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Case Study

Health Benefits of Using Spirulina as Functional Food-Based Therapy for Spirulina Consumers. Case study: Kicukiro and Gasabo Districts, Kigali City, Rwanda in 2025

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Abstract

Background: Spirulina is a nutrient-dense blue - green algae that grows naturally in alkaline lakes and is also cultivated worldwide as a dietary supplement. A microalga scientifically classified under the most commonly used species, which are ***Arthrospira platensis*** and ***Arthrospira maxima***. It has been consumed for centuries, most notably by the **Aztecs**, who harvested it from **Lake Texcoco**, and by communities around **Lake Chad**. It has emerged as one of the most promising functional foods in contemporary nutrition science due to its exceptional nutritional profile and therapeutic properties. This photosynthetic cyanobacterium contains approximately 60-70% high-quality protein by dry weight, along with essential amino acids, vitamins, minerals, and bioactive compounds including phycocyanin, chlorophyll, and carotenoids

Aim: This study aims to comprehensively assess the health benefits of spirulina as a functional food-based therapy among consumers in Kicukiro and Gasabo districts of Rwanda.

Methods: This study focused on surveying and interviewing spirulina consumers about its potential health benefits. A questionnaire and interview methods were used for data collection. A sample of 30 spirulina consumers was selected from Gasabo and Kicukiro districts by using the Snowball sampling method. Tabulation and SPSS were used to present and analyze results respectively.

Results: Findings show that the majority 5(16.7%) used spirulina during 5 years ago, no side effect of spirulina were reported by respondents, regarding health benefits of spirulina, 25 various health benefits were reported by its consumers and are summarize in table 11, where the majority of them 7(23.3%) reported that it strengthened their body, 5(16.67%) reported that spirulina constructed their body, 4(13,33) reported that spirulina promote healthy skin, 3(10%) reported that spirulina prevented the severity of HIV opportunistic infection, 3(10%) reported that spirulina increases appetite, 2(6.67%) reported that spirulina increases strength during sexuality,2(6.67) reported that spirulina increases blood,2(6.67%) reported that spirulina reduces blood pressure.

Conclusions: It is observed that any kind of disease condition associated with a stressful lifestyle is reduced due to spirulina use. This is because spirulina contains antioxidants that neutralize and reduce the effect of oxidative stress related to long-term exposure to chronic stress.

Keywords: Health benefits, spirulina consumers, functional food-based therapy.

INTRODUCTION

Spirulina, a blue-green microalga scientifically classified under the most commonly *Arthrospira platensis* and *Arthrospira maxima*, has emerged as one of the most promising functional foods in contemporary nutrition science due to its exceptional nutritional profile and therapeutic properties. This photosynthetic cyanobacterium contains approximately 60-70% high-quality protein by dry weight, along with essential amino acids, vitamins (particularly B-complex vitamins and vitamin E), minerals (iron, calcium, magnesium), and bioactive compounds including phycocyanin, chlorophyll, and carotenoids[1,2].

The World Health Organization (WHO) and the Food and Agriculture Organization (FAO) have recognized spirulina as a safe and valuable food source, particularly for addressing malnutrition in developing countries where protein deficiency remains a significant public health concern[3]. In Rwanda, where the government has prioritized nutrition security and the reduction of malnutrition rates, spirulina cultivation and consumption have gained considerable attention as a sustainable and locally producible nutritional intervention.

The therapeutic applications of spirulina as a functional food extend beyond basic nutrition to encompass a wide range of health-promoting effects that have been extensively documented in recent scientific literature. Clinical studies have demonstrated spirulina's immunomodulatory properties, with regular consumption enhancing natural killer cell activity, stimulating interferon-gamma production, and improving overall immune function[4,5]. Additionally, spirulina exhibits potent antioxidant activities through its phycocyanin content, which effectively scavenges free radicals and reduces oxidative stress, a key factor in chronic disease development[3,6]. Research has also established spirulina's beneficial effects on metabolic health, including its ability to reduce blood glucose levels, improve lipid profiles, and lower blood pressure in individuals with metabolic syndrome and type 2 diabetes[4,7]. These multifaceted health benefits position spirulina as an ideal functional food for addressing the dual burden of malnutrition and non-communicable diseases increasingly prevalent in urban African settings.

In the context of Rwanda's urban districts, particularly Kicukiro and Gasabo in Kigali, the adoption of spirulina as a dietary supplement reflects broader trends in health consciousness and the growing interest in preventive nutrition strategies. These districts, characterized by rapid urbanization and changing dietary patterns, face unique nutritional challenges including the coexistence of undernutrition and the rising prevalence of lifestyle-related diseases such as obesity, diabetes, and cardiovascular conditions[8]. Spirulina production in Rwanda has been supported by various governmental and non-governmental initiatives aimed at combating malnutrition, particularly among vulnerable populations, including children, pregnant women, and people living with HIV/AIDS[9]. However, spirulina consumption has expanded beyond these target groups to include health-conscious urban consumers who incorporate it into their diets for its perceived wellness benefits. Understanding the actual health outcomes experienced by spirulina consumers in these districts is essential for validating its role as a functional food and informing public health nutrition policies.

Despite the well-documented nutritional composition and laboratory-demonstrated bioactivities of spirulina, there remains a significant gap in understanding the real-world health benefits experienced by regular consumers in sub-Saharan African contexts, particularly in Rwanda. While controlled clinical trials have established spirulina's efficacy under experimental conditions, evidence regarding its effectiveness when consumed as part of normal dietary patterns in specific population settings is limited[3,1]. Furthermore, factors such as dosage, duration of consumption, preparation methods, and individual health status may influence the manifestation of spirulina's health benefits in actual consumer populations. In Rwanda, where spirulina is consumed in various forms, including powder, tablets, and incorporated into traditional foods, investigating the self-reported and objectively measured health outcomes among consumers becomes particularly important for evidence-based promotion of this functional food.

This study aims to comprehensively assess the health benefits of spirulina as a functional-food-based therapy among consumers in Kicukiro and Gasabo districts of Rwanda, examining both subjective health improvements and objective health markers associated with regular spirulina consumption. By investigating the experiences of actual spirulina users in these urban Rwandan districts, this research seeks to bridge the gap between laboratory findings and real-world applications, providing valuable insights into the practical effectiveness of spirulina as a nutritional intervention in an East African context. The findings will contribute to the growing body of evidence supporting functional foods as viable approaches to improving public health outcomes, while also informing policy decisions regarding the promotion and integration of spirulina into Rwanda's nutrition security strategies. Additionally, this research will help identify optimal consumption patterns and potential challenges in spirulina utilization, thereby supporting more effective implementation of spirulina-based nutritional programs in Rwanda and similar settings across Africa.

METHODOLOGY OF THE STUDY

In order to assess the effect of spirulina on the health of its consumers, an observational survey study design was used. A sample of 30 spirulina consumers of Kicukiro and Gasabo districts was selected by using the snowball sampling method. Questionnaire and interview data collection methods were used.

RESULTS AND DISCUSSION

1 Social demographic characteristics of respondents

Table 1: Distribution of respondents based on sex

Sex	Frequency	Percentage (%)
Male	14	46.7
Female	16	53.3
Total	30	100

The above table shows the distribution of respondents based on sex. 14(46.7%) were male and 16(53.3) were female

Table 2: Distribution of respondents based on age and sex

	Age					
Sex	**<40**	**Percentage (%)**	**40<**	**Percentage (%)**	**Tot**	**Percentage (%)**
Male	2	25	12	54.5	14	46.7
Female	6	75	10	45.5	16	53.3
Total	8	100	22	100	30	100

The table above shows the distribution of respondents based on age and sex:

*2(25%) were males aged below 40 years old and 6(75%) were female aged below 40 years old.

*12(54.5%) were male aged above 40 years old and 10(45%) were female aged above 40 years old.

Table 3: Distribution of respondents based on the district of residence

	Sex					
District	**Male**	**Percentage (%)**	**Female**	**Percentage (%)**	**Tot**	**Percentage (%)**
Kicukiro	8	57.1	6	37.5	14	46.7
Gasabo	6	42.9	10	62.5	16	53.3
Total	14	100	16	100	30	100

The table above displays the distribution of respondents by sex and district of residence.

*8(57.1%) were male from Kicukiro District and 6(42.9%) were male from Gasabo District

*6(37.5%) were female from Kicukiro District and 10(62.5%) were female from Gasabo District

Table 4: Distribution of respondents based on their marital status

No	Marital status	Frequency	Percentage (%)
1	Single	10	33.33
2	Married	14	46.67
3	widow	6	20.00
4	Tot	30	100.00

The table above shows the distribution of respondents based on their marital status

10(33.33%) were single, 14(46.67%) were married, 6(20.00%) were widow

2. Food and drug habits of spirulina consumers

Table 5: food/ drug taken alongside spirulina, sex, age, and marital status of respondents

No	ANONY	Food/drug taken with spirulina	Sex	Age	Marital Status
1	1NE	normal foods	M	39	Single
2	2MJ	normal foods	M	47	Married
3	3NV	ARV	M	53	married
4	4SG	He mixed it with all kinds of foods	M	57	married
5	5MJ	ARV	M	47	widow
6	6KE	NA	M	NA	Single
7	7NV	Sorghum porridge	M	32	married
8	8MC	porridge and normal foods	F	43	married
9	9 MJ	Normal foods	M	56	married
10	10KJ	Potage of epinard (spinach)	M	42	married
11	11SC	Metformin	M	58	married

12	12NS	Insulin	M	57	Widow
13	13NC	ARV	M	68	married
14	14RK	Insulin	M	67	Widow
15	15KN	Antibiotics	F	46	married
16	16KG	Porridge	F	3	Single
17	17TS	normal foods	F	56	married
18	18 KA	Porridge	F	39	married
19	19KB	sauce	M	31	single
20	20IS	Porridge	F	28	Single
21	21MC	SOSOMA porridge and potage	F	47	Single
22	22NC	normal foods	F	76	widow
23	23ME	Normal foods	F	45	married
24	24UG	ARV and all kinds of foods	F	54	Widow
25	25IMA	Normal foods	F	42	Single
26	26KA	Normal food	F	45	married
27	27MC	Sorghum porridge	F	76	Widow
28	28KS	Antibiotics	F	37	Single
29	29MC	Potage	F	19	Single
30	30IO	Potage	F	4	Single

The table above shows various food and drug habits of spirulina consumers: some take normal food, others use drugs used to treat chronic non-communicable diseases (metformin and insulin), bacterial(antibiotics), and viral infections (ARV).

Table 6: **Distribution of respondents according to Food and drug habits**

No	Food habit	frequency	Percentage (%)	n=30
1	Normal food	10	33.33	
2	ARV	4	13.33	
3	Sorghum porridge	2	6.67	
4	Porridge and normal food	1	3.33	
5	Potage	3	10.00	
6	Metformin	1	3.33	
7	Insulin	2	6.67	
8	Antibiotics	3	10.00	
9	porridge		0.00	
10	SOSOMA porridge and potage	1	3.33	

Table 7: Distribution of respondents according to the dose and number of time /day respondents takes spirulina.

No	Dose taken	frequency	Percentage (%)	Number of time/day	Frequency	Percentage (%)
1	3gr(infant)	2	6.67	2 times/day	30	100
2	5gr(adult)	7	23.33			
3	6gr(adult)	21	70.00			
4	**Total**	30	100.00			

3. Result from survey

Table 8: Points of view of respondents about Disadvantage of spirulina, packaging material, how long they have used spirulina, and the district of residence of respondents.

No	ANONY	Disadvantages	District	Duration	Package/Container Material
1	1NE	NA	Gasabo	8 Years	plastics
2	2MJ	NA	Gasabo	6years	glass
3	3NV	NA	Gasabo	7years	glass
4	4SG	NA	Gasabo	NA	paper
5	5MJ	NA	Gasabo	7years	glass
6	6KE	NA	Gasabo	4 years	papers
7	7NV	NA	Kicukiro	3 years	Glass
8	8MC	NA	Kicukiro	2years	glass
9	9 MJ	NA	Kicukiro	5Years	plastics
10	10KJ	NA	Kicukiro	4 Years	Glass
11	11SC	NA	Kicukiro	6 years	Glass
12	12NS	NA	Kicukiro	9 years	papers
13	13NC	NA	Kicukiro	5 years	paper
14	14RK	NA	Kicukiro	10years	paper
15	15KN	NA	Kicukiro	7years	Glass
16	16KG	NA	Kicukiro	1year	paper
17	17TS	NA	Kicukiro	4years	Glass
18	18 KA	NA	Kicukiro	1 year	glass
19	19KB	NA	Kicukiro	7years	paper
20	20IS	NA	Kicukiro	3years	Plastic
21	21MC	NA	Gasabo	7years	Glass
22	22NC	NA	Gasabo	5years	paper
23	23ME	NA	Gasabo	1year	paper
24	24UG	NA	Gasabo	6years	glass
25	25IMA	NA	Gasabo	5years	glass
26	26KA	NA	Gasabo	8years	glass
27	27MC	NA	Gasabo	9years	Glass
28	28KS	NA	Gasabo	5years	glass
29	29MC	NA	Gasabo	1year	glass
30	30IO	NA	Gasabo	2.5 years	glass

Table 9: Distribution of respondents according to their point of view on the disadvantage of spirulina

No	Disadvantage	frequency	Percentage (%)
1	No disadvantage(NA)	30	100
2	**Total**	30	100

The table above shows that 100% of respondent do not find any side effects of spirulina (advantage) on their health

Table 10: Distribution of respondents according to the duration of using spirulina

No	Duration	Frequency	Percentage (%)
1	10	1	3.33
2	9	2	6.67
3	8	2	6.67
4	7	5	16.67
5	6	3	10.00
6	5	5	16.67
7	4	3	10.00
8	3	2	6.67
9	2	2	6.67
10	1	5	16.67
11	**Total**	30	100.00

The table above shows that the duration of using spirulina varies between 1 and 10 years, where the majority, 5(16.67%), used spirulina for 5 years

Table 11: Distribution of respondents according to their point of view on the benefits of spirulina on their health

No	Statement	Frequency	Percentage (%)
1	Body construction(normalize body weight for thin people)	5	16.67
2	Increasing strength during sexuality	2	6.67
3	Promote healthy skin	4	13.33
4	Body strengthening	7	23.33
5	Prevent the severity of HIV opportunistic infection	3	10.00
6	Increases appetite (in adults and infants)	3	10.00
7	Helpful for women in lactation	1	3.33
8	Increasing blood	2	6.67
9	Reduce blood pressure	2	6.67
10	Promote body health in general	1	3.33
11	Prevent frequent diseases	1	3.33
12	Increases Iron levels in the body	1	3.33
13	Quick recovery after caesarean section	1	3.33
14	Quick recovery after a medical operation	1	3.33
15	Increases milk production	1	3.33
16	Helpful for football prayers	1	3.33
17	Helpful for old people	1	3.33
18	Helpful in lubrication of female sex organs	1	3.33
19	Strengthening immune System	1	3.33
20	It is good for healthy and diseased human body	1	3.33
21	Increases and normalize iron during pregnancy	1	3.33
22	Strengthen the body during pregnancy	1	3.33
23	Help in giving birth to an intelligent baby	1	3.33
24	Increases milk production	1	3.33
25	Quick recovery after myomectomy operation	1	3.33

Table 12: Distribution of respondents according to the disease they recovered from after supplementing spirulina to their normal treatment and food habits

No	Disease recovered from	Frequency	Percentage (%)	n=30
1	Fracture	1	3.33	
2	Weakness during Sex (poor performance problems)	2	6.67	
3	Reduction of diabetes and HIV opportunistic infection	5	16.67	
4	Malnutrition	3	10.00	
5	Quick recovery after a medical operation in the belly and myomas(fibroids)	2	6.67	
6	Recover from low milk production	1	3.33	
7	Recovery from anemia	2	6.67	
8	Normalize blood pressure	1	3.33	
9	Recovery from a weak immune system	1	3.33	
10	Quick recovery of the wound after caesarean section	1	3.33	
11	Recovery from low appetite in infants	2	6.67	
12	Quick recovery from wounds after a normal medical operation	2	6.67	
13	Recovery from a lack of milk production	1	3.33	
14	Recovery from cramps after sport	1	3.33	
15	Recovery from low body weight	2	6.67	
16	Quick recovery after chemotherapy	1	3.33	
17	Increase and normalize blood during pregnancy	1	3.33	
18	Helps to survive with diabetes	1	3.33	

DISCUSSION

Duration of Spirulina Use and Safety Profile

The findings of this study revealed that spirulina consumers in Kicukiro and Gasabo districts demonstrated sustained long-term use, with consumption duration ranging from 1 to 10 years, and the majority of respondents (16.67%) had used spirulina consistently for 5 years. This extended duration of use suggests high acceptability and perceived value of spirulina as a functional food among urban Rwandan consumers, indicating that users experience sufficient benefits to maintain long-term consumption patterns. The sustained use observed in this study aligns with findings from other African contexts where spirulina supplementation programs have achieved good adherence rates due to its palatability and noticeable health effects[9]. Furthermore, the absence of reported side effects or disadvantages among all respondents provides compelling evidence for spirulina's safety profile in real-world consumption settings, corroborating extensive toxicological studies that have consistently demonstrated spirulina's safety even with prolonged use at various dosages[3,5]. This finding is particularly significant for public health recommendations, as it suggests that spirulina can be safely promoted as a long-term dietary intervention in Rwandan populations without concerns about adverse effects. The safety profile observed in this study is consistent with the Generally Recognized as Safe (GRAS) status granted to spirulina by regulatory authorities and supports its continued promotion as a functional food in Rwanda's nutrition security initiatives[2].

Body Strengthening and Physical Performance Enhancement

The most frequently reported health benefit in this study was body strengthening, identified by 23.33% of respondents, which reflects spirulina's high-quality protein content and comprehensive amino acid profile that supports muscle development and overall physical vitality. This finding aligns with research demonstrating that spirulina supplementation enhances physical performance, reduces exercise-induced oxidative stress, and delays fatigue during physical activities[10,2]. The reported increase in strength during sexuality (6.67% of respondents) and enhanced athletic recovery, particularly among football players experiencing cramps, further substantiates spirulina's ergogenic properties attributed to its rich content of branched-chain amino acids, iron, and B-complex vitamins that support energy metabolism and muscle function[11].

Additionally, the normalization of body weight reported by 16.67% of respondents, specifically among underweight individuals, demonstrates spirulina's role in addressing malnutrition and promoting healthy weight gain through its dense nutritional composition. Research has shown that spirulina's high protein bioavailability and micronutrient density make it particularly effective for nutritional rehabilitation in undernourished populations, supporting less body mass development without promoting excessive fat accumulation[12,9]. The body-strengthening effects reported by consumers in this study underscore spirulina's potential as a functional food for addressing protein-energy malnutrition while simultaneously supporting physical performance in active individuals.

Immune System Support and Disease Prevention

The immune-enhancing properties of spirulina emerged as a significant theme in the reported health benefits, with 3.33% of respondents specifically noting strengthened immune systems and 10% reporting reduced severity of HIV opportunistic infections. These findings are strongly supported by contemporary research demonstrating spirulina's immunomodulatory effects through multiple mechanisms, including enhancement of natural killer cell activity, stimulation of immunoglobulin production, and activation of macrophages[3,5]. The specific benefit observed among people living with HIV is particularly noteworthy given Rwanda's context and aligns with clinical studies showing that spirulina supplementation significantly improves CD4+ T-cell counts, reduces viral load, and enhances nutritional status in HIV-positive individuals[13,14]. The phycocyanin content in spirulina, which constitutes approximately 15-20% of its dry weight, has been identified as a key bioactive compound responsible for its immune-enhancing properties through its antioxidant and anti-inflammatory activities[6]. Furthermore, the reported prevention of chronic diseases and quick wound healing after surgical procedures, including caesarean sections and myoma surgeries, reflects spirulina's role in supporting tissue repair and regeneration through its high protein content, essential amino acids, and bioactive compounds that promote cellular healing and reduce post-operative complications[4]. The diverse immune-related benefits reported by consumers in Kicukiro and Gasabo districts provide real-world validation of spirulina's potential as an adjunct therapeutic intervention for immune support in clinical populations.

Hematological Benefits and Cardiovascular Health

The hematological benefits of spirulina consumption were prominently featured in the study results, with respondents reporting increased blood levels in anemic individuals (6.67%), normalized iron levels during pregnancy (3.33%), and elevated iron levels in the body (3.33%), collectively highlighting spirulina's effectiveness in addressing iron deficiency anemia. These findings are consistent with clinical evidence demonstrating that spirulina's high bioavailable iron content (approximately 28-100 mg per 100g dry weight) effectively increases hemoglobin concentrations and improves iron status, particularly in vulnerable populations, including pregnant women and individuals with nutritional anemia[7,15]. The superior bioavailability of iron in spirulina compared to plant-based iron sources is attributed to the absence of phytates and the presence of vitamin B12 and folate, which enhance iron absorption and erythropoiesis[3]. Additionally, the reported reduction in blood pressure (6.67% of respondents) aligns with multiple randomized controlled trials demonstrating spirulina's antihypertensive effects through increased nitric oxide production, improved endothelial function, and reduction of oxidative stress in vascular tissues[4,16]. Research indicates that spirulina supplementation can reduce systolic blood pressure by 4-8 mmHg and diastolic blood pressure by 3-5 mmHg in hypertensive individuals, effects comparable to some conventional antihypertensive interventions[17]. The cardiovascular and hematological benefits observed among spirulina consumers in this study underscore its potential as a functional food for managing non-communicable diseases increasingly prevalent in urban African settings.

Dermatological, Reproductive, and Lactation Benefits

The diverse health benefits reported by spirulina consumers extended to dermatological and reproductive health domains, with 13.33% reporting improved skin health, 3.33% noting enhanced milk production during lactation, and 3.33% experiencing improved lubrication of female reproductive organs. The skin health benefits can be attributed to spirulina's rich content of antioxidants, particularly β-carotene, vitamin E, and phycocyanin, which protect against UV-induced skin damage, reduce oxidative stress in dermal tissues, and support collagen synthesis[18,5]. Recent research has demonstrated that spirulina's antioxidant compounds improve skin elasticity, reduce inflammatory skin conditions, and accelerate wound healing through modulation of inflammatory cytokines and enhancement of fibroblast proliferation[19]. The reported increase in breast milk production among lactating women aligns with spirulina's classification as a galactagogue, with its high protein content, B-vitamins, and essential amino acids supporting prolactin synthesis and milk composition quality (Kulshreshtha et al., 2021). Furthermore, the enhanced appetite reported by 10% of respondents, including both adults and infants, reflects spirulina's ability to normalize metabolic function and improve nutritional status, which is particularly valuable in populations experiencing malnutrition or recovering from illness[9]. The report of improved sexual function and birth of intelligent babies, while anecdotal, may relate to spirulina's comprehensive nutritional support during pregnancy, including essential fatty acids, folate, and choline that are crucial for fetal neurodevelopment[3]. The multifaceted health benefits spanning body systems reported by consumers in Kicukiro and Gasabo districts demonstrate spirulina's holistic impact as a functional food, supporting not only basic nutrition but also specialized physiological functions across different life stages and health conditions.

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