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Improving the Nutritional Status of Pregnant Women Who Experience Chronic Energy Deficiency with Spirulina Platensis

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Abstract:
The highest prevalence of chronic energy deficiency (CED) in pregnancy occurs in the third trimester of pregnancy. The impacts that occur are abortion, premature birth, premature rupture of membranes, histitis, postpartum hemorrhage, and low birth weight (LBW). To prevent negative impacts, giving Spirulina Platensis is believed to improve nutritional status. This study aimed to analyze the effect of spirulina platensis extract on improving nutritional status in pregnant women. Using a Quasi-Experiment with a pretest and posttest control group design with a sample of 60 participants consisting of an intervention group of n=30 participants and a control group of n=30 participants. The intervention group received treatment, namely being given Spirulina Platensis extract, 1 capsule containing 300 mg, taken once for 30 days and standard care, while the control group received standard care only. The sampling technique used was simple side random. Chi-Square test results in the intervention group mean pretest nutritional status (m=22.04, SD=1.170) and posttest (m=23.33, SD=0.922) p-value=0.000, while the control group showed pretest nutritional status (m=22.16, SD=1.104) and posttest (m=22.39, SD=1.016) p-value=0.150. The difference between the mean posttest nutritional status in the experimental and control groups shows (m=23.33, SD=0.922) vs (m=22.39, SD=1.016) p-value=0.000. There is an increase in the administration of Spirulina Platensis extract on the nutritional status of pregnant women. As input for health workers, especially midwives, to provide non-pharmacological therapy to pregnant women who experience chronic energy deficiency (CED) by administering Spirulina Platensis.

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INTRODUCTION

The World Health Organization in 2017 reported that 35% to 75% of pregnant women worldwide suffer from chronic energy insufficiency (CED), where the highest incidence rate occurs in the third trimester of pregnancy. WHO also notes that CED is a factor in 40% of maternal fatalities in poor nations (SDGs Sustainable Development Goals, 2022). Chronic lack of energy is caused by an inadequacy of macronutrient energy intake (carbohydrates, protein, and fat) and micronutrients, particularly vitamins A, D, folic acid, iron, zinc, calcium, and Iodine, and other trace minerals (Karemoi et al., 2020). undernutrition before the conception period has an impact on pregnancy and will also result in malnutrition in the mother and fetus. Low maternal weight, CED, and anemia prior to conception have an impact on malnutrition in the fetus she is carrying and can cause babies to be born with low birth weight (LBW); premature newborns are contagious illness risk factors and delayed growth and development. Babies will grow up to become malnourished and stunted children and teenagers if their nutrition is not improved from an early age. Many factors can influence maternal malnutrition, including age, academic level, socioeconomic variables, water intake, nutrition consumption, and balance (Reski et al., 2020).

Several variables of pregnant women's nutritional intake, like diet and exercise, and the vitamins needed during pregnancy are C, D, and E. The nutritional needs of pregnant women in the food intake needed during pregnancy, the fetus, in the absence of appropriate formulation, can cause Chronic Energy Deficiency. The supporting factors for maternal nutrition are essentially the same, but the level of nutritional value varies, so the nutritional quality is also different (Wahyuni et al., 2019).

Nutritional problems are insurmountable public health problems that can only be addressed through medical approaches and care. Nutrition-related issues are not only poor conditions closely tied to household food security but also involve knowledge and habits incompatible with leading a healthy lifestyle. Malnutrition will cause failure in intellectual and physical development, reduced output at work, and diminished physical endurance, resulting in elevated mortality and morbidity rates (Razak, 2021; Kurniyawan et al., 2023).

Another study said there was a substantial correlation between MUAC and BMI even after controlling for potential confounders. Also, MUAC shows a positive correlation with BMI with a coefficient of 0.57. The findings show that MUAC can be utilized as a BMI substitute in field settings with limited resources where functional scales and stadiometers are inaccessible. It is simple to measure and doesn't require special skills or intricate math. Additionally, the only tool needed to measure MUAC is a straightforward, user-friendly measuring tape (Salih et al., 2023). MUAC is less expensive and can be used at any time during pregnancy. It will even be helpful for health professionals at the elementary school level who cannot assess nutritional status effectively and, in many cases, go unrecognized, which can lead to a reduction in the baby's health. It is also not susceptible to changes during pregnancy, unlike BMI. Pregnant women are said to have CED if the MUAC result is <23.5 cm (Mishra et al., 2020).

The growth of the fetus and baby and the mother's health and well-being can be significantly impacted by a woman's nutritional state during pregnancy. The early phases of human life and fetal development are crucial times when the molecular, genetic, and metabolic basis is established to determine the development of certain diseases. There is an abundance of evidence that supports the significance of maternal nutrition during pregnancy. Numerous studies have linked high prenatal weight gain and the use of certain drugs (such as alcohol, caffeine, and tobacco) to issues with mother and fetal health as well as clinical concerns both during and after delivery (Olloqui-Mundet et al., 2023). Continuous Pregnant women who consume insufficient amounts of protein and energy are four times more likely to deliver kids with low birth weight (LBW). Major perinatal dangers result from CED prior to pregnancy, such as stillbirth, premature birth, very low birth weight, and tiny for gestational age newborns. Children of undernourished mothers are more likely to be undernourished, which can result in delayed cognitive growth, lower stature, and an increased risk of illness and mortality (Wubie et al., 2020; Rahmawati et al., 2021). Nearly one-third of pregnant women in the United States and 40% of pregnant women globally suffer from CED. CED has been linked to greater incidence of cesarean delivery, preterm birth, preeclampsia, low birth weight, low birth weight kids, and maternal and perinatal mortality among pregnant women (Smith et al., 2019).

Blue-green algae with a spiral structure known as Spirulina platensis has been dubbed a "superfood." It is abundant in the vitamins and minerals chlorophyll, beta-carotene, and phycocyanin. Studies on Spirulina platensis during pregnancy have focused on the mother's hemoglobin and serum retinol levels (Gogna et al., 2023). Low physiological daily doses of beta carotene from Spirulina platensis are beneficial throughout pregnancy and lactation to improve the vitamin A status of mothers and infants. Blood hemoglobin levels, serum protein levels, and serum iron levels all saw small increases. But among multiparous moms that ingested Spirulina Platensis, oligohydramnios was significantly more common (Yusof et al., 2016).

The diet and Drug Administration (FDA) has determined that Spirulina Platensis' high protein and natural vitamin content is safe, according to scientific data, and the World Health Organization has designated it as the best diet for the future (Othoo et al., 2021). Additionally, the Dietary Supplement Information Specialist Committee (DSI-EC) of the United States Pharmacopeial Convention (USP) awarded Spirulina Platensis "Class A" status, indicating its safety for human consumption, after carefully reviewing clinical case reports, animal toxicology data, and side effect reports (Trotta et al., 2022). Spirulina platensis is used not as food alone but as a nutritional supplement; it can be seen as a complement to ordinary cereals such as rice, wheat, or corn. Because this food is limited to certain amino acids, Spirulina platensis can increase its protein value. Spirulina platensis was implemented as a supplement for protein malnutrition, providing positive results regarding weight gain and improving nutritional status in general (Yimer & Wolde, 2022).

Other than Spirulina platensis, meals high in protein include meat, poultry, seafood, eggs, milk, dairy products, beans, peas, nuts, and seeds. These sources also support the dietary intake of calcium, magnesium, iron, zinc, vitamin D, and B vitamins. Furthermore, natural sources of dietary fiber include fruits, vegetables, nuts, legumes, and grain products (Abou-Rizk et al., 2021).

Research in line with this study states that Spirulina platensis is very beneficial for Mexican children suffering from severe malnutrition. In a more detailed study, a diet derived from 50% Spirulina platensis protein was fed through a plastic tube to five malnourished adults for periods varying from 4 to 5 days; there was a significant improvement in positive nitrogen balance and no side effects. In another study conducted in Africa, supplementing children with protein or malnutrition with Spirulina platensis protein energy for 8 weeks, nutritional status showed a significant improvement with the average of the group given Spirulina Platensis experiencing an increase in body weight of 25 g/day while the control group gained 25 g/day. weighing 15 g/day (Gutiérrez-Salmeán et al., 2015).

The difference between researchers in this study is that previous researchers gave Spirulina Platensis capsules to adults and children to treat malnutrition. In contrast, this researcher, to the researchers' knowledge, is the first study to assess the effect of giving Spirulina platensis extract on the nutritional status of pregnant women. This investigation examined how giving pregnant CED women Spirulina platensis (Arthrospira platensis) extract affected their nutritional status.

METHOD

Research Design

This study uses a quasi-experimental design with a control group created using a pretest and post-testing strategy. This research was designed with a two-group design: one intervention group n=30 participants and a control group n=30 participants. The intervention group was treated by providing 30 capsules containing 300 mg of Spirulina platensis extract taken once for 30 days and standard care (providing additional food from a health service facility). Meanwhile, the control group only received standard care by providing additional food from health service facilities.

Technique and Sample

This study uses simple random sampling as part of a probability sampling technique. A total of 60 participants, 30 in the intervention group and 30 in the control group.

Intervention

The intervention given was 30 Spirulina platensis extract capsules containing 300 mg taken once for 30 consecutive days, and participants continued to consume standard supplementary feeding (PMT) care. Spirulina platensis extract was consumed in the morning between 07.00-08.00 am after breakfast, and the group continued to consume standard supplementary feeding (PMT) care. Daily observation of compliance with drinking Spirulina platensis extract was carried out by asking pregnant women to record on an observation sheet each time they consumed.

Measurement and Data Collection

The instrument used in this research was the MUAC Tape to measure nutritional status. Pretest and Posttest were both used to examine the nutritional status of pregnant women, namely the first day before being given the spirulina platensis extract intervention for 30 days, and the Posttest, namely the 30th day after being given the spirulina platensis extract intervention for 30 days. The results of the examination are recorded on the observation sheet. Researchers monitored the group every day by conducting home visits and via WhatsApp. The monitoring is whether pregnant women experience side effects and reactions when consuming the intervention.

Data Analysis

The Chi-Square Test is employed since the nutritional status analytical data is minimal. The nutritional status of the experimental and control groups was compared before and after the intervention using the Independent T-Test. The SPSS (Statistical Package for Social Science) application/software version 22 for Windows was used to test the data.

Ethical Considerations

The research received ethical approval from the Health Polytechnic Ministry of Health Malang Ethics Committee with No.DP.04.03/F.XXI.31/910/2023.

RESULT

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

Characteristics	Experimental Group (n=30)		Control Group (n=30)		p-value
	Mean (SD)	f (%)	Mean (SD)	f (%)	
Age	27.87 (6.678)	30 (100)	32 (7.149)	30 (100)	0.024[b]
Education	-				0.365[a]
Basic		4 (13)	-	7 (23)	
Middle		17 (17)		19 (63)	
High		9 (9)		4 (13)	
Parity	-		-		0.024[a]
≤ 2		25 (83.33)		17 (56.57)	
> 2		5 (16.67)		13 (43.33)	
Pregnancy Distance (years)			-		0.009[a]
< 2	-	18 (60)		8 (26.67)	
≥ 2		12 (40)		22 (73.33)	
Nutritional Status	21.93 (1.143)	30 (100)	22.03 (1.066)	30 (100)	0.000[b]

Information = a: Chi Quadrat test, b: Levene Test

In contrast to the control group, which had participants who were, on average, 32 years old and had a standard deviation of 7.149, the experimental group's members were 27.87 years old with a standard deviation of 6.678. The p-value for this difference was, therefore, 0.024. In the latest educational data, the experimental group had an average secondary education (SMA) of 17 participants (17%) and the control group had an average secondary education (SMA) of 19 participants (63%) with a p-value of 0.365. In the parity status data, the control group had an average parity of 2 years for as many as 17 people (56.67%) with a p-value of 0.024, while the experimental group had an average parity of 2 years for as many as 25 participants (83.33%). In the pregnancy distance data, the experimental group had an average distance of < 2 years for 18 participants (60%), and the control group had an average distance of ≥ 2 years for 22 participants (73.33%) with a p-value of 0.009.

Before the intervention was given, the average nutritional status of the experimental group was 21.93 cm, with a standard deviation of 1.143. In comparison, the average nutritional status of the control group was 22.03 cm with a standard deviation of 1.066, yielding a p-value of 0.000. This shows that before being given spirulina platensis extract in the experimental group and control group, all pregnant women experienced chronic energy deficiency (CED).

Doing a normality test and a homogeneity test may establish whether the data is evenly distributed and homogeneous. Levene's Test was used for the homogeneity test, while the Shapiro-Wilk test was used for the normality test. The results of the analysis are listed in Table 2.

Table 2. Nutritional Status Before and After Giving Arthrospira platensis Extract to Pregnant Women in the Experimental Group

Nutritional Status	Experimental Group (n=30)		p-value
	Pretest	Posttest	
NO CED (F, %)	0 (0)	20 (67)	0.000
CED (F, %)	30 (100)	10 (33)	
MUAC (m, SD)	22.04 (1.170)	23.33 (0.922)	0.000

Description = Chi-Square Test

Considering the findings of examining the nutritional status in the experimental group as shown in table 2. The table shows nutritional status data during the Pretest in the experimental group, all pregnant women experienced chronic energy deficiency (CED) with (m= 22.04, SD= 1.170), while at the posttest, those who did not experience chronic energy deficiency (CED) were 20 pregnant women (67%) and 10 people (33%) still experienced chronic energy deficiency (CED) with (m= 23.33, SD= 0.922). The results of the pre-test and post-test show that there was an increase in nutritional status in the experimental group, namely 1.29 cm. The Chi-Square test results on nutritional status for the experimental group showed significant results, namely p value = 0.000. It can be concluded that nutritional status has improved after being given spirulina platensis extract to pregnant women in the experimental group.

Table 3. Nutritional Status Before and After Giving Arthrospira platensis Extract to Pregnant Women in the Control Group

Nutritional Status	**Control** Group (n=30)		p-value
	Pretest	Posttest	
NO CED (F, %)	20 (67)	2 (7)	0.000
CED (F, %)	10 (33)	28 (93)	
MUAC (m, SD)	22.16 (1.104)	22.39 (1.016)	0.000

Description = Chi-Square Test

Based on Table 3, at the pretest, all pregnant women in the control group had chronic energy deficiency (CED), with a mean of 22.16 and a standard deviation of 1.104; however, at the posttest, only two pregnant women (7%) had CED, and 28 others (93%) still had it, with a mean of 22.39 and a standard deviation of 1.016. The Pretest and Posttest findings reveal that the control group's nutritional status increased somewhat by 0.23 cm. The nutritional status Chi-Square test findings for the control group revealed a p-value of 0.150. It can be said that pregnant women in the control group don't have any different nutritional status.

Table 4. Differences in Nutritional Status in the Experimental Group and Control Group of Pregnant Women

Nutritional Status	**Control** Group (n=30)		p-value
	Experimental Group (n=30)	Control Group (n=30)	
NO CED (F, %)	20 (67)	2 (7)	0.000
CED (F, %)	10 (33)	28 (93)	
MUAC (m, SD)	23.33 (0.922)	22.39 (1.016)	0.000

Description = Paired Sample T-Test

An Independent T-Test was performed using Table 4 to assess the difference in nutritional status between the experimental group and the control group after the administration of spirulina platensis extract. According to the analysis's findings, there were 20 pregnant women in the experimental group (or 67%) who did not have chronic energy deficiency (CED), while there were only 2 pregnant women in the control group (or 7%) who did not have CED. The results of the Independent T-Test on the nutritional status of the two groups showed significant results, namely p value = 0.000. This shows differences in nutritional status in the two groups after receiving spirulina platensis extract treatment in pregnant women.

Tables 2 and 3's assessments of nutritional status before and after the intervention show a significant difference between the two groups, with a p-value for the experimental group of 0.000 and a p-value for the control group of 0.150. Thus, administering spirulina platensis extract can enhance the experimental group's nutritional condition, while the control group also experienced an increased nutritional status but not significantly. The Independent Sample T-Test statistical analysis findings revealed significant differences between the two groups.

DISCUSSION

According to Table 1's findings, nutritional status is more prevalent in people between 20 and 35. This finding is consistent with other studies demonstrating that people between these ages are likelier to experience chronic energy deficiency (CED) (Kuma et al., 2021). According to the most recent educational statistics, 36 participants from the experimental and control groups (60%) had at least a high school diploma. This is consistent with earlier research that demonstrates a connection between pregnant women's nutritional condition and their level of education. The higher the mother's education, the more information she gets (Means, 2020). In parity status, most experimental and control group participants had several deliveries ≤ 2 years, 42 people (70%). This is in line with other research that pregnant women whose parity is more than 3 have the same relative risk of developing chronic energy deficiency (CED) compared to pregnant women whose parity is less than 3 times (Lipoeto et al., 2020). In the experimental group, the majority of pregnancies had a pregnancy distance of < 2 years, 18 people (60%), and in the control group, some participants had a pregnancy distance of ≥ 2 years, 22 people (73.33%). According to another study, pregnancies that are spaced too far apart or too close together put the health of the mother and fetus at risk. This may also be related to the pregnant women's nutritional quality (Starbird & Crawford, 2019).

Table 4 contrasts the nutritional status of the experimental group, the control group, and the intervention group before and after receiving spirulina platensis extract, as well as the posttest nutritional status results for the intervention group, based on the findings, namely 20 pregnant women who did not experience chronic energy deficiency (CED) and the posttest in the control group, Specifically up to two women who were pregnant but did not have chronic energy deficiency (CED). Therefore, it can be concluded that after giving spirulina platensis extract to pregnant women with chronic energy deficiency (CED), there is a noticeable difference in the two groups' nutritional statuses.

Many pregnant women in low- and middle-income nations do not consume enough nutrients, which might have detrimental effects. According to earlier studies, a large number of pregnant women in low- and middle-income nations also consume insufficient amounts of fruits, vegetables, meat, and dairy products. Pregnant women who eat fewer animal sources are less likely to get enough protein and iron. Pregnant women with protein energy deficiency (PED) are measured at a MUAC of less than 23.5 cm. Iron intake from animal food sources may impact pregnant women with a protein-energy shortage (Mulyantoro & Kusrini, 2021). Improper dietary restrictions and bad eating habits will impact the poor quality of food intake, giving rise to the risk of chronic energy deficiency (KED) in pregnant women (Angkasa & Iswarawanti, 2021).

Chronic energy deficiency (CED) is a problem for global health, particularly in developing nations. Chronic energy deficiency occurs when the body's needs for protein, energy, or perhaps both are unmet. Chronic energy deficiency (CED) is when the body goes for extended periods without eating and has an energy deficit. The body mass index (BMI) is below the adult standard 18.5. Pregnant women with chronic energy deficiency (CED) had upper arm circumferences (LILA) less than 23.5 cm (Wahyuni et al., 2019). Age, family income, gender equality, birth spacing, pregnancy problems, family history of illness, employment, food, level of education, and usage of iron supplements are just a few of the variables that can contribute to chronic energy insufficiency in pregnant women. Nutritional and calorie requirements are based on age. Public health issues with nutrition cannot be resolved solely by using medicine and healthcare services (Tafara et al., 2023).

In addition to being a symptom of poverty, nutritional issues are directly linked to global food security issues. Home level is also connected to information and habits that don't promote a healthy way of life. Malnutrition will result in slowed rates of physical and mental growth, decreased labor productivity, and diminished physical stamina, all of which will raise morbidity and death rates (Razak, 2021). The impact of chronic energy deficiency will be risks and complications such as anemia, bleeding, the mother's weight not gaining normally, infections, miscarriage, congenital defects, intrapartum asphyxia, low birth weight (LBW), disrupted growth and development, stunting—even increasing maternal and newborn deaths (Bhatnagar & Padilla-Zakour, 2021).

Women who are pregnant and have chronic energy deficiency (CED) may have had it prior to becoming pregnant. When a mother is sluggish about eating and feels nausea and vomiting in the first trimester of pregnancy, the risk of chronic energy deficiency (CED) rises. The mother's diet prior to becoming pregnant may then have an impact on the development of CED since it does not satisfy her nutritional demands or intake and is therefore out of harmony with her energy levels ("Introduction," 2021). Due to the increased energy metabolism brought on by pregnancy, more energy and other nutrients are required. An additional 340–450 calories per day are required in the second and third trimesters of pregnancy. Around 80,000 kcal is needed for energy throughout a full-term pregnancy for the metabolism of the mother and the fetus, as well as for fetal and placental growth (Sinha et al., 2018).

This study found that the nutritional status of pregnant women was examined before and after the administration of spirulina platensis (Arthrospira platensis) extract. All 30 participants in the experimental group experienced an increase in nutritional status. This is caused by spirulina platensis, a development of non-pharmacological methods involving patient belief factors that can create confidence in improving nutritional status after intervention. Researchers also reminded mothers to continue consuming additional food. Researchers concluded that providing pregnant women with spirulina platensis (Arthrospira platensis) extract could be a substitute for midwives in addressing the issue of chronic energy deficiency (CED) in pregnant women. The post-test nutritional status of the experimental group showed 20 pregnant women who did not have chronic energy deficiency (CED).

In comparison, the post-test nutritional status of the control group showed two pregnant women who did not have chronic energy deficiency (CED). These results showed differences in nutritional status between the experimental and control groups after receiving spirulina platensis extract. Looking at the results between the experimental and control groups' posttest, it can be concluded that there were differences in nutritional status in the two groups after receiving spirulina platensis extract treatment in pregnant women.

The results of other studies state that Fe tablets can significantly improve pregnant women's nutritional status if accompanied by additional food (PMT). Consuming PMT and Fe, if accompanied by balanced food consumption, will provide maximum results (Sinha, Patro, & Patro, 2020).

Spirulina platensis has historically been utilized as a dietary component, and it has undergone extensive research for its function in the management of human health utilizing in vitro and in vivo trials (Sorrenti et al., 2021). Spirulina platensis (SP), also known as Arthrospira platensis, Spirulina Maxima (Arthrospira Maxima), and Spirulina fusiformis (Arthrospira fusiformis) are three of these spirulina species. They are frequently consumed due to their high nutritional value, research, and possibly medicinal capabilities. Since the 1990s, numerous studies have been published describing the benefits of Spirulina platensis for health in cell and tissue culture, animal testing, and human clinical trials. These publications report promising results for experimental procedures, including the production of entire cells, different cell extracts, and purified biomolecules (c-phycocyanin, GLA, sulfated polysaccharides). These experiments aimed to clarify any potential health advantages of consuming these microalgae. Antioxidant, anticancer, antiviral, antibacterial, immunomodulatory, and beneficial effects on malnutrition, hyperlipidemia, diabetes, obesity, inflammatory allergic reactions, heavy metal/chemical-induced toxicity, radiation damage, and anemia are only a few possible health impacts (Wan et al., 2016).

Spirulina platensis also showed increased serum ferritin levels. The most precise biochemical test corresponding to the body's relative iron storage is serum ferritin concentration. Low serum ferritin levels reflect a lack of iron stores and are a precursor to iron deficiency in the absence of infection (Leal-Esteban et al., 2021). The results showed that ferritin and iron levels increased significantly. Supplementing with spirulina may be more successful in improving ferritin and iron levels in patients who were somewhat malnourished prior to surgery. With a concentration comparable to the iron in beef, spirulina is a good source of iron. Spirulina species' iron content can replace serum and ferritin storage (E et al., 2016).

Due to its great nutritional content, Spirulina platensis has been consumed as food in Central Africa for millennia and is now widely utilized as a nutritional dietary supplement worldwide (Grosshagauer et al., 2020). One of the richest protein sources is arthrospira, often known as

Spirulina platensis. It has been discovered that employing Spirulina platensis as a protein supplement can replace up to 40% of the protein content, roughly 60%. Spirulina platensis sp. cyanobacteria had a total lipid content that ranged from 6.4% to 14.3% of their dry body weight and were high in sulfolipids and non-essential fatty acids such -linolenic acid (GLA, C18:3). Other food sources are abundant in minerals including zinc, iron, calcium, phosphorus, magnesium, and manganese as well as vitamins (K, B12, and provitamin A). Spirulina platensis dietary supplements have decreased the prevalence of anemia during pregnancy and breastfeeding (Bitam & Aissaoui, 2020).

Spirulina platensis is rich in protein (60 to 70%), vitamins, and minerals and is used as a protein supplement in the diets of poor and malnourished children in developing countries (Niang et al., 2017). One gram of Spirulina platensis protein is equivalent to one kilogram of various vegetables. Spirulina platensis cultivation is carried out on a large scale in fresh water and wastewater. Spirulina platensis grown in clean water and under strictly controlled conditions can be used as human food. Microalgae growing in wastewater is used as animal feed and as a source of chemicals and fuel. This wastewater treatment technology is extremely appropriate in densely populated nations like India, where trash is produced in large amounts and poses environmental difficulties. This waste contains significant amounts of vitamins, minerals, phenolic compounds, important fatty acids, amino acids, and pigments. Furthermore, there is a pressing need to create alternative protein sources to make up for these dietary inadequacies, and Spirulina platensis proteins play a significant part in this (Shariat et al., 2019). In this situation, finding an extraction method that maximizes protein output and fully utilizes biomass is vital, and ultrasound has proven to be a successful extraction method (Algohary et al., n.d.).

Spirulina can be produced in powder, liquid, oil, tablet, or capsule form and is used in many food industries, including candy, snacks, and cakes. In addition to including spirulina in the production of functional drinking water, such as fruit juice, which is very important for health, Spirulina is also used in producing dairy products, pasta, petroleum derivatives, and nutritional products. Besides being a colorant in the food industry, Spirulina has many uses in food, animal feed, and fish (AlFadhly et al., 2022).

The addition of Spirulina platensis needs to be done to make it easier for vegetarians to obtain a protein source easily digested by the body. This is because the vegetable protein content in S. Platensis is a vegetable protein that is easily digested when compared to vegetable protein in other microalgae. This is because 95% of the cell walls are mucopolysaccharides, easily absorbed by the intestine (ElFar et al., 2022). Vegetarians need protein that is easily digested to prevent protein deficiency. This is because protein is important in forming body tissue; if the body lacks protein intake, it can disrupt the growth process (Irandegani et al., 2019).

In addition to having a high protein content, spirulina platensis also has many vital fatty acids, vitamins, minerals, and plant pigments like phycocyanin, chlorophyll, and carotenoids. According to reports, phytonutrients can pass across the placental barrier in humans and animals (Moradi et al., 2021). Consuming Spirulina Platensis in pregnant and breastfeeding women can provide important components needed for the development of the uterus and placenta and the development, growth, and survival of the fetus. Overall, other studies show that the consumption of Spirulina platensis by mothers during pregnancy and breastfeeding can improve behavioral and cognitive changes caused by PMN (Sinha, Patro, Tiwari, et al., 2020). Spirulina platensis consumption during pregnancy may successfully combat the negative consequences of maternal protein shortage. In order to determine whether the observed health benefits of Spirulina platensis are caused solely by the protein content of Spirulina platensis or by the presence of other ingredients like vitamins, minerals, fatty acids, polysaccharides, and phytopigments, more research is required to provide a mechanistic explanation (Tezera Damessa, 2021).

This research also aligns with research that states that spirulina platensis is very beneficial for Mexican children who suffer from severe malnutrition. In a more detailed study, a diet derived from 50% Spirulina platensis protein was fed through a plastic tube to five malnourished adults for periods varying from 4 to 5 days; there was a significant improvement in positive nitrogen balance and no side effects (Aritonang & Rahayu Sanusi, 2019). In another study conducted in Africa, children with protein or malnutrition were given Spirulina Platensis protein for 8 weeks; nutritional status showed a significant improvement, with the average group given Spirulina Platensis increasing their body weight by 25 g/day while the control group gained 15 g/day. g/day (Gutiérrez-Salmeán et al., 2015). These results show that Spirulina platensis influences on improving nutritional status.

It can be concluded that based on the results of the analysis of research that has been carried out, it was concluded that the nutritional status after being given Spirulina platensis (Arthrospira platensis) extract experienced significant changes compared to before being given Spirulina platensis (Arthrospira platensis) extract.

Implications and Limitations

At this stage, the research could not control external factors influencing the process. Factors that influenced nutritional status included different rest patterns for each pregnant woman and the diet consumed by pregnant women. Apart from that, providing standard care is not avoided because it has become a permanent procedure. In this study, an experiment gave spirulina platensis extract by paying attention to the standard care schedule consumed by the group. Another limitation of this research is the condition of pregnant women who cannot be met because they are working, so they look for other times to meet them.

CONCLUSION

Giving spirulina platensis extract to pregnant women can improve nutritional status in the intervention group compared to the control group. This research has a good contribution as a non-pharmacological therapy in the field of obstetrics to improve the nutritional status of pregnant women who experience chronic energy deficiency (CED). Suggestions for further research are that the results of research on the influence of Spirulina platensis (Arthrospira platensis) extract can be studied further by looking at other factors that influence the improvement of nutritional status in pregnant women who experience chronic energy deficiency (CED).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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