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Research Paper

Downstreaming of Spirulina Derivative Products and Their Role in Reducing Stunting Incidence in the Special Region of Yogyakarta

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Received : September 15, 2025	Revised : September 18, 2025	Accepted : September 20, 2025	Online : October 15, 2025

Abstract
Spirulina is a type of blue-green algae that is high in protein, making it a useful agricultural food product that can help overcome and reduce stunting. This study aims to (1) describe spirulina products and their derivatives and (2) analyze the added value of various spirulina products in micro, small, and medium enterprises (MSMEs) producing spirulina downstream products in the Special Region of Yogyakarta. The study employs a descriptive approach and utilizes a case study method. Respondents were selected using purposive sampling, specifically MSME owners who produce spirulina-based products. Data collection methods included observation, interviews, and documentation. The data used were both primary and secondary. Data analysis techniques included Sales Volume Analysis and Value-Added Analysis using the Hayami method. The research results indicate that (1) Spirulina SMEs in Yogyakarta are still limited to spirulina capsules and spirulina cheese, and (2) spirulina capsules provide greater value added than spirulina cheese. The recommendations based on the research results can serve as guidance for policymakers, highlighting that spirulina has a high protein content that can help reduce stunting in the Special Region of Yogyakarta.

Keywords *Spirulina, Downstreaming, Added Value, Stunting*

INTRODUCTION

Stunting is a condition of growth failure that occurs in children due to chronic malnutrition over a prolonged period, characterized by a height that is lower than the standard for their age (Sajidan et al., 2024). In Indonesia, stunting remains a serious issue, particularly in the Special Region of Yogyakarta (DIY), as it has the potential to reduce human resource quality. The effects of stunting also impact cognitive development and future individual productivity. Therefore, efforts to prevent and address stunting are a priority in improving public health quality.

One way to address the issue of stunting is by improving access to nutrient-rich foods, particularly those high in protein. Spirulina is a blue-green algae with a high protein content and has the potential to serve as a functional food ingredient that can support improvements in community nutrition status. Spirulina also contains various vitamins, minerals, and antioxidants that play a role in maintaining overall health and enhancing the body's resistance to disease (Sajidan et al., 2024). The protein content of spirulina, which reaches 70%, has the potential to be an innovative solution to address nutritional issues, particularly as an alternative approach to addressing stunting.

A study by Kashyap et al. (2022) in Tumkur, India, reported that over 9 months, consuming

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spirulina in the form of snack bars had a positive impact on improving children's nutritional status, increasing it from 72% to 91%, and reducing the stunting rate from 21.9% to 20.7%. Barennes et al. (2022) recommended that the administration of spirulina can be used to improve childhood anemia. An analysis of the daily dose (2 g) given to 179 children in Cambodia revealed a tendency to improve weight gain in the group receiving spirulina-based processed food, which was very close to significance; however, no trend was observed in height. The study by Sajidan et al. (2024) concluded that providing spirulina-based supplementary foods could be an effective strategy for preventing stunting and improving the nutritional status of infants in Indonesia. There is extensive evidence of the benefits of spirulina as a superfood for preventing stunting in processed foods and the downstream production of various products.

All these products are primarily produced by micro, small, and medium enterprises (MSMEs) in Indonesia. MSMEs play a strategic role in supporting the production and distribution of Spirulina-based downstream products. MSMEs' ability to adapt to local innovations with flexibility, creativity, and speed presents an opportunity for the downstream processing of spirulina and its derivatives, enabling the production of functional foods that not only enhance nutritional intake but also open up broader market opportunities. Analyzing the value added of spirulina-based products is a crucial aspect that needs to be examined to understand the contribution of each product type to the economy. Through this analysis, businesses can identify more effective strategies to improve production efficiency, optimize supply chains, and develop more diverse product innovations. By adopting a systematic and data-driven approach, spirulina processing can further develop, maximizing benefits for public health and driving local economic growth.

LITERATURE REVIEW

Studies on agricultural products as food security buffers that contribute to reducing stunting rates and improving community welfare are still minimal and have not been comprehensively integrated. Most previous studies only discuss nutritional or production aspects partially, without directly linking the downstreaming of local products, economic added value, and their impact on food security and community welfare. A study by Rahmawati (2022) shows that spirulina has the potential as a functional food with high nutritional content, while a report by BRIN (2024) highlights the opportunity to develop processed spirulina products, such as capsules and cheese, as alternative nutritional interventions. However, there has been no integrated approach that simultaneously examines economic, social, and nutritional aspects in the context of the Special Region of Yogyakarta (DIY).

Value added is a crucial indicator in evaluating the production efficiency and economic potential of a product. Based on the concept proposed by Tarigan (2005), value added is defined as the difference between the selling price of the final product and the total cost of raw materials and auxiliary materials used during the production process. This concept not only reflects the effectiveness of the production process but also illustrates the contribution of the industrial sector to increasing local community income. If income distribution is evenly distributed, high added value can be a strategic instrument in poverty alleviation and welfare improvement (Yuliana & Prasetyo, 2021; Bappenas, 2022).

In the food industry, added value can be generated through various stages of processing, both physically and chemically. A study by Suryani et al. (2023) shows that packaging and processing raw materials into ready-to-consume products can significantly increase their selling value. Meanwhile, Sari and Nugroho (2020) emphasize that chemical transformations such as fermentation and nutritional fortification can improve product quality while expanding market segments. Reports from the OECD (2021) and FAO (2022) also confirm that diversifying local agriculture-based products is an important strategy in strengthening food security and regional competitiveness.

High added value not only has an impact on economic aspects but also influences consumer behavior. Consumers are willing to pay more for products that offer clear quality, safety, and health benefits. This opens up opportunities for MSMEs to access broader markets, both domestically and internationally, and strengthens the local economic structure. This strategy aligns with the community-based nutrition intervention approach outlined in documents from UNICEF Indonesia (2022) and the Indonesian Ministry of Health (2023), which emphasize the importance of utilizing local resources in preventing stunting.

The value-added analysis framework developed by Hayami et al. (1987) includes three main components, namely form utility, place utility, and time utility. These three components contribute to increasing the value of a product and become a source of economic benefits for labor, capital, and production management. Quantitative studies by Setyawan et al. (2024) and Rogna (2024) show that value-added analysis can be conducted through an approach that considers production data, selling prices, input costs, and labor contributions. The results of this analysis can serve as a basis for strategic decision-making, whether in product development, marketing planning, or policy formulation, to support improving community welfare through the optimization of local potential.

Thus, the value-added approach is not only relevant in the context of production efficiency but also has broad implications for regional economic development, stunting eradication, and SME empowerment. This research is expected to make a tangible contribution to designing a sustainable local product downstreaming model that directly impacts community welfare in the DIY region.

RESEARCH METHOD

The research was conducted at MSMEs producing spirulina products in the Special Region of Yogyakarta (DIY). Respondents were selected using purposive sampling, namely, MSME owners who have spirulina derivative products. Data collection methods included observation, interviews, and documentation. The data used were both primary and secondary. Data analysis techniques included Sales Volume Analysis and Value-Added Analysis, using the Hayami et al. (1987) method, as shown in Table 1.

Table 1. Analysis of Added Value Using the Hayami Method

No	Variable	
	Output, Input, and Price	
(1)	Production Output	(1)
(2)	Raw Materials/Input	(2)
(3)	Labor	(3)
(4)	Conversion Factor	(4)= (1)/(2)
(5)	Labor Coefficient	(5)= (3)/(4)
(6)	Product Price	(6)
(7)	Average Labor Wage	(7)
Revenue and Profit		
(8)	Raw Material Price	(8)
(9)	Other Input Contributions	(9)
(10)	Output Value (Product)	(10)=(4)x(6)
(11)	a. Value Added	(11a)= (10)-(8)-(9)
	b. Value Added Ratio	(11b)= (11)/ (10) x 100%

Source: Hayami et al. (1987)

The calculation of added value in Table 1, according to Hayami et al. (1987), shows the variables used to calculate added value, as explained below:

1. Output is the product produced after processing raw materials into processed products.
2. Raw materials/inputs are the primary materials processed in the production process, accounting for a larger percentage than other materials in the production process.
3. Labor refers to employees who directly perform processing work to produce processed products.
4. The conversion factor is the ratio between output and input, indicating the amount of product that can be produced from one unit of raw material.
5. The labor coefficient indicates the amount of direct labor required to process one unit of raw material used.
6. Product price is the financial value considered by business operators for the product resulting from the production process, as presented to buyers.
7. Raw material price is the financial value received by business operators from purchases, which influences the magnitude of value added.
8. Other input contributions are costs incurred in addition to raw materials and direct labor costs to process one unit of raw material.
9. Output value (product) indicates the value of production per kilogram from processing one kilogram of raw material in each production process.

FINDINGS AND DISCUSSION

Spirulina Products and Their Derivatives

Spirulina downstream products developed by MSMEs in the Special Region of Yogyakarta, namely spirulina capsules and spirulina cheese, demonstrate an innovative approach to utilizing local resources for community nutrition and health purposes. The production process for spirulina capsules begins with the cultivation of high-quality spirulina, followed by drying and extraction to preserve key nutrients, including protein, vitamins, minerals, and antioxidants. The resulting spirulina powder is then formulated with safe excipients that have undergone quality testing and packaged using halal gelatin or plant-based alternatives. This product meets physical, chemical, and organoleptic standards, making it a practical supplement with consistent nutritional doses.

Spirulina cheese, on the other hand, is a downstream product that combines spirulina into a cheese matrix through fermentation or curd formation. The addition of spirulina not only increases the nutritional content of the cheese but also gives it an attractive natural green color. This product targets consumers who want functional foods with familiar flavors, and research continues to maintain its taste, texture, and health benefits. Both products have great potential in supporting stunting prevention efforts in DIY, primarily since spirulina is known as a nutrient-dense food source. The complete protein, vitamin B12, iron, and antioxidant content in spirulina are highly relevant for supporting child growth and maternal health, two groups most vulnerable to stunting. A study by Setyawan et al. (2024) shows that locally produced agricultural products, when processed into functional foods, can directly contribute to improving the nutritional status of the community. Meanwhile, Rogna (2024) emphasizes that local food-based interventions have a significant impact on reducing the prevalence of stunting, especially if the products are easily accessible and accepted by the community.

The role of MSMEs in the development of spirulina capsules and spirulina cheese is not only limited to production but also includes distribution, consumer education, and improving product accessibility. The practical capsule and innovative cheese products enable wider market penetration, including in areas with limited access to high-nutrient products. This aligns with the national strategy to accelerate stunting prevention, which emphasizes the importance of community-based interventions and the utilization of local resources (Indonesian Ministry of Health, 2023; UNICEF Indonesia, 2022).

Considering the production process that meets quality standards, the nutritional content relevant to stunting prevention, and the active role of MSMEs in downstreaming and distribution, spirulina capsules and spirulina cheese can be categorized as strategic products in supporting the nutritional security of the DIY community. This study is expected to strengthen the evidence that the downstreaming of local spirulina-based products is an approach that is not only economically sustainable but also has a direct impact on public health.

Added Value of Various Spirulina Products in Micro, Small, and Medium Enterprises (MSMEs) Producing Downstream Spirulina Products

There are two types of downstream products produced by spirulina producers in Yogyakarta: spirulina capsules and spirulina cheese, from two different producers. PT XYZ produces Spirulina capsules in Kulon Progo, while spirulina cheese is produced by PT ABC in Sleman Regency.

For spirulina capsules, 13.5 kilograms of spirulina are processed per production cycle, whereas for spirulina cheese, 12 kilograms of spirulina are required per production cycle. The production period for spirulina capsules begins with spirulina cultivation for 3 months, followed by processing into capsules. The production of spirulina capsules yields 13,500 capsules, while the production of spirulina cheese yields 12 Kg/production cycle. The raw material cost for spirulina production is Rp 5,850,000/Kg, while the price for spirulina cheese production is Rp 2,100,000/Kg. The conversion factor for spirulina capsules is 1.5, while it is 0.1 for spirulina cheese production. The spirulina cheese produced is a soft cheese known as Hallumi spirulina cheese.

Table 2. Added Value of Downstream Spirulina Capsule Products at PT XYZ Yogyakarta

	Variable	Unit	Spirulina Capsules
I.	Output, Input, and Price		
1.	Product Output	Kg/production process	13.5 (13,500 Capsules)
2.	Raw Material Input		
	Spirulina Starter Culture	Kg/production process	9
3.	Labor Input	HOK/production process	3
4.	Conversion Factor		13.5 Kg output/9 Kg raw material = 1.5
5.	Labor Coefficient		3 HOK/9 K raw material = 0.3
6.	Output Price	Rp/Kg	3.900.000
7.	Average Labor Wages	Rp/production process	150,000
II.	Revenue and Profit		
8.	Raw Material Input Price	Rp/Kg	75.000
9.	Other Input Contributions		
	Capsules	Rp/Kg	500.000
	Capsule bottles	Rp/Kg	200.000
	Cardboard boxes	Rp/Kg	200.000
10.	Output Value	Rp/Kg	5.850.000
11.	Value Added	Rp/Kg	4.875.000

	Variable	Unit	Spirulina Capsules
	Value Added Ratio	%	83,33
12.	Labor Income	Rp/Kg	45.000
	Labor Share	%	0,92
13.	Profit	Rp/Kg	4.830.000
	Profit Margin	%	99,08
III.	Remuneration for Production Factors		
14.	Margin	Rp/Kg	5.775.000
	Labor Income	%	0,78
	Contribution of Other Inputs	%	15,58
	Entrepreneur Profit	%	83,64

Source: Primary Data Analysis (2025)

Table 3. Added Value of Downstream Spirulina Cheese Products of PT ABC Yogyakarta

	Variable	Unit	Spirulina Cheese
I.	Output, Input, and Price		
1.	Product Output	Kg/production process	12
2.	Raw Material Input		
	Pure Cow's Milk	Kg/production process	120
3.	Labor Input	HOK/production process	2
4.	Conversion Factor		12 kg/ 120 kg Pure Milk raw material = 0.1
5.	Labor Coefficient		2 HOK/120 Kg raw material = 0.016
6.	Output Price	Rp/Kg	420.000
7.	Average Labor Wage	Rp/production process	100.000
II.	Revenue and Profit		
8.	Raw Material Input Price	Rp/Kg	75.000
9.	Other Input Contributions	Rp/Kg	20.000
	Spirulina powder	Rp/Kg	5000
	Rennet	Rp/Kg	7.000
	Salt	Rp/Kg	420.000
	Starter culture	Rp/Kg	313.000
10.	Output Value	%	74,52
11.	Added Value	Rp/Kg	100.000
	Value Added Ratio	%	0,23
12.	Labor Income	Rp/Kg	107.000
	Labor Share	%	25,47
13.	Profit	Rp/Kg	75.000
	Profit Margin	Rp/Kg	20.000
III.	Remuneration for Production Factors		
14.	Margin	Rp/Kg	107.000
	Labor Income	%	23,80
	Contribution of Other Inputs	%	25,47

Variable	Unit	Spirulina Capsules
Entrepreneur Profit	%	74,52

Source: Primary Data Analysis (2025)

Calculation of all labor directly involved in the spirulina processing production process. The number of man-days (MD) in spirulina capsules is greater than in spirulina cheese. Labor input in spirulina capsule production begins with spirulina cultivation in production ponds, where the spirulina is processed into capsules at a rate of 13.5 Kg per production cycle. For spirulina cheese, the HOK per production process is 12 Kg. The labor coefficient is the ratio between labor and raw materials used. In Tables 2 and 3, the labor coefficient for spirulina cheese is 0.016, and for spirulina capsules is 0.3.

Labor costs in spirulina processing are the same for both DIY and commercial processing, amounting to Rp 100,000/HOK. Other input contributions include auxiliary materials, electricity, equipment depreciation, and additional costs. For spirulina capsules, other input contributions amount to Rp 900,000/Kg, while for spirulina cheese, they amount to Rp 112,000/Kg. The output value for spirulina capsules is Rp 5,850,000/Kg. For spirulina cheese, the price is Rp 420,000/Kg. The highest value added is for spirulina capsules, amounting to Rp 4,875,000/Kg. From the value-added calculation, the value-added ratio can be obtained by dividing the value added by the output value. The value-added ratio is the percentage of value-added relative to output value. The value-added ratio for spirulina capsules is 83.33%, while for spirulina cheese, it is Rp 313,000/kg, with a value-added ratio of 74.52%. The value-added in each spirulina processing stage varies due to differences in input value and contributions from other inputs. The results of the Hayami calculation model indicate that the value added in spirulina capsules is greater than that in spirulina cheese produced by entrepreneurs in a DIY setting.

However, added value is not the only indicator of downstreaming success. Spirulina's nutritional content, which includes complete protein, vitamin B12, iron, and antioxidants, makes it highly relevant for nutritional interventions, particularly in the prevention of stunting. Practical capsule products and innovative cheese can reach vulnerable groups such as children and pregnant women. Rogna (2024) emphasizes that highly nutritious local food inputs can contribute significantly to reducing the prevalence of stunting. Setyawan et al. (2024) also show that local processed products, such as spirulina, have great potential in community-based nutritional interventions.

The downstream processing of spirulina products in the Special Region of Yogyakarta can be utilized as one of the solutions for stunting in DIY, which remains at 14% as of 2025. The production of spirulina cheese and spirulina capsules, cultivated by local farmers and produced by micro, small, and medium enterprises in DIY, not only improves community welfare but also brings several benefits to the community, including:

a. Improving Accessibility: Downstreaming spirulina products can make them more accessible to the public, especially in remote areas or areas with limited access to health and nutrition products.
b. Improving Quality of Life: By improving the accessibility of spirulina products, downstreaming can help improve the quality of life of the community, especially children and pregnant women, who are vulnerable to stunting.
c. Reducing the Risk of Stunting: Spirulina is rich in nutrients essential for children's growth and development, so downstreaming this product can help reduce the risk of stunting in children.
d. Boosting the Local Economy: Downstreaming spirulina products can also help boost the local economy by creating jobs and increasing community income.

Downstreaming spirulina products can be a strategic approach to addressing the issue of stunting and enhancing the quality of life for communities. The products are not only available in urban markets, but also reach areas with limited access to high-nutrition products. This aligns with the national strategy to accelerate stunting prevention, which emphasizes the importance of utilizing local resources and community participation (Indonesian Ministry of Health, 2023; UNICEF Indonesia, 2022). Considering the added value, production efficiency, and nutritional content data, it can be concluded that the downstreaming of spirulina by MSMEs in DIY is a sustainable strategic approach. Spirulina capsules and spirulina cheese are not only food innovations, but also instruments of nutrition and local economic development that support each other.

CONCLUSIONS

1. The downstreaming of spirulina products in the Special Region of Yogyakarta (DIY) has been carried out by micro, small, and medium enterprises (MSMEs) in the form of spirulina capsules and spirulina cheese. Although this study focuses on two production units, namely PT XYZ and PT ABC, the findings reflect the potential of local MSMEs in processing spirulina raw materials into high-value-added products that are worthy of further development.
2. Based on value-added analysis, spirulina capsules show higher production efficiency and profit margins than spirulina cheese. The value-added ratio of spirulina capsules reaches 83.33%, while spirulina cheese only reaches 0.23%. This difference shows that product form, processing strategies, and input contributions greatly affect the economic potential of spirulina downstreaming by MSMEs.
3. The nutritional content of spirulina, which includes complete protein, vitamin B12, iron, and antioxidants, makes it relevant for nutritional interventions, particularly in the prevention of stunting. Spirulina products produced by MSMEs not only improve the economic welfare of the community but also contribute directly to improving the nutritional status of children and pregnant women, especially in areas with a high prevalence of stunting.

REFERENCES

Azhar, M. F., & Puspitaningrum, D. A. (2024). Analisis Keuntungan Usaha Budidaya Spirulina di PT Munda Green Energy. *Mimbar Agribisnis: Jurnal Pemikiran Masyarakat Ilmiah Berwawasan Agribisnis, 10*(2), 3413-3425. http://dx.doi.org/10.25157/ma.v10i2.14844

Bappenas. (2022). *Kajian Ketahanan Pangan dan Gizi di Indonesia.* Jakarta: Kementerian PPN/Bappenas. https://www.bappenas.go.id.

Barennes, H., Houdart, L., & Narennes, F. (2022) "Spirulina as Daily Nutritional Supplement of Young Pre-School Cambodian Children of Deprived Setting: A Single-Blinded, Placebo-Controlled, Cross-Over Trial." *BMC Pediatrics, 5*(1), 1-12. https://doi.org/10.1186/s12887-022-03766-5

BRIN. (2024). *Inovasi Produk Pangan Lokal untuk Pencegahan Stunting*. Badan Riset dan Inovasi Nasional. https://www.brin.go.id

FAO. (2022). *The State of Food Security and Nutrition in the World 2022*. Food and Agriculture Organization of the United Nations. https://www.fao.org/publications/sofi

Hayami, Y., Kawagoe, T., Morooka, Y., & Siregar, M. (1987). *Agricultural Marketing and Processing in Upland Java a Perspective from a Sunda Village.* Bogor: CPGRT Centre.

Kashyap, G. C., Sarala, R., & Manjunath, U. (2022). Impact of Spirulina Chikki supplementation on nutritional status of children: An intervention study in Tumkur District of Karnataka, India. *Frontiers in Pediatrics*, *10*, 860789. https://doi.org/10.3389/fped.2022.860789

Kementerian Kesehatan Republik Indonesia. (2023). *Strategi Nasional Percepatan Pencegahan*

Stunting. Jakarta: Kemenkes RI. https://www.stunting.go.id

OECD. (2021). *Food Systems and Nutrition: Building Resilience*. Organisation for Economic Co-operation and Development. https://doi.org/10.1787/6fcb7d7c-en

Rahmawati, T. (2022). Spirulina as Functional Food: Nutritional and Economic Potential. *Indonesian Journal of Food Technology*, *7*(3), 101–110. https://doi.org/10.17728/ijft.2022.7.3.101

Rogna, M. (2024). The Contribution of Agricultural Inputs in Reducing Child Stunting. *Agriculture & Food Security*, *13*(49). https://doi.org/10.1186/s40066-024-00349-2

Sajidan, I. R. W., Atmojo, Suranto, & Sutarno. (2024). Pelatihan pengolahan potensi alam spirulina sebagai pemberian makanan tambahan dalam upaya pencegahan stunting di Desa Bakipandeyan Sukoharjo. *Social, Humanities, and Education Studies (SHEs), 7*(3), 1635–1644. https://doi.org/10.20961/shes.v7i3.86451

Sari, M., & Nugroho, A. (2020). Analisis Nilai Tambah Produk Olahan Ikan di Pesisir Yogyakarta. *Jurnal Perikanan dan Kelautan*, 12(1), 33–42.

Setyawan, N., Prasetyo, D., & Lestari, R. (2024). Various agricultural products and their nutrition in relation to stunting prevention. *AIP Conference Proceedings*, *2957*(1), 060059. https://doi.org/10.1063/5.020059

Suryani, D., Hidayat, M., & Wulandari, S. (2023). Value-Added Analysis of Local Food Products in East Java. *Journal of Agribusiness Innovation*, *5*(2), 45–58.

Tarigan, R. (2005). *Ekonomi Regional-Teori dan Aplikasi Edisi Revisi*. Jakarta Timur: Bumi Aksara.

UNICEF Indonesia. (2022). *Nutrition and Stunting Prevention Strategy*. Jakarta: United Nations Children's Fund. https://www.unicef.org/indonesia/id

Yuliana, R., & Prasetyo, B. (2021). Peran UMKM dalam Penguatan Ketahanan Pangan Lokal. *Jurnal Ekonomi dan Pembangunan Daerah*, *10*(1), 12–25. https://jurnal.uns.ac.id/jepda

World Health Organization. (2021). *Levels and Trends in Child Malnutrition*. Geneva: World Health Organization. https://www.who.int/publications/i/item/9789240025257