ISSN: 2581-1274

Protein Content and Glycemic Index of Snack Bars from Pigeon Pea and Yellow Sweet Potato

Nur Afni [a,1,*], Riezka Zuhriatika Rasyda[a,2], Lingga Gita Dwikasari[a,3]

[a] *Food Science and Technology Study Program, Faculty of Food Technology and Agroindustry, University of Mataram, Indonesia*
[1*]*nurafni@staff.unram.ac.id**; [2]*riezka_rasyda@unram.ac.id*; [3]*linggadwikasari@unram.ac.id*
* *corresponding author*

ARTICLE INFO

Article history:
Published
March 1, 2026

Keywords:
Pigeon pea
Yellow sweet potato
Snack bar formulation
Protein content
Glycemic index

ABSTRACT

This study investigates the potential of Indonesia's indigenous crops, pigeon pea and yellow sweet potato, for the development of nutritious snack bars with desirable protein content and glycemic index (GI). Eleven formulations with varying ratios of pigeon pea and yellow sweet potato (0%:100% to 100%:0%) were produced and analyzed for protein content using AOAC methods and for GI using glucose as the reference standard. Data were evaluated using one-way ANOVA followed by DMRT at a 5% significance level. Protein content ranged from 3.05 ± 0.01% to 13.64 ± 0.19%, while GI values spanned from 14.00 ± 0.65 to 76.00 ± 0.14. Increasing the proportion of pigeon pea resulted in a concurrent rise in both protein content and GI, indicating a strong positive correlation between these parameters and highlighting the challenge of formulating high-protein, low-GI snack bars from these ingredients. The findings indicate that thermal processing may enhance starch digestibility, thereby contributing to elevated GI in formulations with high pigeon pea content. A key limitation of this study is the absence of detailed analysis of processing-related factors such as heating intensity, matrix modification, and starch gelatinization that may influence glycemic response. Further investigation is required to elucidate these mechanisms.

I. Introduction

Snack bars, or often used interchangeably with cereal bars and granola bars, consist of compressed mixtures of ingredients combined with a binding agent and shaped into a bar [5]. Typically composed of refined or whole grain cereals, snack bars offer valuable amounts of energy, carbohydrates, fiber, and protein [9]. Consumers favor these products for their filling effect, which is enhanced by the inclusion of additional fiber and protein [14]. Most snack bars (45%) also categorized as low glycemic index (GI) foods [3]. These convenient, ready-to-eat snacks need no cooking and can include diverse components, such as cereals, nuts, dried fruit, honey, and even tuber [17].

Various indigenous raw materials in Indonesia can be used in the manufacture of snack bars, including pigeon pea. The production of pigeon pea (*Cajanus cajan*), better known as *Kacang Gude* in Indonesian and *Lebui* beans in Lombok Island, West Nusa Tenggara Province, reaches 70–80 tons/year [10]. As indigenous food materials, the utilization of pigeon pea has the potential to replace imported food materials while increasing local commodity's economic value. Pigeon pea is a great source of protein, fiber, and carbohydrate [4].

Moreover, Pigeon pea can be counted as a plant-based protein ingredient that can be incorporated into foods to enhance the protein content while also reducing starch digestibility [15]. Pigeon pea also has low GI (GI≤55), ranged from 7 – 54 [16]. Thus, it can be considered a beneficial food substitute for those with diabetes and cardiovascular diseases [7]. Because it also has strong antihyperglycemic activity, which has the ability to lower blood glucose levels [8]. These characteristics of pigeon pea make it a suitable ingredient for nutritional snack bars.

Other indigenous raw materials that can be used in the manufacture of snack bars is yellow sweet potato (*Ipomoea batatas* L.). According to the data set provided by Reference [20], sweet potato production in West Nusa Tenggara Province reached 12,649 tons in 2024. Sweet potato flour contains 82.47% of carbohydrate, 3.28% of fiber, 5.86% of protein, 1.5% of fat, 1.22% of ash, and 5.68% of moisture [11]. Sweet potato has medium to high GI, ranged from 39 to 95 per edible portion size [19]. Thus, to maximize the nutritional benefit of snack bars which has high protein yet low GI, the yellow sweet potato needs to be combined with pigeon pea.

The combination of pigeon pea and yellow sweet potato (using together as nutritious formulation) predicted will produce snack bars that are high in protein with low glycemic index. Several studies have developed pigeon pea and sweet potato-based food products such as cookies [6], cakes [11], and biscuits [1]. However, specific research on snack bar formulations based on the ratio of pigeon pea and yellow sweet potato is still very limited.

The aim of this study is to determine the glycemic index and protein content of snack bars made from pigeon pea and yellow sweet potato. The results of this study are expected to be used as a source of information related to the production of snack bars made from pigeon pea and yellow sweet potato. Furthermore, the use of pigeon pea and yellow sweet potato in the production of snack bars is expected to increase added value for the two local commodities especially for Lombok Island communities.

II. Method

A. Material

Pigeon pea and yellow sweet potato as snack bars main ingredients were obtained from "Kebon Roek" local market in Ampenan District, West Nusa Tenggara Province, Indonesia. Fructose syrup, ripe bananas, cornstarch, eggs, and butter were also procured from the same source.

B. Snack Bars Production

Snack bars were produced as described by Reference [9] with slight modification of ingredients. The main ingredients of snack bars produced in this study are the mixture of pigeon pea granules and thinly-grated yellow sweet potato in the ratios of 0%:100%; 10%:90%; 20%:80%; 30%:70%; 40%:60%; 50%:50%; 60%:40%; 70%;30; 80%:20%, 90%:10%; and 100%:0%, respectively. The ingredient components used to prepare the snack bars were grouped into two types: dry components and binder components.

The dry components included the main ingredients (100 g), ripe banana granules (15 g), and cornstarch (9 g). The binder components consisted of fructose syrup (30 g), egg yolks (10 g), and butter (6 g). The dry components were mixed until homogeneous, while the binder components were heated to 60°C with continuous stirring. Both components were then blended immediately until well combined and pressed into a 10×10 cm buttered molder tray. The dough was baked at 160°C for 30 minutes, then cooled to room temperature and cut into 5×2.5 cm snack bars.

C. Analysis

This study used Completely Randomized Design with one factor, namely the ratio of pigeon pea and yellow sweet potato. Eleven treatments with different combinations of the ratio between pigeon pea and yellow sweet potato were observed (0%:100%; 10%:90%; 20%:80%; 30%:70%; 40%:60%; 50%:50%; 60%:40%; 70%;30; 80%:20%, 90%:10%; and 100%:0%, respectively). Each treatment replicated two times. Protein content was determined by AOAC method [2]. Glycemic Index was determined by the method of [8] using glucose as reference. Obtained data were analyzed using SPSS (Statistical Package for Social Sciences) software with One-way ANOVA (Analysis of Variance) and further tested using Duncan's Multiple Range Tests (DMRT) at 5% significance level.

III. Results and Discussion

A. Protein Content

The ratio of pigeon pea and yellow sweet potato has a significant effect ($p<0.05$, indicated by different notation letter at the end of value means, DMRT 5% = 0.16) on the protein content of snack

bars, ranging from 3.05±0.01% to 13.64±0.19% (Figure 1). This aligns with similar findings by [9] which reported multigrain bars having 5.46% to 16.11% of protein. Supporting this, Taula'bi' et al. (2021) also reported that snack bars made from various local raw materials in Indonesia having 3.49% to 17.61% of protein.

According to Reference [12], solid food products can be labeled as a "source of protein" if they contain at least 20% of protein. This means that none of the snack bar samples in this study can be claimed as a source of protein. For reference, the European Union regulates that a product can be claimed as a source of protein if it has a minimum protein content of 12%.

Currently, Indonesia lacks standardized references specific for snack bars. But for reference, the United States requires granola bars (soft, uncoated, with nuts and raisins) to have at least 8% protein [18]. As such, snack bars formulated with pigeon pea and yellow sweet potato in ratios from 0%:100% through 30%:70% do not meet this standard.

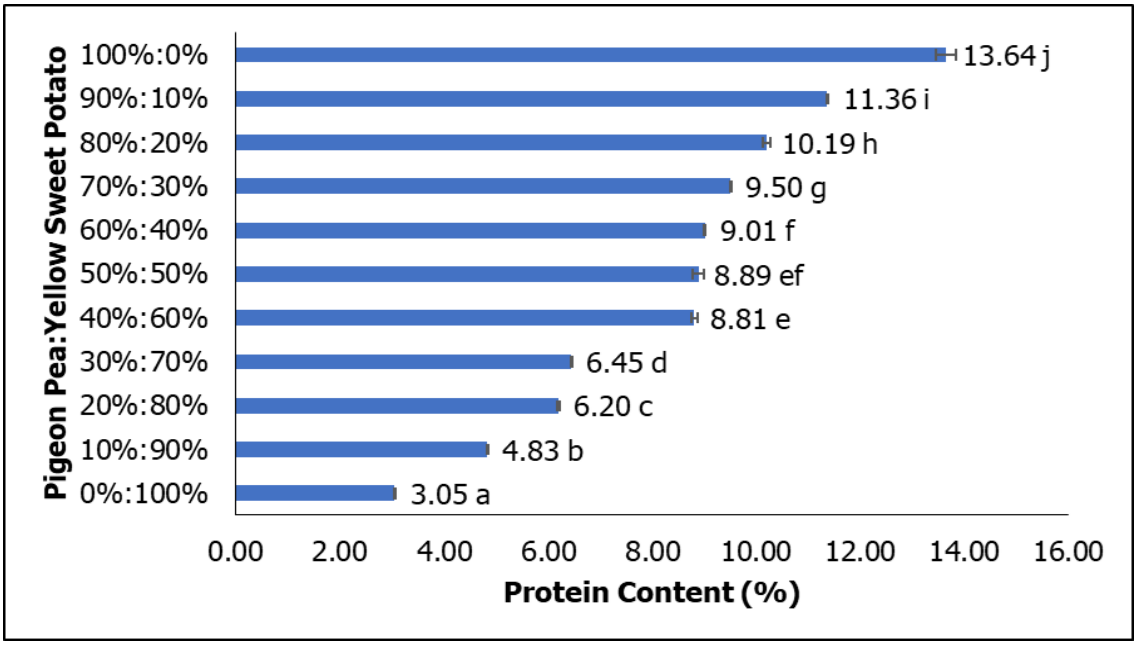

Fig 1. Protein content of snack bar samples

A closer look at Figure 1 indicates a steady rise in protein content as pigeon pea utilization increases. The ratios range from 0%:100% (all sweet potato) to 100%:0% (all pigeon pea). The results demonstrate a consistent upward trend: as the proportion of pigeon pea increases, the protein content of the snack bar also increases. This pattern occurs because pigeon pea naturally contains much higher protein (≈22–23%) compared to yellow sweet potato (≈5–6%).

This indication aligns with the research results of snack bars made from tannia flour and pigeon pea [21], and cookies made from sweet potato flour and pigeon pea flour [6] both of which reported that increasing the concentration of pigeon pea would increase the protein content of the end products. The increase occurs because pigeon pea contains 22.74% protein, which is higher than the 5.86% found in sweet potato [11].

The lowest protein content appears in the 0%:100% formulation (3.05%), which contains no pigeon pea. Adding just 10% pigeon pea raises the protein to 4.83%, and further increases in the pigeon pea ratio continue to elevate protein significantly. Mid-range formulations (30%–60% pigeon pea) show protein levels between 6.20% and 9.01%, while high-pigeon-pea formulations (70%–100%) reach 9.50% to 13.64%. The highest value, 13.64%, occurs at 100% pigeon pea. Supporting this, Reference [19] reported that observed various sweet potato varieties having less than 6% protein.

B. Glycemic Index

The ratio of pigeon pea and yellow sweet potato has a significant effect ($p<0.05$, indicated by different notation letter at the end of value means, DMRT 5% = 0.77) on the glycemic index (GI) of snack bars, ranging from 14.00±0.65% to 76.00±0.14% (Figure 2). GI values could be categorized as low (GI ≤55), medium (GI 56 – 69), and high (GI ≥70) [3]. As such, 55% snack bar samples (the ratio of pigeon pea and yellow sweet potato from 0%:100% through 50%:50%) are classified as low-GI foods; 18% snack bar samples (the ratio of pigeon pea and yellow sweet potato 60%:40 and 70%:30%) are classified as medium-GI foods (18%); and 27% snack bar samples (the ratio of pigeon pea and yellow sweet potato from 80%:20% through 100%:0%) are classified as high-GI foods (27%).

The findings align with similar findings by Atkinson et al. (2021) which reported 65%; 15%; and 20% of observed products in snack bars category having low-GI; medium-GI; and high-GI, respectively. Although, pigeon pea is widely recognized to have low GI in its native form (GI ≈ 7–54) (Singh et al., 2021) but in the present snack-bar formulations the GI increased with higher inclusion levels of pigeon pea, most likely due to thermal processing and starch gelatinization [16].

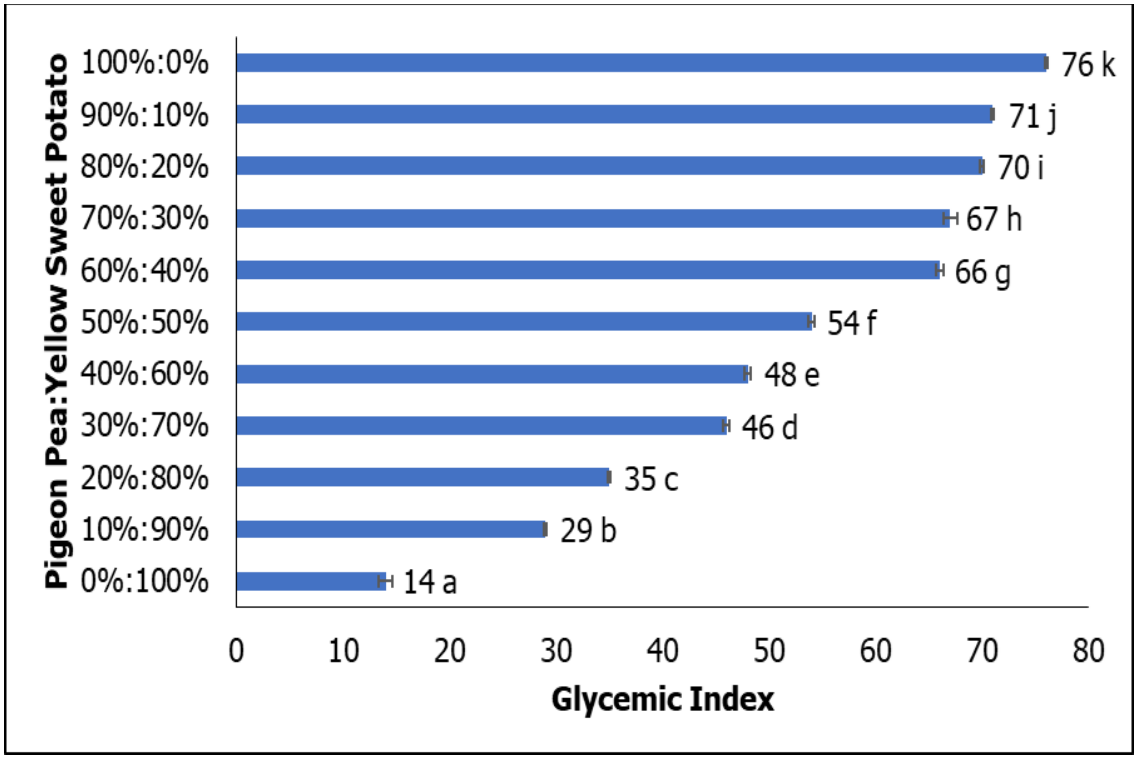

Fig 2. Glycemic Index of snack bar samples

IV. Conclusion and Limitation

A strong positive correlation was observed between the protein content and glycemic index of the formulated snack bars, indicating the inherent difficulty in achieving a product that is simultaneously high in protein and low in GI when using pigeon pea and yellow sweet potato as primary ingredients. Across all treatments, protein content ranged from 3.05 ± 0.01% to 13.64 ± 0.19%, while GI values varied from 14.00 ± 0.65 to 76.00 ± 0.14. Increasing the proportion of pigeon pea consistently elevated both parameters, reflecting its higher intrinsic protein level and its susceptibility to processing-induced increases in starch digestibility. These finding and limitation underscore the need for further investigation into how thermal processing conditions particularly baking modulate starch structure and enzymatic accessibility, thereby influencing the glycemic index of pigeon pea-based snack bars.

Acknowledgment

The authors express our sincere gratitude to University of Mataram as the research funder through the 2025 PNBP (Non-Tax State Revenue) research scheme.

References

[1] Adeola, A. A., & Ohizua, E. R. (2018). Physical, chemical, and sensory properties of biscuits prepared from flour blends of unripe cooking banana, pigeon pea, and sweet potato. Food Science and Nutrition, 6(3), 532–540. https://doi.org/10.1002/FSN3.590;WGROUP:STRING:PUBLICATION

[2] AOAC International. (2023). Official Methods of Analysis of AOAC INTERNATIONAL (G. W. J. Latimer (ed.); 22nd ed.). Oxford University Press. https://doi.org/10.1093/9780197610145.001.0001

[3] Atkinson, F. S., Brand-Miller, J. C., Foster-Powell, K., Buyken, A. E., & Goletzke, J. (2021). International tables of glycemic index and glycemic load values 2021: a systematic review. The American Journal of Clinical Nutrition, 114(5), 1625–1632. https://doi.org/10.1093/AJCN/NQAB233

[4] Augustyn, G. H., Moniharapon, E., Resimere, S., Teknologi, J., Pertanian, H., & Pertanian, F. (2017). ANALISA KANDUNGAN GIZI TEPUNG KACANG GUDE HITAM (Cajanus cajan) DENGAN BEBERAPA PERLAKUAN PENDAHULUAN. AGRITEKNO: Jurnal Teknologi Pertanian, 6(1), 27–32. https://doi.org/10.30598/JAGRITEKNO.2017.6.1.27

[5] Boukid, F., Klerks, M., Pellegrini, N., Fogliano, V., Sanchez-Siles, L., Roman, S., & Vittadini, E. (2022). Current and emerging trends in cereal snack bars: implications for new product development. International Journal of Food Sciences and Nutrition, 73(5), 610–629. https://doi.org/10.1080/09637486.2022.2042211;PAGE:STRING:ARTICLE/CHAPTER

[6] Delia, L. K. B., Puryana, I. G. P. S., & Antarini, A. A. N. (2019). Pengaruh Komposisi Tepung Ubi Jalar Ungu (Ipoemea batatas) Dan Tepung Kacang Gude (Cajanus cajan L.Millsp.) Terhadap Karakteristik Cookies. Jurnal Ilmu Gizi: Journal of Nutrition Science, 9(1), 34–42. http://ejournal.poltekkes-denpasar.ac.id/index.php/JIG/article/view/jig792

[7] Ishaya, F. A., Ayoade, G. W., Olaoye, A. B., & Hassan, M. A. (2020). Carbohydrate content and glycemic index of lima bean and pigeon pea. Food Processing & Technology, 11(S1), 1–6.

[8] Manzo, J. A. M., & Vitor, R. J. S. (2017). Antihyperglycemic effects of Cajanus cajan L. (pigeon pea) ethanolic extract on the blood glucose levels of ICR mice (Mus musculus l.). National Journal of Physiology, Pharmacy and Pharmacology, 7(8), 860–864. https://doi.org/10.5455/njppp.2017.7.0410801052017

[9] Mathur, M., & Kumari, A. (2022). Development and evaluation of multigrain fibre and protein enriched composite bars. The Pharma Innovation Journal, 11(3), 30–41. https://www.thepharmajournal.com/archives/?year=2022&vol=11&issue=3&ArticleId=11842

[10] Mushollaeni, W. (2018). Optimasi Proses Produksi Bubuk Dari Ekstrak Kacang Lebui (Cajanus Sp.) Yang Mengandung Senyawa Bioaktif. Brawijaya University.

[11] Olatunde, S. J., Ajayi, O. M., Ogunlakin, G. O., & Ajala, A. S. (2019). Nutritional and sensory properties of cake made from blends of pigeon pea, sweet potato and wheat flours. Food Research, 3(5), 456–462. https://doi.org/10.26656/fr.2017.3(5).255

[12] Peraturan Badan Pengawas Obat Dan Makanan Nomor 1 Tahun 2022 Tentang Pengawasan Klaim Pada Label Dan Iklan Pangan Olahan (2022).

[13] Pratiwi, S. A., Darawati, M., Widiada, I. G. N., & Irianto, I. (2018). Pembuatan Cookies Udela Bebas Gluten Dan Kasein Berbahan Tepung Kombinasi Ubi Jalar Ungu, Kacang Gude, Labu Kuning Untuk Anak Autis. Jurnal Gizi Prima (Prime Nutrition Journal), 3(2), 80–85. https://doi.org/10.32807/JGP.V3I2.112

[14] Ramírez-Jiménez, A. K., Gaytán-Martínez, M., Morales-Sánchez, E., & Loarca-Piña, G. (2018). Functional properties and sensory value of snack bars added with common bean flour as a source of bioactive compounds. LWT, 89, 674–680. https://doi.org/10.1016/J.LWT.2017.11.043

[15] Sachanarula, S., Chantarasinlapin, P., & Adisakwattana, S. (2022). Substituting Whole Wheat Flour with Pigeon Pea (Cajanus cajan) Flour in Chapati: Effect on Nutritional Characteristics, Color Profiles, and In Vitro Starch and Protein Digestion. Foods (Basel, Switzerland), 11(20), 3157. https://doi.org/10.3390/foods11203157

[16] Singh, M., Manickavasagan, A., Shobana, S., & Mohan, V. (2021). Glycemic index of pulses and pulse-based products: a review. Critical Reviews in Food Science and Nutrition, 61(9), 1567–1588. https://doi.org/10.1080/10408398.2020.1762162;JOURNAL:JOURNAL:BFSN18;WGROUP:STRING:PUBLICATION

[17] Taula'bi', M. S., Oessoe, Y. Y., & Sumual, M. F. (2021). Study of the Chemical Composition of Snack Bars from Various Local Raw Materials : Systematic Review. AGRI-SOSIOEKONOMI, 17(1), 15–20. https://doi.org/10.35791/AGRSOSEK.17.1.2021.32236

[18] 18. (2019). Snacks, granola bars, soft, uncoated, nut and raisin - Nutrients - SR Legacy | USDA FoodData Central. FoodData Central Food Details. https://fdc.nal.usda.gov/food-details/169676/nutrients

[19] Waidyarathna, G. R. N. N., Ekanayake, S., & Chandrasekara, A. (2021). Comparative analysis of nutrient composition and glycaemic indices of nine sweet potatoes (Ipomoea batatas) varieties. International Journal of Biological and Chemical Sciences, 15(4), 1410–1420. https://doi.org/10.4314/IJBCS.V15I4.9

[20] West Nusa Tenggara Province's Department of Agricultural and Plantation. (2025). Produksi, Luas Panen dan Produktivitas Ubi Jalar berdasarkan Kabupaten/Kota. https://data.ntbprov.go.id/dataset/9d37dc3b-b63f-42e1-92a1-64b7d7d03769/show

[21] Wulandari, N. W. M., & Prambandita, K. D. S. (2024). Nilai Gizi dan Serat Pangan pada Snack Bar Berbasis Tepung Kimpul (Xanthosoma sagittifolium) dan Kacang Gude (Cajanus cajan). Antigen : Jurnal Kesehatan Masyarakat Dan Ilmu Gizi, 2(2), 174–183. https://doi.org/10.57213/ANTIGEN.V2I2.328