Amerta Nutrition
e-ISSN: 2580-1163 (Online)
p-ISSN: 2580-9776 (Print)
Rahma et al. | Amerta Nutrition Vol. 9 Issue 2 (June 2025). 310-318

RESEARCH STUDY
English Version

OPEN ACCESS

Glycemic Index and Organoleptic Test of Gluten-Free Chips Made from Composite Flour Enriched with *Spirulina Platensis*

Uji Indeks Glikemik dan Organoleptik Keripik Berbahan Komposit Tepung Bebas Gluten yang Diperkaya Spirulina Platensis

Amalia Rahma[1]*, Dwi Novri Supriatiningrum[1], Sutrisno Adi Prayitno[2], Endah Mulyani[1], Eka Srirahayu Ariestiningsih[1]

[1]Program Studi Ilmu Gizi, Universitas Muhammadiyah Gresik, Gresik, Indonesia
[2]Program Studi Teknologi Pangan, Universitas Muhammadiyah Gresik, Gresik, Indonesia

ARTICLE INFO

Received: *18-09-2024*
Accepted: *05-02-2025*
Published online: *20-06-2025*

****Correspondent:***
Amalia Rahma
amaliarahma@umg.ac.id

DOI:
10.20473/amnt.v9i2.2025.310-318

Available online at:
https://e-journal.unair.ac.id/AMNT

Keywords:
Glycemic Index, Organoleptic, Composite Flour, Gluten-Free, Spirulina sp.

ABSTRACT

Background: The World Health Organization (WHO) recommends consuming low glycemic index (GI) foods to manage blood glucose. The GI value of foods is influenced by the ratio of amylose to amylopectin and also the addition of bioactive compounds. Spirulina platensis is a type of microalgae rich in bioactive compounds, including phenolic acids and volatile compounds.
Objectives: This study aimed to evaluate the glycemic index (GI) levels and organoleptic properties of chips made from gluten-free composite flour enriched with Spirulina sp.
Methods: The research design was experimental. Three formulations were tested: A413 (mocaf: 30%; cornstarch: 20%; corn grits: 20%; tapioca: 30%), A531 (mocaf: 30%; cornstarch: 20%; corn grits: 10%; tapioca: 40%), A249 (mocaf: 30%; cornstarch: 10%; corn grits: 20%; tapioca: 40%). The GI testing involved 10 respondents who met the following criteria: normal BMI, aged 20-40 years, drug-free, non-smoking, non-drinking, no history of chronic diseases, not pregnant or breastfeeding. The GI value was calculated based on the area under the curve (AUC) of blood glucose measurement before and after consuming the standard and test food at 0, 30, 60, 90 and 120 minutes. Organoleptic testing was conducted using a hedonic test with 35 semi-trained panelists.
Results: Formula A531 had the lowest GI value (GI = 28) among the three formulations. There was no significant difference in scent and flavor between the three formulations. However, formula A531 was the most preferred in terms of texture (p-value = 0.029) and crispiness (p-value = 0.050) compared to the other formulations.
Conclusions: Gluten-free chips enriched with Spirulina sp. (Formula A531) can serve as a healthy, low-glycemic-index snack alternative that is acceptable to consumers.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic disease caused by decreased insulin sensitivity or insufficient insulin production, characterized by elevated blood glucose levels. According to the RISKESDAS (2018) report, 2% of Indonesians aged over 15 years were diagnosed with Type 2 of Diabetes Mellitus (T2DM) by a doctor. This figure reflects a 0.5% increase in the prevalence of T2DM compared to the RISKESDAS (2013) report, which recorded a prevalence of 1.5%. The prevalence of T2DM, based on blood glucose levels, also increased from 6.9% in 2013 to 8.5% in 2018. This indicates that only about 25% of individuals with T2DM are aware of their condition[4].

The International Diabetes Federation (IDF) estimated that approximately 463 million people aged 20–79 worldwide was living with Diabetes Mellitus (DM) in 2019. According to gender, The International Diabetes Federation estimates that the prevalence of DM is higher in men (9.65%) than in women (9%). The number of individuals with DM is projected to increase, reaching 578 million by 2030 and 700 million by 2045[5].

Unhealthy dietary habits and lifestyles are the leading causes of the rising prevalence of DM patients[6]. One example of an unhealthy lifestyle is the habit of consuming snacks, such as chips, during activities like social gatherings, watching TV, or as accompaniments to tea or coffee[7]. Chips often have low nutritional value and are high in calories and sodium, which can contribute to excessive body fat accumulation—a major risk factor for the development of T2DM[8].

Gluten intake is closely associated with carbohydrate consumption, particularly from processed grains, starches, and cereals, which are commonly used as primary ingredients in snacks such as chips[9]. For individuals sensitive to gluten, consuming it can trigger inflammation, potentially exacerbating metabolic conditions and contributing to insulin resistance, thereby increasing the risk of T2DM[10]. Research indicates that gluten consumption is associated with autoimmune

How to cite: *Rahma, A., Supriatiningrum, D. N., Prayitno, S. A., Mulyani, E., & Ariestiningsih, E. S. (2025) Glycemic Index and Organoleptic Test of Gluten-Free Chips Made from Composite Flour Enriched with Spirulina Platensis: Uji Indeks Glikemik dan Organoleptik Keripik Berbahan Komposit Tepung Bebas Gluten yang Diperkaya Spirulina Platensis. Amerta Nutrition, 9(2), 310–318.*

responses that affect pancreatic β-cells, which are responsible for insulin production. This disruption can impair metabolism and glucose regulation, leading to uncontrolled blood sugar levels[11]. Consuming low-glycemic-index (GI) foods is an effective non-pharmacological approach to controlling blood glucose levels[12]. Such foods have been shown to significantly reduce fructosamine levels in patients with DM[13]. Fructosamine, a stable ketoamine formed by the non-enzymatic reaction between glucose and amino acids, is commonly used as a biological marker for monitoring blood glucose control. Consuming low-GI foods effectively supports blood glucose regulation[13]. The World Health Organization (WHO) recommends consuming low-GI foods to improve blood sugar control while maintaining appropriate carbohydrate intake[6]. Additionally, avoiding gluten-containing foods can help reduce inflammation and prevent spikes in blood glucose levels[8].

The glycemic index (GI) of food is influenced by various factors, including the characteristics of the ingredients, particle size/surface area, ingredients types, and processing methods[14]. The polysaccharide content, particularly amylose, in food contributes to a lower GI value[15]. Another factor influencing the GI of foods is the presence of bioactive components, such as polyphenols. Digestive enzymes typically break down complex starch bonds through hydrolysis. However, the formation of complexes between starch and polyphenols inhibits these enzymes, preventing the starch from being broken down into simpler forms like glucose. The more intricate the starch-polyphenol bonds in food products, the less starch is hydrolyzed, resulting in reduced starch digestibility. This, in turn, lowers the insulin response and subsequently reduces blood glucose levels[6].

Spirulina platensis is a type of microalga that is rich in bioactive compounds, making it a promising candidate for functional food applications[16]. The polysaccharides produced by *Spirulina platensis, such as immulina and immurella,* are complex and possess biological activities that may help prevent various diseases. Additionally, *Spirulina platensis* contains various bioactive compounds, including phenolic compounds (e.g., caffeic acid, ferulic acid, p-coumaric acid) and folate derivatives (e.g., carbonyl, alcohol, aldehyde, ester, terpene)[17]. Spirulina platensis is characterized by its high phycocyanin content, which imparts a deep bluish-green color and exhibits proven antioxidant activity.[18]

Antioxidant supplementation has been shown to effectively prevent complications resulting from oxidative stress caused by hyperglycemia in patients with T2DM[19]. The phycocyanin present in *Spirulina platensis* inhibits the activity of enzymes α-amylase and α-glucosidase, which are key enzymes involved in carbohydrate digestion. These enzymes catalyze the hydrolysis of oligosaccharides into glucose, facilitating its absorption in the small intestine. Inhibiting these enzymes slows the rate of carbohydrate digestion, resulting in reduced glucose absorption and transport into circulation[20].

The formulation of functional foods that combine low-GI ingredients with antioxidant-rich *Spirulina platensis* is expected to provide a healthy alternative for controlling blood glucose levels in patients with T2DM. Maintaining controlled blood glucose levels can reduce the risk of complications and improve the quality of life for individuals with diabetes. This study aims to evaluate the glycemic-index (GI) and organoleptic properties of a composite gluten-free flour-based chip formulation enriched with *Spirulina sp*.

METHODS

Design, Time, and Place

The research design was experimental. The study was divided into three stages. The first stage involved the development of the product with three different composition variations. The second stage included the organoleptic and glycemic index testing of the product. The third stage focused on testing the product's nutritional content. The research was conducted from October 2023 to February 2024 at the Dietetics and Culinary Laboratory, Organoleptic Laboratory, PSG Laboratory, and Chemistry Laboratory of the Health Faculty at Universitas Muhammadiyah Gresik. This Research was approved by the Research Ethics Clearance (KEP) of Universitas Muhammadiyah Gresik (Approval Number: 240/KET/II.3.UMG/KEP/A/2023), issued in September 2023.

How To Make Product

The product formula was based on the main ingredients for making chips, which included mocaf flour, cornstarch, millet corn, and tapioca. Each formula was enriched with 2% organic *Spirulina platensis* powder sourced from The Little Herbalist. The three formulations group were as follows: A413 (mocaf: 30%; cornstarch: 20%; millet corn: 20%; tapioca: 30%), A531 (mocaf: 30%; cornstarch: 20%; millet corn: 10%; tapioca: 40%), and A249 (mocaf: 30%; cornstarch: 10%; millet corn: 20%; tapioca: 40%). The tools used to make the product included a blender, oven, cookie cutters, baking tray, knife, and mixing bowl. The steps for product preparation are shown in Figure 1.

Calculation Test Food

The number of Spirulina chips provided was calculated based on the carbohydrate content of the product, equivalent to 25 grams of carbohydrates from pure glucose. The amount of test food was calculated using the following formula:

$$\text{Total Sample} = \frac{25 \text{ gram}}{\text{Carbohydrate sample}} \, x \, 100\%$$

Previous research determined the carbohydrate content of the formulas, with the result as follows: A413 contained 81.6% carbohydrates, A531 contained 82.3%, and A249 contained 80.12%. Based on these calculations, the amount of Spirulina chips provided to the respondents was as follows: A413 = 31 g, A531 = 30 g, and A249 = 31 g.

Glycemic Index Test

The glycemic index (GI) test was conducted with 10 respondents who met specific inclusion criteria. These

How to cite: Rahma, A., Supriatiningrum, D. N., Prayitno, S. A., Mulyani, E., & Ariestiningsih, E. S. (2025) Glycemic Index and Organoleptic Test of Gluten-Free Chips Made from Composite Flour Enriched with Spirulina Platensis: Uji Indeks Glikemik dan Organoleptik Keripik Berbahan Komposit Tepung Bebas Gluten yang Diperkaya Spirulina Platensis. Amerta Nutrition, 9(2), 310–318.

criteria included having normal nutritional status (BMI: 18.5–22.9 kg/m²), being between 20–30 years old, not taking medications regularly, being non-smokers and non-drinkers, having no history of chronic diseases (e.g., diabetes, kidney disease, or liver disease), and not being pregnant or breastfeeding. Before participating, respondents provided informed consent by completing a consent form.

The GI measurement procedure began after an 8–10-hour fasting period, during which blood glucose levels were first measured (minute 0). Prior to fasting, respondents were instructed to eat regular meals (neither excessive nor restricted) and to avoid intense physical activity. For the initial test, respondents consumed the standard food which consisted of 28 g of pure glucose dissolved in 200 ml of water. Blood glucose measurements were taken at 30, 60, 90, and 120 minutes after consuming the glucose solution.

The same procedure was repeated with the test food (Spirulina chips), with a one-week interval separating the standard food and test food tests. Blood glucose levels were plotted on two axes: time (minutes) on the X-axis and blood glucose levels (mg/dL) on the Y-axis. The GI value was calculated by determining the area under the curve (AUC) for the blood glucose response to the Spirulina chips, comparing it to the AUC for pure glucose, and multiplying the result by 100[21]. Foods were classified into three categories based on their GI value: low GI (<55), moderate GI (55–70), and high GI (>70)[22].

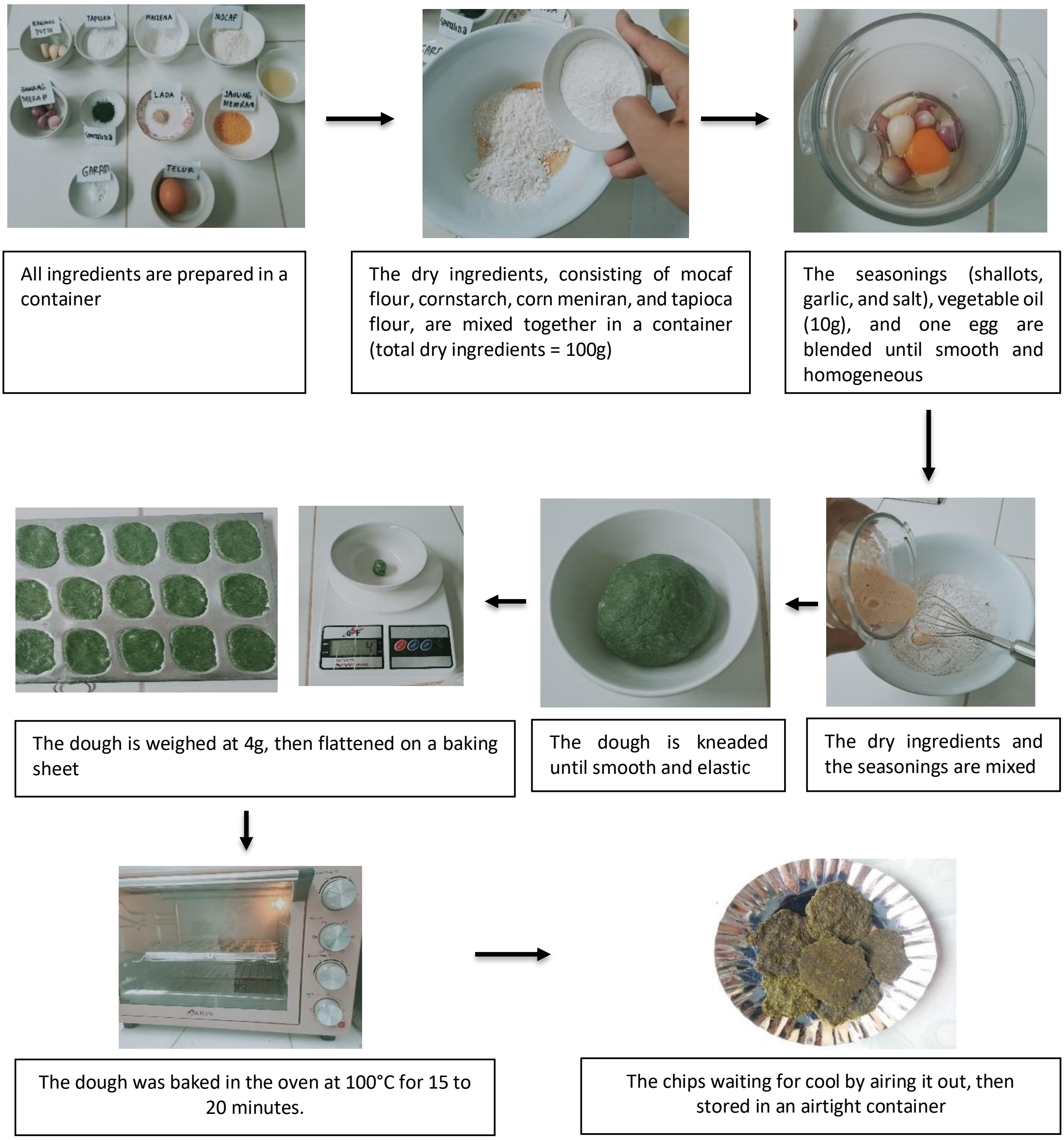


Figure 1. Steps Product Preparation

How to cite: *Rahma, A., Supriatiningrum, D. N., Prayitno, S. A., Mulyani, E., & Ariestiningsih, E. S. (2025) Glycemic Index and Organoleptic Test of Gluten-Free Chips Made from Composite Flour Enriched with Spirulina Platensis: Uji Indeks Glikemik dan Organoleptik Keripik Berbahan Komposit Tepung Bebas Gluten yang Diperkaya Spirulina Platensis. Amerta Nutrition, 9(2), 310–318.*

Organoleptic Test

The organoleptic test was conducted using a hedonic scale involving 35 semi-trained panelists aged 20–40 years. These panelists had prior experience or education in food sensory evaluation and had passed a sensory quality sensitivity test conducted by the researcher[23]. During the test, panelists provided subjective evaluations of Spirulina chips based on taste, aroma, texture, flavor, and color. Their responses were recorded on a hedonic scale ranging from 1 to 5 , where 1 indicated "Strongly dislike," 2 "Dislike," 3 "Neutral," 4 "Like," and 5 "Strongly like."[24].

Nutritional Test

The nutritional analysis of the Spirulina chips included the following parameters:

- Moisture and Ash Content: determined using the gravimetric method
- Fat Content: measured using the Soxhlet method
- Protein Content: measured using the Kjeldahl method
- Carbohydrate Content: calculated by difference

Data Analysis

The GI value was calculated by determining the area under the curve (AUC) for blood glucose measurements after consuming Spirulina chips and comparing it to the AUC for blood glucose measurements after consuming the standard food (pure glucose). The result was then multiplied by 100 to obtain the GI value.

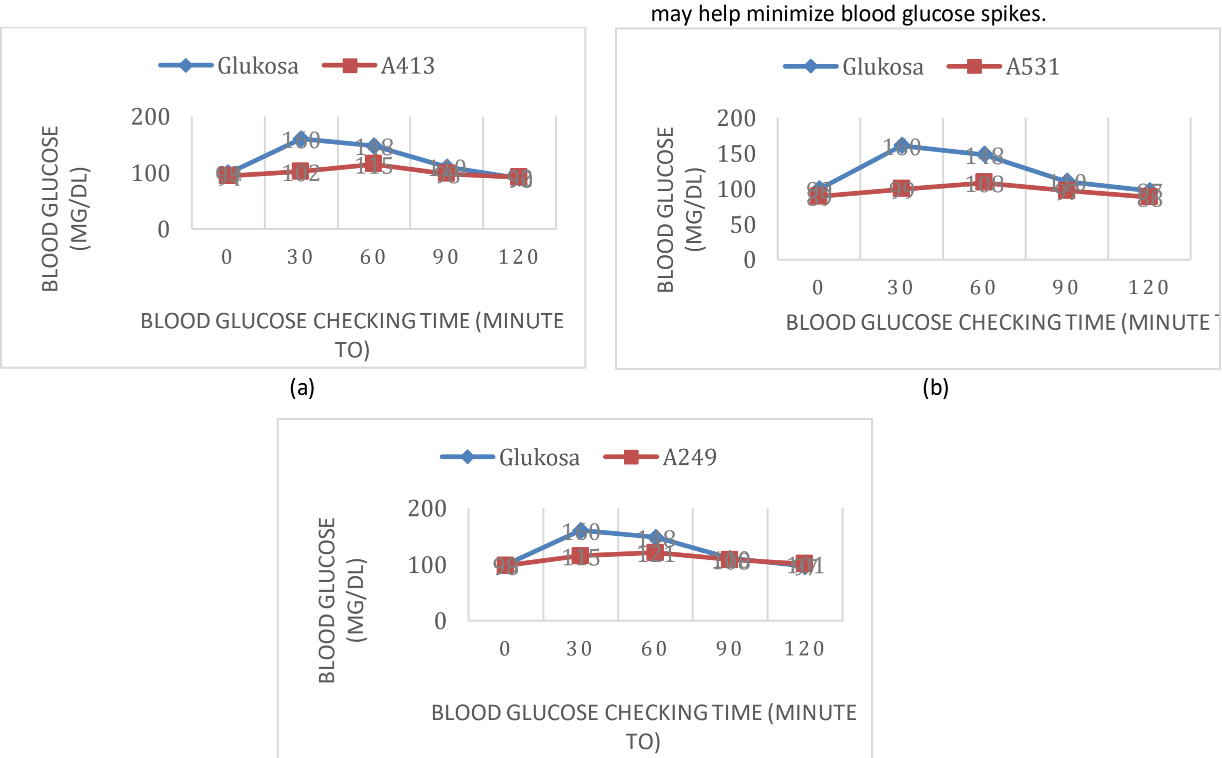
The organoleptic test data were analyzed using non-parametric statistical methods in SPSS, employing the Kruskal-Wallis test and a post-hoc test with the 2-independent sample (Mann-Whitney) test. Significant differences were assessed using the 2-independent sample (Mann-Whitney) test.

RESULTS AND DISCUSSIONS

Glycemic Index Test

The GI value represents the ability of carbohydrate-containing foods to influence blood glucose response[21]. In this study, the average blood glucose levels of respondents who consumed pure glucose were as follows: minute 0 = 99 mg/dL, at minute 30 = 160 mg/dL, at minute 60 = 148 mg/dL, at minute 90 = 110 mg/dL, and at minute 120 = 97 mg/dL. These results show a sharp rise in blood glucose levels at 30 minutes after consuming pure glucose, followed by a steady decline from 60 to 120 minutes. In comparison, the blood glucose levels after consuming Spirulina chips peaked at minute 60 and then declined. Unlike the pure glucose results, the blood glucose curve for Spirulina chips was much flatter and remined so up to minute 120 (Figure 2).

The calculated GI values for the test foods were as follows: Formula A413 had a GI value of 33, Formula A531 had a GI value of 28, and Formula A249 had a GI value of 34. All three chip formulations, made with composite gluten-free flour and enriched with Spirulina sp., were classified as having a low GI (<55). This finding suggests that using composite gluten-free flour enriched with *Spirulina platensis* as the main ingredient in chips may help minimize blood glucose spikes.



(a) (b) (c)

Figure 2. The Comparison of The Blood Glucose Response After Consumed Glucose and Formulation of A413, A531, and A249

Several studies have explored the glycemic index (GI) of gluten-free snack formulations. For example, a snack bar made from "kepok" banana flour and mung bean flour had a GI value of 33.2, classifying it as low GI[26].

How to cite: Rahma, A., Supriatiningrum, D. N., Prayitno, S. A., Mulyani, E., & Ariestiningsih, E. S. (2025) Glycemic Index and Organoleptic Test of Gluten-Free Chips Made from Composite Flour Enriched with Spirulina Platensis: Uji Indeks Glikemik dan Organoleptik Keripik Berbahan Komposit Tepung Bebas Gluten yang Diperkaya Spirulina Platensis. Amerta Nutrition, 9(2), 310–318.

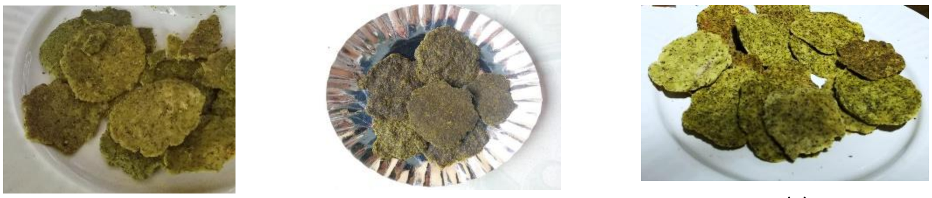
Similarly, research by Ningrum et al. (2022) investigated modified chips made from "bandeng" and "kenikir" leaves, combined with a mixture of mocaf flour, cornstarch, and tapioca flour, which resulted in a low GI value of 26.3[27]. Additionally, Trisnawati (2017) studied chips formulated with rice bran flour and pumpkin flour, which had a GI value of 51, also within the low GI range. In contrast, commercially available were found to have a high GI value of 87[28].

The glycemic index of food is influenced by its polysaccharide content, particularly amylose. Amylose, a resistant form of starch, is digested more slowly, resulting in a gradual release of glucose into bloodstream and a lower GI[15]. Another key factor is the presence of bioactive compounds such as polyphenols. Digestive enzymes are responsible for breaking down complex starch bonds through hydrolysis. However, the formation of complex compounds between starch and polyphenols prevents digestive enzymes from breaking these bonds into simpler forms (e.g., glucose). This process can reduce insulin response, contributing to lower blood glucose levels[29].

When carbohydrates are consumed, the body signals the pancreas to respond. The intake of carbohydrates causes blood glucose levels to rise, prompting the β-cells of the pancreas release insulin. Insulin facilitates the entry of glucose into cells by opening the cell membranes. Once inside the cells, glucose is used as fuel to produce energy. Insulin plays a crucial role in metabolic processes, particularly by increasing the rate of glycolysis and glycogenesis in muscles and the liver. It also enhances the synthesis of lipids and proteins derived from glucose[21]. Foods with a low glycemic index (GI) are broken down into monosaccharides (glucose) slowly and gradually. This results in a lower and more stable peak in blood glucose levels, preventing extreme fluctuations. Such gradual increases in blood glucose are especially important for individuals with diabetes (DM), as they allow for better blood sugar control[25].

Organoleptic Test

Organoleptic testing, also known as sensory evaluation, is based on the assessment of the senses, involving both physiological and psychological aspects. It entails recognizing the properties of a product based on the stimuli received by the sensory organs. In this study, three samples—A413, A531, and A249—which evaluated for their color, aroma, taste, texture, and crispness. The samples used for the organoleptic testing are shown in Figure 3.



(a) (b) (c)

Figure 3. The Chips Sample for Organoleptic Test

Based on assessments from 35 moderately trained panelists, significant differences were observed among the three formulas in terms of color, texture, and crispness (Table 1). Sample A413 was preferred in terms of color (3.5 ± 0.6) compared to the other samples. Sample A531 had an advantage in texture and crispness over sample A249, although there its texture was no significantly different from that of A413. While A531 was preferred for texture and crispness, there was no significant difference in the overall sensory quality ratings between A413 and A531 (p-value > 0.05).

Table 1. Results of the Organoleptic Test

Sample	Color	Aroma	Taste	Texture	Crispness	Average
A413	3.5 ± 0.6[a]	3.4 ± 0.7[a]	2.8 ± 0.8[a]	2.8 ± 0.7[ab]	2.7 ± 0.8[a]	3.1 ± 0.4[a]
A531	3.1 ± 0.7[b]	3.0 ± 0.8[a]	3.1 ± 0.7[a]	3.0 ± 0.5[b]	3.1 ± 0.9[b]	3.1 ± 0.5[a]
A249	2.9 ± 0.6[b]	3.0 ± 0.7[a]	2.8 ± 0.7[a]	2.6 ± 0.7[a]	2.8 ± 0.6[a]	2.9 ± 0.5[b]
p-value[1]	0.003*	0.110	0.309	0.029*	0.050*	0.048*

[1)] Kruskal-Wallis Test (followed by post-hoc Mann-Whitney U test, *) significant at p-value<0.05; different superscript letters ([a],[b]) indicate significant differences between samples

The differences in composition of the main ingredients for each sample clearly resulted in varying sensory responses. Crispness is a critical quality parameter for chip products, as it significantly impacts the overall eating experience. Additionally, chips are a type of snack that primarily emphasize appearance and texture, which play a significant role in consumer preference. The texture, particularly crispness, often influences the first impression of the product, making it a critical factor in the sensory evaluation of chips[30]. The higher composition of tapioca flour (40%) in Sample A531 positively influenced its crispness. Tapioca contains high levels of amylopectin, which influences the texture of the final product. Starches with higher amylopectin content tend to form a more flexible, non-rigid gel, whereas starches with lower amylopectin content form firmer, more rigid gels. The high amylopectin content in tapioca starch allows it to absorb more water due to the greater number of hydroxyl groups in its starch molecules. As the proportion of tapioca flour increases in the product, the amylopectin content also increases, resulting in greater water absorption during the baking process. This causes the starch to swell, rupture, and absorb more water, contributing to better crispness in the final product.[31].

As a result, Spirulina chips with higher tapioca flour content, such as Sample A531, are crispier. Although statistically, there was no significant difference in the overall sensory quality ratings between A413 and A531, Formula A531 excelled in the most important sensory parameters for chip products—texture and crispness. This made A531 the preferred choice for these attributes, even though the overall sensory scores were similar across formulas.

Nutritional Product

The nutritional analysis of the chips focused on macronutrients, including carbohydrates, protein, fat, water, and ash. The results showed that the average carbohydrate content across the samples ranged from 80 to 82 g per 100 g of product, with Formula A531 showing a comparable carbohydrate profile. The differences in carbohydrate content across the formulas were minimal because the main ingredients were the same, with only slight variations in their proportions. Carbohydrate contributed to approximately 320 kcal per 100 g of the product. The proximate analysis results are presented in Table 2.

Table 2. Nutritional Composition of 100 g of Spirulina Chips

Nutritional Composition	A413 (g)	A531 (g)	A249 (g)
Carbohydrate	81.64	82.32	80.12
Protein	8.91	8.79	8.65
Fat	2.11	2.03	1.91
Water	4.78	4.37	4.22
Ash	2.56	2.49	2.31

The protein, fat, water, and ash content in Formula A413 were the slightly higher than in the other two formulas, although the differences were small (Table 2). The primary protein source in all three products was eggs and spirulina, with equal amounts used across all formulations. Similarly, the fat content was derived from vegetable oil, with 10 g added to each formula. These consistent ingredient proportions contributed to the minimal variations in nutrient composition between the formulas.

In general, regulations established by the Indonesian National Standard (SNI) 2886-2015 for extruded snacks set the maximum water content at 4%. This standard ensures optimal shelf life, texture, and overall quality by minimizing excess water, which could lead to spoilage or undesirable changes in product quality[32]. In this study, all formulation samples had a moisture content exceeding 4%, which does not meet the SNI standard. Moreover, several factors may have contributed to this, such as shape, size, thickness of the chips, as well as baking time, and temperature. Larger and thicker products require longer baking times to allow sufficient moisture evaporation. Adjustments to product dimensions and baking conditions are necessary to reduce moisture content and comply with the required standards.[33].

The SNI 2886-2015 also limits acid-insoluble ash content to a maximum of 0.1%. The ash content in all three samples exceeded this standard. Ash content reflects the mineral content of the product, which can enhance nutritional value. However, exceeding the allowable limit may suggest elevated levels of certain minerals that could negatively affect the product's quality[34]. Additionally, **ash content** is closely related to the raw materials used and the **cleanliness** of the production process[32].

The fat content standard set by SNI for extruded snacks that are not fried is 30%. All three product formulations met this SNI quality requirement[32], with significantly lower than the maximum allowed. This is closely related to the processing method used. Baking the products in an oven reduces the need for oil, resulting in lower fat content compared to fried products. This baking method supports achieve a healthier fat profile, aligning with the standard for non-fried snacks.

An strength of this study was the involvement of a sufficient number of respondents (10 individuals, both male and female) for the glycemic index measurement, with strict inclusion criteria. This approach ensured that the measurement results were objective and reliable. Additionally, the involvement of 35 semi-trained panelists in the organoleptic test provided a representative assessment of the product's sensory qualities and its potential acceptance in the target market. However, a limitation of this study was lack of clinical trials to assess the efficacy of the product in controlling blood glucose levels over time. Conducting clinical trials would provide more concrete evidence of the product's long-term impact on glycemic control.

CONCLUSIONS

The gluten-free chip formulation enriched with Spirulina sp. can serve as healthy snack alternatives with a low glycemic index. Among the different formulations, Formula A531 stood out as the most promising due to its lowest glycemic index and better acceptance in terms of texture and crispness compared to the other formulas. This makes Formula A531 a suitable option for individuals seeking snacks that are both nutritionally beneficial and enjoyable to consume.

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to the leadership of Universitas Muhammadiyah Gresik, particularly the Rector and the Director of the Directorate of Research and Community Service, along with their respective teams, for their financial support and provision of the necessary facilities that enabled the successful implementation of this research. We also extend our heartfelt thanks to the Dean and the Head of the laboratory of the Faculty of Health, Universitas Muhammadiyah Gresik, for their invaluable assistance and for facilitating access to the laboratories, which ensured the timely completion of the research. Additionally, we are grateful for the help and support from out colleagues in the Nutrition Science Program, whose collaboration was essential for the success of this study.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

All authors declare no conflict of interest related to this article. This research was funded by Universitas Muhammadiyah Gresik under the research contract Number: 055/II.3.UMG/MoU/DPPM/2022.

AUTHOR CONTRIBUTIONS

AR: conceptualization, investigation, supervision, writing-original draft, funding acquisition; DNS: conceptualization, investigation, data curation; SAP: formal analysis, methodology, supervision validation; EM: project administration, resources, software, writing-original draft; ESA: writing-review & editing.

REFERENCES

1. Marbun, A.S., Aryani, N., Sipayung, N., & Sinaga, A. . Pengetahuan lima pilar dengan kadar gula darah pada pasien diabetes melitus tipe II di UPT Puskesmas Kenangan. *J. TEKESNOS* **4**, 208–217 (2022).
2. [KEMENKES RI] Kementrian Kesehatan Republik Indonesia. *Profil Kesehatan Indonesia 2018*. (2019).
3. [BALITBANGKES] Balai Penelitian dan Pengembangan Kesehatan. *Riset Kesehatan Dasar*. *Riset Kesehatan Dasar (RISKESDAS)* (2013).
4. Saputri, R. D. Komplikasi Sistemik pada Pasien Diabetes Melitus Tipe 2. *J. Ilm. Kesehat. Sandi Husada* **11**, 230–236 (2020). https://doi.org/10.35816/jiskh.v11i1.254
5. Selano, M. K. Hubungan Lama Menderita Dengan Kejadian Neuropati Diabetikum Pada Pasien Diabetes Melitus. *J. Smart Keperawatan* **8**, 129 (2021). https://doi.org/10.34310/jskp.v8i2.505
6. Septianingrum, E., Liyanan, L. & Kusbiantoro, B. Review Indeks Glikemik Beras: Faktor-Faktor yang Mempengaruhi dan Keterkaitannya terhadap Kesehatan Tubuh. *J. Kesehat.* **9**, 1 (2016). https://doi.org/10.23917/jurkes.v9i1.3434
7. Lazarou, C., Panagiotakos, D. & Matalas, A.-L. The Role of Diet in Prevention and Management of Type 2 Diabetes: Implications for Public Health. *Crit. Rev. Food Sci. Nutr.* **52**, 382–389 (2012). https://doi.org/10.1080/10408398.2010.500258
8. Lazarou, C., Panagiotakos, D. & Matalas, A. The Role of Diet in Prevention and Management of Type 2 Diabetes: Implications for Public Health. *Crit. Rev. Food Sci. Nutr.* **52**, 382–389 (2012). https://doi.org/10.1080/10408398.2010.500258
9. Zong, G. *et al.* Gluten intake and risk of type 2 diabetes in three large prospective cohort studies of US men and women. *Diabetologia* **61**, 2164–2173 (2018). https://doi.org/10.1007/s00125-018-4697-9
10. Ludvigsson, J. F. *et al.* The Oslo definitions for coeliac disease and related terms. *Gut* **62**, 43–52 (2013). https://doi.org/10.1136/gutjnl-2011-301346
11. Serena, G., Camhi, S., Sturgeon, C., Yan, S. & Fasano, A. The Role of Gluten in Celiac Disease and Type 1 Diabetes. *Nutrients* **7**, 7143–7162 (2015). https://doi.org/10.3390/nu7095329
12. Warsito, H. & Sa'diyah, K. Studi Pembuatan Klepon dengan Substitusi Tepung Sagu sebagai Alternatif Makanan Selingan Indeks Glikemik Rendah Bagi Penderita Diabetes Meliitus Tipe 2. *J. Kesehat.* **7**, 45–57 (2019). https://doi.org/10.25047/j-kes.v7i1.74
13. Pateda, V. & Nofi, L. S. Pengaruh Konsumsi Beras Indeks Glikemik Rendah Terhadap Pengendalian Metabolik Diabetes Melitus Tipe-1. *Sari Pediatr.* **10**, 320 (2016). https://doi.org/10.14238/sp10.5.2009.320-4
14. Suloi, A.N.F., Rumitasari, A., Farid, J. A., Fitriani, S. N. A., & & Ramadhani, N. L. Snack bars : camilan sehat rendah indeks glikemik sebagai alternatif pencegahan penderita diabetes. **2**, 118–125 (2020).
15. Bintanah, S., Jauharany, F. F., Gizi, P. & Muhammadiyah, U. Analisa Zat Gizi dan Tingkat Kesukaan Pada Tepung Talas Bening (xanthosoma undipes koch) Sebagai Pangan Fungsional Untuk Menurunkan Kadar Gula Darah efek metabolik yaitu mengurangi episode hipoglikemia . (Giacco R , 2002) . glikemik yang renada dari s. 1689–1697.
16. Iqbal, M., Ma'aruf, W.F., S. Pengaruh penambahan mikroalga Spirulina platensis dan mikroalga Skeletonema costatum terhadap kualitas sosis ikan bandeng (Chanos chanos frosk). **5**, 56–63 (2016).

17. Andrade, L. M. Chlorella and Spirulina Microalgae as Sources of Functional Foods, Nutraceuticals, and Food Supplements; an Overview. *MOJ Food Process. Technol.* **6**, (2018). https://doi.org/10.15406/mojfpt.2018.06.00144
18. Firdayani, F. & Winarni Agustini, T. Ekstraksi Senyawa Bioaktif sebagai Antioksidan Alami Spirulina Platensis Segar dengan Pelarut yang Berbeda. *J. Pengolah. Has. Perikan. Indones.* **18**, 28–37 (2015). https://doi.org/10.17844/jphpi.2015.18.1.28
19. Prawitasari, D. S. Diabetes Melitus dan Antioksidan. *KELUWIH J. Kesehat. dan Kedokt.* **1**, 48–52 (2019). https://doi.org/10.24123/kesdok.V1i1.2496
20. Siti Halimatul Munawaroh, H. *et al.* In-vitro molecular docking analysis of microalgae extracted phycocyanin as an anti-diabetic candidate. *Biochem. Eng. J.* **161**, 107666 (2020). https://doi.org/10.1016/j.bej.2020.107666
21. Solang, M., Ningsih N. Ismail, Y. & D. Uno, W. Komposisi Proksimat dan Indeks Glikemik Nira Aren. *Biospecies* **13**, 1–9 (2020). https://doi.org/10.22437/biospecies.v13i2.8761
22. Istiqomah, A. *Indeks Glikemik , Beban Glikemik , Kadar Protein , Serat Dan Tingkat Kesukaan Kue Kering Tepung Garut Dengan Substitusi Tepung Kacang Merah*. (2015). https://doi.org/10.14710/jnc.v4i4.10171
23. Khairunnisa, A. & Syukri, A. A. Praktik Sensorik dan Bias Panelis. *Univ. Terbuka* 1–29 (2019).
24. Sarastani, D., Kusumanti, I. & Indriastuti, C. E. Uji Penerimaan Konsumen terhadap Mutu Organoleptik Petis Ikan Situbondo dengan Metode Uji Kesukaan. *Biosci. J. Ilm. Biol.* **11**, 32 (2023). https://doi.org/10.33394/bioscientist.v11i1.6984
25. Dini, R. Z. & Rustanti, N. Pengaruh Substitusi Tepung Ampas Kelapa terhadap Nilai Indeks Glikemik, Beban Glikemik, dan Tingkat Kesukaan Roti. *J. Nutr. Coll.* **3**, 213–221 (2014). https://doi.org/10.14710/jnc.v3i1.4599
26. Afifah, D. N. *et al.* Analisis Kandungan Zat Gizi, Pati Resisten, Indeks Glikemik, Beban Glikemik dan Daya Terima Cookies Tepung Pisang Kepok (Musa paradisiaca) Termodifikasi Enzimatis dan Tepung Kacang Hijau (Vigna radiate). *J. Apl. Teknol. Pangan* **9**, 101–107 (2020). https://doi.org/10.17728/jatp.8148
27. Ningrum, D. O. *et al.* Pengukuran Indeks Glikemik Pangan Modifikasi Snack Berbahan Dasar Ikan Gabus (Chana micropeltes) dan Daun Kenikir(Cosmos caudatus). *Ghidza Media J.* **4**, 117 (2022). https://doi.org/10.30587/ghidzamediajurnal.v4i1.4784
28. Trisnawati, W. Analisis Indeks Glikemik dan Komposisi Gizi Keripik Simulasi Substitusi Tepung Bekatul dengan Tepung Labu Kuning. *J. Apl. Teknol. Pangan* **6**, 143–147 (2017). https://doi.org/10.17728/jatp.235
29. Fajriah, F., Faridah, D. N. & Herawati, D. Penurunan Indeks Glikemik Nasi Putih dengan Penambahan Ekstrak Serai dan Daun Salam. *J. Teknol. dan Ind. Pangan* **33**, 169–177 (2022). https://doi.org/10.6066/jtip.2022.33.2.169
30. Parhusip, A., Neysha, A., Halim, L. & Iwantoro, F. O. Aplikasi Pre-Heating dan Edible Coating untuk Peningkatan Kualitas Keripik Kentang. *J. Mutu Pangan Indones. J. Food Qual.* **8**, 53–62 (2021). https://doi.org/10.29244/jmpi.2021.8.1.53
31. Rahman, M. & Mardesci, H. Pengaruh Perbandingan Tepung Beras dan Tepung Tapioka terhadap Penerimaan Konsumen pada Cendol. *J. Teknol. Pertan.* **4**, 18–28 (2015). https://doi.org/10.32520/jtp.v4i1.76
32. Malik, Z. K., Puspasari, E. & Nurlaela, R. S. Karakteristik Kimia dan Sensori Stik Bawang dengan Penambahan Tepung Biji Alpukat (Persea americana Mill). *Karimah Tauhid* **3**, 5600–5619 (2024). https://doi.org/10.30997/karimahtauhid.v3i5.13203
33. Taula'bi', M. S. D., Oessoe, Y. Y. E. & Sumual, M. F. Kajian Komposisi Kimia Snack Bars Dari Berbagai Bahan Baku Lokal : Systematic Review Study of the Chemical Composition of Snack Bars From Various Local Raw Materials : Systematic Review. *Agri-Sosioekonomi* **17**, 15 (2021). https://doi.org/10.35791/agrsosek.17.1.2021.32236
34. Julfi Restu Amelia, Intan Nurul Azni, Iman Basriman, F. N. W. P. Karakteristik Kimia

Minuman Sari Tempe-Jahe dengan Penambahan Carboxy Methyl Cellulose dan Gom Arab pada Konsentrasi yang Berbeda. *Chim. Nat. Acta* **9**, 36–44 (2021). https://doi.org/10.24198/cna.v9.n1.33038

How to cite: *Rahma, A., Supriatiningrum, D. N., Prayitno, S. A., Mulyani, E., & Ariestiningsih, E. S. (2025) Glycemic Index and Organoleptic Test of Gluten-Free Chips Made from Composite Flour Enriched with Spirulina Platensis: Uji Indeks Glikemik dan Organoleptik Keripik Berbahan Komposit Tepung Bebas Gluten yang Diperkaya Spirulina Platensis. Amerta Nutrition, 9(2), 310–318.*