels.

Table 3. Hemoglobin Levels Before and After Standard Care in the Control Group

Variables	**Control Group (n=30)**		***P-Value***
	PreTest	***PostTest***	
	Mean±SD	**Mean±SD**	
Hemoglobin level	9.60±0.498	9.70±0.535	0.083

Description = Independent T-Test Test

Table 3 shows the data concerning the analysis results of the hemoglobin levels in the control group. The data shows that the average hemoglobin level at the pretest is 9.60 gr/dL, while at the posttest, it is 9.70 gr/dL. In this case, the control group's hemoglobin levels rose by 0.1 gr/dL less than the experimental group. The control group exhibited a slight rise in hemoglobin levels compared to the pre- and post-test values. Furthermore, the Paired Sample T-test results on hemoglobin levels for the control group showed a p-value of 0.083. Therefore, the hemoglobin levels of the pregnant women in the control group did not vary significantly from one another.

Table 4. Differences in Pregnant Women's Hemoglobin Levels Between the Experimental and Control Groups

Variable	**Experiment Group (n=30)**		**Control Group (n=30)**		***P-Value***
	Mean	**±SD**	**Mean**	**±SD**	
Hemoglobin level	10.93	0.907	9.70	0.535	0.000

Description = Paired Sample T-Test

The table above displays the disparities in hemoglobin levels between the experimental and control groups following the administration of spirulina platensis extract. Moreover, the results of the independent T-test revealed that following the intervention, the experimental group exhibited a mean hemoglobin level of 10.93 g/dL. In contrast, the control group had a mean hemoglobin level of 9.70 g/dL. The Independent T-Test revealed significant results for the hemoglobin levels of both groups, with a p-value of 0.000. This demonstrates a disparity in hemoglobin levels between the two groups after administering spirulina platensis extract to pregnant women.

Discussion

Anemia is a global problem for poor countries, affecting human health and hindering social and economic progress. An individual is diagnosed with anemia when their hemoglobin (Hb) concentration falls below the typical level, and their red blood cell (RBC) count is insufficient to meet physiological requirements. In this case, the World Health Organization (WHO) defines maternal anemia as a Hb value of less than 11 g/dL (Chaparro et al., 2019).

Pregnant women develop anemia due to insufficient iron levels. The iron needed during pregnancy is substantially higher. Iron consumption is crucial for transporting oxygen from the mother to the developing fetus. During pregnancy, there is an increased demand for ATP to facilitate the growth of organs, particularly the brain. Thus, a daily intake of approximately 4-5 mg of iron is required throughout the early stages of the second trimester. The placenta is a large, metabolically active organ capable of storing iron. Giving birth leads to significant iron depletion, approximately 250 mg (Agarwal et al., 2021).

Spirulina, a microalgae used for generations as a food source in Central Africa, is currently extensively utilized as a nutritious dietary supplement all over the globe due to its high nutrition (Grosshagauer et al., 2020). Arthrospira (Spirulina) is a very high-protein food. Protein is essential in nutrition for the development and regulation of substances. Protein also regulates human health by providing precursors to amino acid molecules and functions as a component in the body's cells. Protein also plays a role in transporting iron to the spinal cord to form blood cells. Red. Protein intake, especially animal protein intake, helps increase iron absorption. Therefore, low protein intake can reduce Hb levels, which can cause anemia (Erningtyas et al., 2023). Spirulina effectively replaces up to 40% of the protein in a diet due to its high protein concentration (about 60%). Spirulina sp. cyanobacteria contain many non-essential fatty acids, specifically γ-linolenic acid (GLA, C18:3) and sulfolipids. The total lipid content of Spirulina sp. cyanobacteria ranges from 6.4% to 14.3% of their dry body weight. Numerous other food items are abundant in vitamins K, B12, and provitamin A, along with zinc, iron, calcium, phosphorus, magnesium, and manganese—pregnant and lactating moms who incorporate spirulina supplements into their diet experience a reduced likelihood of getting anemia. (Bitam et al., 2020).

This study investigated pregnant women's hemoglobin levels before and after spirulina platensis extract (Arthrospira platensis) administration. Based on the investigation, it was found that all 30 participants in the experimental group exhibited elevated hemoglobin levels. Following therapy, the increase in hemoglobin levels can be attributed to spirulina platensis, a non-pharmacological approach that incorporates patient belief variables to instill confidence. The researcher also reminded the woman to continue taking the primary care Fe pills. Spirulina has several health benefits, such as containing antioxidants that protect against inflammation and oxidative damage caused by free radicals, full of nutrients such as vitamins B1, B2, and B3, iron and folic acid, which are beneficial for baby's brain development, has omega-3 and omega-1 fatty acids. 6, especially gamma-linolenic acid, an omega-6 fatty acid derived from plants, helps produce hemoglobin and red blood cells and can lower blood pressure, potentially reducing the risk of cardiovascular disease. In general, spirulina is considered safe. However, the specific risks and side effects during pregnancy are still unknown, and more research is needed on pregnant people. This has the potential risk of spirulina being contaminated with microcystin (toxin) and heavy metals such as mercury. Based on previous research, no side effects occurred. In this study, the researchers also made observations regarding the side effects that occurred during administration. The results showed that no side effects occurred during or after the study. Researchers concluded that administering spirulina platensis extract (Arthrospira platensis) to pregnant women can be an alternative for midwives in overcoming the anemia problem in pregnant women (Niang et al., 2017). After receiving spirulina platensis extract, the experimental group had a mean posttest hemoglobin level of 10.93 g/dL, whereas the control group had a mean posttest hemoglobin level of 9.70 g/dL, demonstrating significant differences. After the treatment using spirulina platensis extract, pregnant women's hemoglobin levels were found to be different from those of the control group on average, as measured by the post-test in this study.

A separate investigation revealed that the administration of spirulina could markedly enhance hemoglobin levels compared to pregnant women solely consuming iron supplements. According to this study, it is clear that combining spirulina with regular iron supplements might lead to significant improvements in cases of pregnant anemia (Leal-Esteban et al., 2021). Spirulina has a long history of being used as a food additive and has been extensively studied in laboratory and animal experiments to determine its possible health advantages for humans (Sorrenti et al., 2021). Since the 1990s, numerous papers have explored the health advantages of Spirulina, covering various areas such as cell and tissue culture, animal experimentation, and human clinical trials. The publications discuss various experimental methodologies, such as using whole cells, different cell extracts, and isolated biomolecules, to investigate the potential health benefits of consuming this microalgae. These methodologies specifically focus on c-phycocyanin, Gamma Linolenic Acid, and sulfated polysaccharides. Potential health benefits encompass safeguarding against malnutrition, elevated cholesterol levels, diabetes, obesity, inflammatory allergies, toxicity caused by heavy metals/chemicals, radiation-induced damage, and anemia (Wan et al., 2016).

Chlorophyll A and Phycocyanin are only two of the antioxidant pigments in the cyanobacterium Spirulina, which contains proteins, carbs, vitamins, minerals, and vital fatty acids. Obesity, diabetes, hypertension, cardiovascular disease, anemia, cancer, oxidative stress, arthritis, immunity, and muscular cramping are just some of the conditions that have been shown to benefit from it. Spirulina may cause acute poisoning, liver damage, indigestion, and cancer due to the toxins it produces, such as microcystins and hepatotoxins. Adults may consume up to 30 g daily without ill effects, although the safe range is 3-10 g. (Gogna et al., 2022).

Conclusions

Giving spirulina platensis extract to pregnant women can increase hemoglobin levels in the intervention group compared to the control group. This study has made a good contribution as a non-pharmacological therapy in midwifery in increasing hemoglobin levels in pregnant women who experience anemia. Suggestions for further research are the results of research on the effect of Spirulina platensis Extract (*Arthrospira platensis*), which can be studied further by looking at other factors that influence overcoming the increase in hemoglobin levels in pregnant women who experience anemia.

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References

Agarwal, A. M., & Rets, A. (2021). Laboratory approach to the investigation of anemia in pregnancy. *International Journal of Laboratory Hematology*, *43*(S1), 65–70. https://doi.org/10.1111/ijlh.13551

Ampofo, G. D., Tagbor, H., & Bates, I. (2018). Effectiveness of pregnant women's active participation in their antenatal care for controlling malaria and anemia in pregnancy in Ghana: A cluster randomized controlled trial ISRTCTN88917252 ISRTCTN. *Malaria Journal*, *17*(1), 1–15. https://doi.org/10.1186/s12936-018-2387-1

Batool, A., Zafar, M. U., Abdullah, M., Mumtaz, H., Siddique, S., Sattar, S., & Rana, A. (2022). Comparative Effects of Spirulina with Iron Supplemented Sangobion Capsules among Anemic Females in Hafizabad. *Pakistan Journal of Medical and Health Sciences*, *16*(5), 957–960. https://doi.org/10.53350/pjmhs22165957

Bitam, A., & Aissaoui, O. (2020). Spirulina platensis, oxidative stress, and diabetes. *Diabetes: Oxidative Stress and Dietary Antioxidants*, *32*, 325-331. https://doi.org/10.1016/B978-0-12-815776-3.00033-4

Chaparro, C. M., & Suchdev, P. S. (2019). Anemia epidemiology, pathophysiology, and etiology in low- and middle-income countries. *Annals of the New York Academy of Sciences*, *1450*(1), 15–31. https://doi.org/10.1111/NYAS.14092

De Sá, S. A., Willner, E., Pereira, T. A. D., De Souza, V. R., Boaventura, G. T., & De Azeredo, V. B. (2015). Anemia in pregnancy: Impact on weight and in the development of anemia in newborn. *Nutricion Hospitalaria*, *32*(5), 2071–2079. https://doi.org/10.3305/nh.2015.32.5.9186

ElFar, O. A., Billa, N., Lim, H. R., Chew, K. W., Cheah, W. Y., Munawaroh, H. S. H., Balakrishnan, D., & Show, P. L. (2022). Advances in delivery methods of Arthrospira platensis (spirulina) for enhanced therapeutic outcomes. *Bioengineered*, *13*(6), 14681–14718. https://doi.org/10.1080/21655979.2022.2100863

Fitriningsih, J., Stang, Sampara, N., Sudirman, J., Kusniyanto, R. E., & Lisnawati. (2021). The effect of consuming seaweed capsules of Spirulina on hemoglobin levels of pregnant women at Batua Public Health Center of Makassar. *Enfermeria Clinica*, *31*, S697–S699. https://doi.org/10.1016/j.enfcli.2021.07.019

Georgieff, M. K. (2020). Iron deficiency in pregnancy. *American Journal of Obstetrics and Gynecology*, *223*(4), 516–524. https://doi.org/10.1016/j.ajog.2020.03.006

Gogna, S., Kaur, J., ORCID Icon, K. S., Prasad, R., Singh, J., Bhadariya, V., Kumar, P., & Departme, & S. J. (2022). Spirulina- An Edible Cyanobacterium with Potential Therapeutic Health Benefits and Toxicological Consequences. *Journal of the American Nutrition Association*, *42*, *2023*(6), 559–572. https://doi.org/10.1080/27697061.2022.2103852

Grosshagauer, S., Kraemer, K., & Somoza, V. (2020). The True Value of Spirulina. *Journal of Agricultural and Food Chemistry*, *68*(14), 4109–4115. https://doi.org/10.1021/acs.jafc.9b08251

Gusriani, Wahida, Nur Indah Noviyanti, N. (2022). The Effect of consuming seaweed on hemoglobin levels of pregnant women. *International Journal of Health and Pharmaceutical*. http://www.ijhp.net/index.php/IJHP/article/view/72/73

Jung, J., Rahman, M. M., Rahman, M. S., Swe, K. T., Islam, M. R., Rahman, M. O., & Akter, S. (2019). Effects of hemoglobin levels during pregnancy on adverse maternal and infant outcomes: a systematic review and meta-analysis. *Annals of the New York Academy of Sciences*, *1450*(1), 69–82. https://doi.org/10.1111/NYAS.14112

Karemoi, T. M., Mardiah, W., & Adistie, F. (2020). Factors Affecting Nutritional Status of Pregnant Women. *Asian Community Health Nursing Research*, *2*(2), 39. https://doi.org/10.29253/achnr.2020.23958

Kuma, M. N., Tamiru, D., & Belachew, T. (2021). Hemoglobin Level and Associated Factors among Pregnant Women in Rural Southwest Ethiopia. *BioMed Research International*, *2021*. https://doi.org/10.1155/2021/9922370

Leal-esteban, L. C., Campos, R., Veauvy, M., Mascarenhas, B., Mhatre, M., Menon, S., Graz, B., & Weid, D. Von Der. (2021). Spirulina supplementation : A double-blind , randomized , comparative study in young anemic Indian women. *Clinical Epidemiology and Global Health*, *12*(May), 100884. https://doi.org/10.1016/j.cegh.2021.100884

Marlina, D., & Nurhayati, F. (2020). The Effectiveness of Spirulina Compared with Iron Supplement on Anemia among Pregnant Women in Indonesia. *International Journal of Caring Sciences*, *13*(3), 1783–1787. https://search.proquest.com/scholarly-journals/effectiveness-spirulina-compared-with-iron/docview/2480382379/se-2?accountid=13771

Means, R. T. (2020). Iron deficiency and iron deficiency anemia: Implications and impact in pregnancy, fetal development, and early childhood parameters. *Nutrients*, *12*(2). https://doi.org/10.3390/nu12020447

Niang, K., Ndiaye, P., Faye, A., Tine, J. A. D., Diongue, F. B., Camara, M. D., Leye, M. M., & Tal-Dia, A. (2017). Spirulina Supplementation in Pregnant Women in the Dakar Region (Senegal). *Open Journal of Obstetrics and Gynecology*, *07*(01), 147–154. https://doi.org/10.4236/ojog.2017.71016

Organização Mundial de Saúde. (2022). *World health statistics 2022 (Monitoring health of the SDGs)*. http://apps.who.int/bookorders.

Othoo, D. A., Ochola, S., Kuria, E., & Kimiywe, J. (2021). Impact of Spirulina corn soy blend on Iron deficient children aged 6–23 months in Ndhiwa Sub-County Kenya: a randomized controlled trial. *BMC Nutrition*, *7*(1), 1–12. https://doi.org/10.1186/s40795-021-00472-w

Sharma, A., & Datt, C. (2020). Supplementation effect of red seaweed powder on dry matter intake , body weight and feed conversion efficiency in crossbred cows. *Journal of Entomology and Zoology Studies*, *8*(2), 1056–1059. https://www.entomoljournal.com/archives/?year=2020&vol=8&issue=2&ArticleId=6566

Smith, C., Teng, F., Branch, E., Chu, S., & Joseph, K. S. (2019). Maternal and Perinatal Morbidity and Mortality Associated with Anemia in Pregnancy. *Obstetrics and Gynecology*, *134*(6), 1234–1244. https://doi.org/10.1097/AOG.0000000000003557

Sorrenti, V., Castagna, D. A., Fortinguerra, S., Buriani, A., Scapagnini, G., & Willcox, D. C. (2021). Spirulina microalgae and brain health: A scoping review of experimental and clinical evidence. *Marine Drugs*, *19*(6), 1–12. https://doi.org/10.3390/md19060293

Sundararajan, S., & Rabe, H. (2021). Prevention of iron deficiency anemia in infants and toddlers. *Pediatric Research*, *89*(1), 63–73. https://doi.org/10.1038/s41390-020-0907-5

Sunuwar, D. R., Sangroula, R. K., Shakya, N. S., Yadav, R., Chaudhary, N. K., & Pradhan, P. M. S. (2019). Effect of nutrition education on hemoglobin level in pregnant women: A quasi-experimental study. *PloS One*, *14*(3). https://doi.org/10.1371/JOURNAL.PONE.0213982

Tan, J., He, G., Qi, Y., Yang, H., Xiong, Y., Liu, C., Wang, W., Zou, K., Lee, A. H., Sun, X., & Liu, X. (2020). Prevalence of anemia and iron deficiency anemia in Chinese pregnant women (IRON

WOMEN): a national cross-sectional survey. *BMC Pregnancy and Childbirth*, *20*(1). https://doi.org/10.1186/S12884-020-03359-Z

Trotta, T., Porro, C., Cianciulli, A., & Panaro, M. A. (2022). Beneficial Effects of Spirulina Consumption on Brain Health. *Nutrients*, *14*(3), 1–17. https://doi.org/10.3390/nu14030676

Wan, D., Wu, Q., & Kuča, K. (2016). Spirulina. *Nutraceuticals: Efficacy, Safety and Toxicity*, 569–583. https://doi.org/10.1016/B978-0-12-802147-7.00042-5

Yadav, U. K., Ghimire, P., Amatya, A., & Lamichhane, A. (2021). Factors Associated with Anemia among Pregnant Women of Underprivileged Ethnic Groups Attending Antenatal Care at Provincial Level Hospital of Province 2, Nepal. *Anemia*, *2021*. https://doi.org/10.1155/2021/8847472

Yusof, J., Mahdy, Z. A., & Noor, R. M. (2016). Use of complementary and alternative medicine in pregnancy and its impact on obstetric outcome. *Complementary Therapies in Clinical Practice*, *25*, 155–163. https://doi.org/10.1016/j.ctcp.2016.09.005