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ANALISA PROKSIMAT, INDEKS GLIKEMIK, DAN BEBAN GLIKEMIK PADA GULO PUAN: MAKANAN KHAS PAMPANGAN, SUMATERA SELATAN

Proximate Analysis, Glycemic Index, and Glycemic Load in Gulo Puan: A Culinary Investigation of a Traditional Dish from Pampangan, South Sumatra

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ABSTRAK

Gulo puan adalah salah satu makanan khas yang berasal dari Pampangan, Sumatera Selatan. Gulo puan berbahan dasar susu kerbau dan gula pasir sehingga memiliki rasa manis dan gurih. Gulo puan dikonsumsi oleh masyarakat setempat sebagai camilan ataupun tambahan untuk memasak. Tujuan penelitian ini untuk menganalisa kandungan proksimat, indeks glikemik dan beban glikemik pada gulo puan. Penelitian ini merupakan penelitian kuantitatif yang bersifat eksperimental. Analisa proksimat dilakukan di laboratorium SIG sedangkan Analisa beban dan indeks glikemik dilakukan pada 15 orang yang dipilih menggunakan metode *purposive sampling*. Hasil uji proksimat dianalisa secara deskriptif sedangkan analisis data indeks glikemik dan beban glikemik menggunakan uji *Mann-Whitney*. Hasil analisa komposisi proksimat diketahui bahwa gulo puan memiliki kandungan total energi (417,44 kkal), karbohidrat (55,93%), lemak (16,65%), protein (10,25%), abu (1,64%), dan air (15,03%). Hasil penelitian menunjukkan perbandingan indeks glikemik gulo puan (88,69%) dan gula merah (95,05%) dengan perbedaan rata-rata yang bermakna (*p-value* 0,004 (< 0,05)). Perbandingan beban glikemik gulo puan (44,34%) dan gula merah (47,52%), dengan perbedaan rata-rata yang bermakna *p-value* 0,004 (< 0,05).

Kata kunci: Analisa Proksimat, Gulo Puan, Indeks Glikemik, Kadar Glukosa Darah

ABSTRACT

Gulo Puan, originating from Pampangan, South Sumatra, stands out as one of the region's specialties. Crafted from buffalo milk and sugar, Gulo Puan boasts a delightful combination of sweet and savory flavors. Locally embraced, this delicacy is commonly enjoyed as a snack or incorporated into various culinary preparations. This study's primary objective was to comprehensively analyze the proximate content, glycemic index, and glycemic load of Gulo Puan. Employing an experimental quantitative research approach, the proximate analysis took place in the GIS laboratory, while the study of glycemic load and glycemic index involved 15 participants selected through purposive sampling. The results of the proximate study, presented descriptively, revealed the following composition in Gulo Puan: total energy (417.44 kcal), carbohydrate (55.93%), fat (16.65%), protein (10.25%), ash (1.64%), and water (15.03%). Comparisons of glycemic index between Gulo Puan (88.69%) and brown sugar (95.05%) exhibited a statistically significant average difference (p-value 0.004 (<0.05)). Similarly, a comparison of glycemic load between Gulo Puan (44.34%) and brown sugar (47.52%) also demonstrated a significant average difference (p-value 0.004 (<0.05)).

Keywords: *Proximity Analysis, Gulo Puan, Glycemic Index, Blood Glucose Levels*

INTRODUCTION

Sugar is a significant concern for individuals with diabetes, leading them to steer clear of foods with a sweet taste derived from sugar. This avoidance stems from various forms of sugar, including granulated sugar and brown sugar, which can elevate the body's glycemic index level and glycemic load (Astuti & Maulani, 2017). Foods with a high glycemic index are linked to heightened blood glucose levels in patients with type II diabetes mellitus.

Despite sugar being commonly employed to enhance the flavor of dishes, such as the use of granulated sugar, it poses a challenge for individuals with diabetes due to its elevated glycemic index value and limited nutritional

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content. Consequently, those with diabetes mellitus actively seek alternative sugars deemed safe for maintaining blood glucose levels.

The quantity of glucose in the bloodstream is called the blood glucose level. Typically, blood glucose levels are deemed normal when blood sugar test results fall within the 80 to 100 mg/dL range. According to Habib (as cited in (Ridwanto et al., 2021), blood glucose is a type of sugar present in the blood, originating from carbohydrates in food. Subsequently, these carbohydrates are stored as glycogen in the liver and muscles.

Brown sugar stands out as a favorable alternative to white sugar. This preference is attributed to the additional nutrients present in brown sugar, such as manganese, boron, nitrogen, and phosphorus. Brown sugar boasts higher zinc, iron, potassium, and magnesium concentrations than white sugar. Consequently, brown sugar is the preferred choice.

Protein plays a crucial role in determining the glycemic index of food. Foods with a high protein content exhibit a lower glycemic index than those with equivalent carbohydrate levels (Probosari, 2019). Among animal foods, milk and its derivatives stand out for their nutritional value, particularly their high protein content. Moreover, these products are readily available and widely consumed by the public (Suciati & Safitri, 2021). Exploring options with a higher protein content is essential to address the need for an alternative sugar with a lower glycemic index.

In South Sumatra, specifically in OKI Pampangan, a unique type of sugar known as gulo puan is produced. Gulo puan is crafted from buffalo milk and granulated sugar, with these ingredients heated over low heat for 4-5 hours until the milk undergoes caramelization. Residents commonly enjoy gulo puan as a snack or as an addition to various dishes, relishing its sweet and savory taste. Notably, gulo puan, derived from buffalo milk, renowned for its high nutritional value, holds the potential as a source of antioxidants (Miskiyah, 2011; Suciati & Safitri, 2021). According to Jenkins et al. (as cited in, foods with elevated protein and fat content exhibit a lower glycemic index than similar foods with lower protein and fat content. This characteristic positions gulo puan as a promising processed product with a high protein content. There is also optimism that gulo puan can be developed as an additional ingredient in food, imparting a sweet taste and serving as a viable alternative for individuals with diabetes mellitus. However, the current absence of data regarding the nutritional content, glycemic index, and glycemic load of gulo puan necessitates further investigation. In this research, we aim to conduct a proximate analysis of gulo puan and analyze its glycemic index and glycemic load compared to other sugars.

METHODS

This research constitutes a laboratory experimental study in which proximate analysis will be conducted on gulo puan. The objective is to compare the glycemic index and glycemic load of gulo puan with granulated and brown sugar.

Nutrient of gulo puan content analysis was performed at the laboratory of PT Saraswati Indo Genetech Bogor. The total energy and energy derived from fat were calculated using a specific method. The assessment of ash content employed the SNI 01-2891-1992 point 6.1 test method, while water content analysis utilized the SNI 01-2891-1992 point 5.1 test method. For carbohydrate analysis, the difference method was applied with the 18-8-9/MU/SMM-SIG test (calculation), total fat content was determined using the Weibull Test (18-8-5/MU/SMM-SIG point 3.2.2), and protein levels were measured through the Titrimetric Test (18-8-31/MU/SMM-SIG).

Gulo puan was obtained directly from the original gulo puan craftsmen in Pampangan village, and experimental assessments of glycemic index and glycemic load were conducted by administering glucose loads from gulo puan, granulated sugar, and brown sugar to respondents. The test protocol is outlined as follows:

The respondent selection was executed through the purposive sampling method. The criteria for selecting subjects were based on prior glycemic index research, as demonstrated in the study by (Ningrum et al., 2011), where ten respondents were deemed sufficiently representative for determining the glycemic index. For the present study, researchers selected 15 subjects who satisfied the predefined inclusion and exclusion criteria. Inclusions encompassed adults without health issues (aged 18-25), willing to

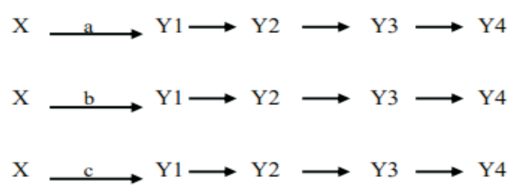

Figure 1. Research Stages

Note:
X: Initial measurement of blood glucose levels before administering the test foods
a: Treatment involving the administration of gulo puan as a test food
b: Treatment involving the administration of sugar as a test food
c: Treatment involving the administration of brown sugar as a test food
Y1: Measurement of blood glucose levels 30 minutes before administering the test foods
Y2: Measurement of blood glucose levels 60 minutes after administering the test foods
Y3: Measurement of blood glucose levels 90 minutes after administering the test foods
Y4: Measurement of blood glucose levels 120 minutes after administering the test foods

commit to three-week participation in the research, possessing a body mass index (BMI) within the range of 18.5 to 25.0, and lacking a history of glucose metabolism problems, diabetes, or food allergies. Exclusions were applied to respondents with a history of difficult-to-stop bleeding diseases or blood clotting issues, those taking excessively long to consume the test food, and those failing to attend scheduled research meetings.

This research was conducted for 3 weeks. Every week respondents will be given treatment. The treatment stages are as follows :

1. Before giving the test food, respondents were asked to fast for 10-12 hours at night, eat normal portions before fasting, and not do heavy activities.
2. The respondent came to biomedical laboratory once in a week in every morning then received treatment as: in the first week respondents were given granulated sugar treatment, in the second week they were given gulo puan and in the last week they were given brown sugar.
3. The respondent primary data for the study consisted of blood samples and blood glucose levels of the subjects measured at 0 (fasting blood), 30, 60, 90, and 120 minutes (after ate the test food). The blood sample was taken by researcher using portable glucose test.

The test foods (Gulo puan, granulated sugar, and brown sugar) will be dissolved in 200 mL of warm water to facilitate dissolution and consumption by the respondents. Respondents are instructed to complete the ingestion of the test foods within a 10-minute timeframe. Each portion of the test food should correspond to 50 grams of carbohydrates, resulting in the following quantities: granulated sugar (53.2 grams), puan sugar (92.6 grams), and brown sugar (54.4 grams). These amounts are determined based on the calculation of carbohydrate content according to TKPI 2017 (Indonesian food composition table of 2017).

The analysis and presentation of data regarding the nutritional content of gulo puan were conducted descriptively. For the glycemic index and glycemic load, the area under the curve was calculated using the trapezoid method both manually and with the Microsoft Excel program. The calculation of the area of a trapezoidal shape is determined by the formula:

$$\text{Area of trapezium} = \frac{number\ of\ parallel\ sides}{2} \times height \ldots (1)$$

To ascertain the values of the glycemic index (GI) and glycemic load (GL), calculations are performed using the following formula:

$$\text{GI} = \frac{x}{y} \times 100\% \ldots (2)$$

where;
x = the area under the blood glucose response curve after two hours of the test food
y = the area under the blood glucose response curve after two hours to a standard meal

$$\text{GL} = \frac{GI \times z}{100} \ldots (3)$$

where;
z = total carbohydrates in one serving of test food

In this research, statistical data analysis was conducted using Microsoft Excel. The normality of the data was assessed using the Shapiro-Wilk test due to the sample size being less than 50 individuals. Subsequently, the researcher employed the Independent T-test for normally distributed data and the Mann-Whitney test for data that did not exhibit normal distribution (Suyanto & Gio, 2017).

All stages of this research received approval from the Sriwijaya University FKM Health Research Ethics Committee, as indicated by the letter with reference number 059/UN9.FKM/TU.KKE/2023, dated January 25, 2023.

RESULTS AND DISCUSSIONS

Nutritional Value of Gulo Puan

Gulo puan, a distinctive food originating from South Sumatra, is crafted from granulated sugar and buffalo milk and subjected to a 4-5 hour low-temperature heating process. An analysis of 100 g of gulo puan reveals an average total energy of 417.44 kcal, with 153.36 kcal derived from fat. The moderate ash content in gulo puan is 1.64%, demonstrating compliance with the ash content standards outlined in SNI 1-6237-2000. This standard dictates a maximum ash content of 2% for cane brown sugar (Erwinda & Susanto, 2014). Notably, ash content serves as a determinant for assessing metal contamination in food, and additionally, it acts as an indicator of food safety (Kristiandi et al., 2021).

The average water content in gulo puan is 15.03%, surpassing the water content in palm sugar, commonly known as molded and crystalline brown sugar, which stands at 10.28% and 3.64%, respectively (Ismail et al., 2020). Water plays a crucial role in determining food quality, as Ismail et al. (2020) emphasize.

Table 1. Proximate analysis of Nutritional Composition Gulo Puan

No	Parameter	Mean Result (%)
1.	Total Energy / 100 gr	417.44 kcal
2.	Energy from Fat / 100 gr	153.36 kcal
3.	Carbon	1.64
4.	Water	15.03
5.	Carbohydrate	55.93
6.	Total Fat	17.04
7.	Protein	10.10

Source : primary laboratory data (2023)

Riawan (as cited in Ismail et al., 2020) asserts that carbohydrate calculations are based on the remaining water, ash, protein, and fat content. In the case of gulo puan, the average carbohydrate content is 55.93%, indicating a lower carbohydrate content compared to molded and crystal palm sugar, which registers at 84.99% and 92.62%, respectively (Ismail et al., 2020). (Ismail et al., 2020) further note in their research that the carbohydrate content in food is linked to blood glucose response, providing insights into the glycemic index.

Gulo puan serves as an alternative sugar rich in both fat and protein. The average total fat content in gulo puan is 17.04%. In contrast, (Ismail et al., 2020) state that palm sap lacks fat. Gulo puan's protein content averages 10.10%, starkly contrasting the 0.41% protein content found in palm sap (Ismail et al., 2020). The elevated fat and protein levels in gulo puan can be attributed to buffalo milk, one of its key ingredients. Both protein and fa in food can influence the glycemic index. Simultaneously, increased protein content in food is believed to stimulate insulin secretion, contributing to regulating blood glucose levels (Arif et al., 2013; Ismail et al., 2020).

Higher fat content in food can slow down gastric emptying, consequently retarding the digestion process in the small intestine. Fat in food has a special taste that affects the deliciousness of the food. The PUFA content in food, including ω-3 and ω-6 fatty acids, prevents diabetes, obesity, atherosclerosis and autoimmune-inflammatory diseases (Simopoulos, 2016). Excessive amounts of cholesterol in the blood will cause accumulation or atherosclerosis which is the main trigger for stroke and coronary heart disease (CHD) and can increase the risk of obesity and result in decreased fitness and work productivity (Kushargina & Purnamasari, 2021; Permatasari et al., 2022). Therefore, it is necessary to pay attention to the choice of type of fat from the food consumed

Granulated Sugar Intervention

The presented graph depicts the intervention administered to 15 respondents, indicating an average fasting blood glucose level of 91.4 mg/dL. Subsequent measurements at 30, 60, 90, and 120 minutes reveal blood glucose levels of 136.73 mg/dL, 131 mg/dL, 112.73 mg/dL, and 92.46 mg/dL, respectively.

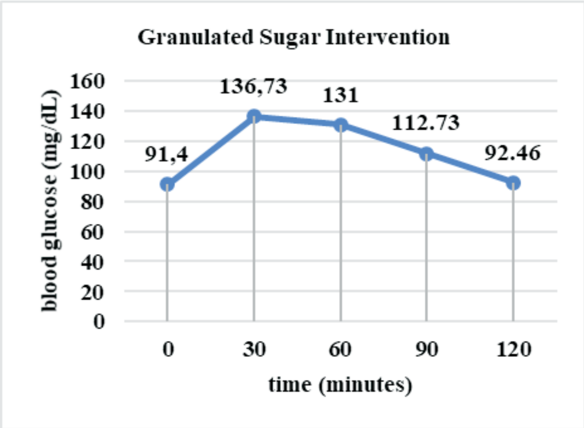

Figure 2. Granulated sugar intervention result.

These findings align with established theoretical principles positing a notable elevation in blood sugar levels after administering simple carbohydrates to respondents. However, the magnitude of this increase varies depending on the glycemic index and the quantity consumed (Fadhilah, 2012). Notably, simple carbohydrates and complex carbohydrates exhibit disparate glycemic indexes. Pujiastuti (2022) elucidated that simple carbohydrates can stimulate heightened insulin hormone production, thereby precipitating a rapid surge in blood sugar levels.

According to the research findings of (Novrian & Hajar, 2020), a statistically significant difference is evident in the blood glucose levels increase before and after administering sugar and honey. Blood glucose, the primary type of sugar in the bloodstream, is the body's principal energy source. Originating from consumed food, glucose can also be synthesized by the liver and muscles through the breakdown of glycogen stores into glucose. As elucidated by Novrian & Hajar (2020), blood glucose undergoes conversion into energy for utilization by all cells in the body. The hormones insulin and glucagon intricately regulate the mechanism of glucose control. Following a meal, increased glucose levels prompt elevated insulin secretion, stimulating the liver to store glucose as glycogen. This facilitates the saturation of cells, particularly in the liver and muscles, with glycogen. Surplus glucose, if present, is stored as fat.

Conversely, a decrease in blood glucose levels triggers a reduction in insulin secretion and an increase in glucagon secretion by the pancreas. Subsequently, the liver and muscles respond to this hormonal signal, leading to a depletion of glycogen stores and the subsequent breakdown of glycogen into glucose. This released glucose enters the bloodstream, maintaining blood glucose levels within the normal range (Novrian & Hajar, 2020).

Gulo Puan Intervention

The graph's findings illustrate that the elevation in blood glucose levels following the gulo puan intervention is comparatively lower than that observed with granulated sugar. This discrepancy can be attributed to the high protein content inherent in gulo puan. According to (Frid et al., 2005), adding 18 grams of whey protein to carbohydrate-containing foods facilitates expedited digestion and absorption. This, in turn, leads to an increase in plasma insulin concentration and a subsequent decrease in postprandial glucose levels. The fluctuations in postprandial blood glucose are intricately linked to satiety levels and food intake dynamics (Akhavan et al., 2011). Mayer's glucostatic theory (as cited in Akhavan et al., 2011) posits that alterations in blood glucose can influence changes in food intake. Hunger initiates when glucose levels are low, while a surge in glucose levels induces a sensation of fullness. Given the brain's dependence on glucose as an energy source, glucose concentration becomes a pivotal factor in appetite control (Marty et al., 2007).

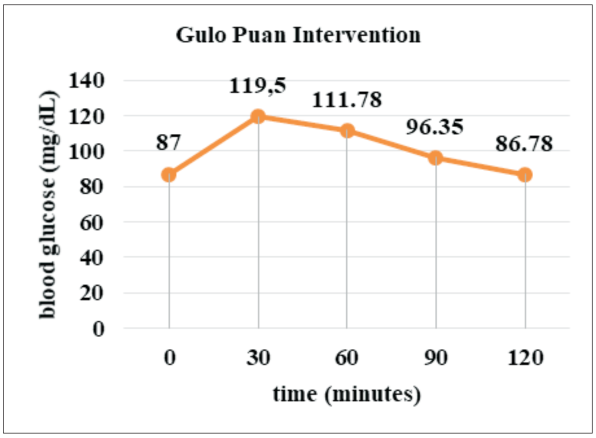

Figure 3. Gulo puan intervention result.

Confirming this perspective, (Van Meijl & Mensink, 2013) research asserts that the administration of high-protein milk can decrease postprandial blood glucose levels by 24%

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compared to controls. Similar outcomes were reported by (Kung et al., 2018), wherein the high protein milk group exhibited a superior reduction in postprandial blood glucose, as indicated by the iAUC value, compared to the control group ($p < 0.005$). The advantage of milk protein lies in its capacity to stimulate insulin release, potentially modifying glucose absorption in tissues and mitigating postprandial blood glucose fluctuations (McGregor & Poppitt, 2013).

Brown Sugar Intervention

The elevation in postprandial blood glucose levels after ingesting brown sugar has been empirically substantiated to be comparatively less pronounced than the corresponding surge observed upon the consumption of granulated sugar. (Swastini et al., 2018) posit the potential of brown sugar as an agent with antidiabetic properties. Notably, Mody et al. and Merentek (as referenced in Swastini et al., 2018) contend that brown sugar contains calcium, which plays a crucial role in the glucose metabolism process facilitated by glucokinase. The antidiabetic activity of calcium has been shown to enhance insulin excretion, subsequently reducing blood glucose levels. This process induces changes in the ATP/ADP ratio, resulting in the closure of potassium ion channels and neutralization of cell membranes. Consequently, calcium channels open, allowing calcium to enter the cells. Merentek (as cited in Swastini et al., 2018) further asserts that an increase in intracellular calcium can translocate insulin granules to the membrane, facilitating insulin release into the bloodstream.

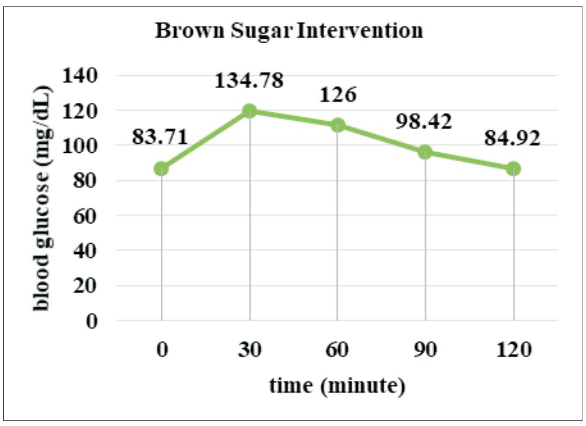

Figure 4. Brown sugar intervention result.

Suroso (as cited in Fajriansyah, 2020) asserts that consuming brown sugar is more advantageous for the body due to its derivation from natural ingredients and its production without the incorporation of significant chemicals. Moreover, brown sugar is rich in vitamins, which is attributed to its natural processing methods, ensuring that its inherent nutritional content remains preserved (Fajriansyah, 2020).

Swastini et al.'s research (2018) collected data regarding the fluctuations in blood glucose levels for each treatment across various test periods, namely 7, 14, 21, and 28 days. The conclusive measurements on day 28 and the difference test results assessing the decrease in blood glucose levels between day 0 and day 28 demonstrated a significant reduction in blood glucose levels compared to the negative control. Butcher's findings indicate that physiological responses to anxiety can impact endocrine function, explicitly affecting the hypothalamus and pituitary, resulting in an elevation of cortisol levels. This, in turn, produces an antagonistic effect on insulin function, leading to suboptimal blood glucose control and subsequent fluctuations in blood glucose levels during therapy (Swastini et al., 2018).

This observation aligns with Sujarwo's research (as cited in Fadhilah, 2012), indicating that elevated blood sugar levels are influenced by the consumption of carbohydrates, encompassing both simple and complex carbohydrates. These two categories of carbohydrates exhibit distinct glycemic indexes.

Glycemic Index

The presented tabular data delineates the glycemic indices of brown sugar and gulo puan, registering at 95.05% and 88.69%, respectively. The glycemic index classification entails three distinct categories: low glycemic index (<50), medium glycemic index (50-70), and high glycemic index (>70). Despite the marginal difference in numerical values, it is discernible that the glycemic index of gulo puan is 6.36% lower than that of

Table 2. Glycemic Index of the Intervention Food

Food	Glycemic Index (100%)	P- value*
Gulo Puan	88.69	0.004
Brown sugar	95.05	

brown sugar, albeit both substances fall within the high glycemic index category. The assessment of the difference between two independent means, conducted through the Mann-Whitney test, reveals non-homogeneous data variance for the two groups. This implies a statistically significant average distinction between the glycemic indices of gulo puan and brown sugar, corroborated by a calculated p-value of 0.004 ($p > 0.05$).

Gulo puan, characterized by a lower glycemic index, owes this attribute to its processing method and inherent composition, which influence absorption in the digestive tract and consequently impact blood glucose levels. The principle is that the food absorption rate correlates inversely with its glycemic index; thus, slower absorption results in a lower glycemic index. The heightened fat content in gulo puan contributes to its delayed absorption. This aligns with Probosari's research (2019), which elucidates that fatty foods can decelerate gastric emptying, impeding HCl secretion. Consequently, the fat content induces a more gradual blood glucose response, diminishing the glycemic index level.

In contrast to brown sugar, gulo puan is characterized by noteworthy protein content. The protein content emerges as a salient determinant exerting influence over the glycemic index of food, with an observed inverse relationship between higher protein content and lower glycemic index levels, as elucidated by Probosari (2019). The confluence of elevated protein content and diminished glycemic index levels in comestibles precipitates a moderated insulin secretion and a constrained glycemic response (Makris et al., 2011). Moreover, contributors to a subdued glycemic response encompass the gradual conversion of protein into glucose, resulting in a nominal protein-to-glucose transformation. Additionally, the hepatic breakdown of glycogen occurs without a simultaneous escalation in glucose release (Molitch et al., 2004).

This phenomenon is further influenced by the distinctive characteristics of proteins, particularly their capacity to elicit insulin secretion without concurrent elevation in blood glucose levels. Makris et al. (2011) contend that this occurrence is plausible due to the relatively weaker insulin secretion induced by the presence of protein compared to carbohydrates. Additionally, the digestive process of protein is known to stimulate the release of cholecystokinin, a hormone associated with heightened feelings of satiety. Consequently, proteins emerge as a macronutrient exerting a prolonged satiating effect compared to carbohydrates and fat (Makris et al., 2011).

This investigation showed that gulo puan and brown sugar exhibited relatively high glycemic index levels, possibly attributable to specific processing techniques. How food undergoes processing can significantly impact its glycemic index. Drawing insights from Amalia's research (as cited in Arif et al., 2013), it is observed that sweet corn subjected to different processing methods—namely boiling, sautéing, and roasting—demonstrates a heightened glycemic index in the case of grilled corn when compared to boiled and fried counterparts. This disparity arises due to the protracted exposure to high temperatures during processing, rendering the carbohydrate composition more readily digestible. This assertion is substantiated by (Eleazu, 2016), who contends in his study that roasting contributes to an elevated glycemic index in food compared to frying or boiling methods. This outcome is ascribed to the transformative gelatinization induced by high temperatures, causing a permanent alteration in the amylose-amylopectin structure. Consequently, the food becomes more susceptible to enzymatic digestion, resulting in a concomitant surge in blood sugar levels directly associated with a high glycemic index. The extended cooking duration of gulo puan, spanning 4-5 hours, may elucidate why, despite its protein richness, it sustains a high glycemic index level.

Glycemic Load

In the table, the highest glycemic load is attributed to brown sugar at 47.52%, whereas gulo puan exhibits a comparatively lower glycemic load of 44.34%. An evaluation employing the test of the difference between two independent means (Mann-Whitney) revealed a lack of homogeneity in the p-value of the data for the two groups.

Table 3. Glycemic load of the Intervention foods

Food	Glycemic Load (100%)	*P- value**
Gulo Puan	44.34	0.004
Brown sugar	47.52	

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Notably, a significant average difference between the glycemic load of Gulo Puan and brown sugar was identified ($p = 0.004$, $p > 0.05$).

Glycemic load delineates the quantity of carbohydrates present in a food item, with each gram of carbohydrates capable of eliciting an increase in blood sugar levels. Consequently, glycemic load is intricately linked to two determining factors: the glycemic index and the serving size. The interplay between glycemic load and the size of food portions can impart varying effects on blood sugar response. This variability is notable when comparing foods with a high glycemic load consumed in small quantities versus those consumed in larger quantities. In this investigation, a standardized carbohydrate portion of 50 grams was employed for each sugar, equivalent to 92.6 grams for gulo puan and 54.4 grams for brown sugar.

The Ministry of Health of the Republic of Indonesia (KEMENKES RI) recommends a daily sugar intake of 5 tablespoons or 50 grams per person. Excessive consumption beyond this prescribed limit is anticipated to result in a heightened glycemic load, impacting an elevation in blood sugar levels. This is postulated to contribute to the elevated glycemic load observed in Gulo Puan. The rationale behind this assertion is that the portion administered during the test surpasses the stipulated recommendation. Consequently, a plausible scenario exists wherein the glycemic load of Gulo Puan could be categorized as moderate if adhering to the recommended portion size.

Brown sugar is a food ingredient with a higher glycemic content when juxtaposed with gulo puan. This discrepancy arises from distinct variations in food composition, influencing absorption within the digestive tract. In contrast, gulo puan manifests a lower glycemic load. Consuming foods with a low glycemic load can mitigate the pace of blood sugar absorption and inhibit pancreatic insulin secretion, consequently averting spikes in blood sugar levels (Idris et al., 2014).

The study by Idris et al. (2014) underscores that individuals exhibiting favorable glycemic load values comprise 50% of the patient cohort, mirroring the percentage observed in patients with unfavorable glycemic load values. However, the latter signifies that the most significant proportion, accounting for 95.7%, belongs to the subgroup of patients with inadequately controlled blood sugar levels. Hence, these findings illuminate a discernible and statistically significant relationship between the glycemic load of dietary intake and blood sugar levels in individuals with type 2 diabetes mellitus.

Foods characterized by a high glycemic load pose potential health risks, including obesity and diabetes. Therefore, heightened consumer awareness is imperative to ensure adherence to recommended daily limits. In a parallel vein, gulo puan can be safely consumed by individuals with diabetes, adhering to the specified portion of 50 grams, as endorsed by the Indonesian Ministry of Health.

Gulo puan, boasting a distinctive flavor reminiscent of sweet cheese, offers versatility as a beverage enhancer or a spread on bread (Shandy, 2022). Serving as an alternative sugar for individuals managing diabetes, gulo puan stands out as a nutritionally sound food product and holds promise as a primary or supplementary ingredient for locally inspired products in food development. This is exemplified by the research of (Yuliati & Hamzah, 2022), wherein gulo puan is featured as a critical component in the production of chocolate bars. Furthermore, investigations conducted by (Sartika et al., 2019) showcased the innovative transformation of gulo puan into Puan Candy. The utilization of gulo puan emerges as a means to augment food content with commendable nutritional value and as a strategy to enhance the allure of gulo puan as an emblematic culinary offering from Pampangan, South Sumatra.

There is a critical need to advocate for the significance of reading food packaging labels, as this endeavor is anticipated to assist individuals in transcending prevailing paradigms associated with degenerative diseases, particularly diabetes. Such paradigms often manifest as perceived limitations in the consumption of specific foods. Elevating consumer awareness regarding the interpretation of food labels can empower individuals to make informed choices about their dietary intake. This, in turn, is a proactive measure to mitigate the risk of blood sugar spikes associated with suboptimal food choices.

CONCLUSION

Based on the outcomes of comparative tests assessing the glycemic index and glycemic load of gulo puan, granulated sugar, and brown sugar, it is deduced that the average blood glucose levels of respondents before consuming gulo puan, granulated sugar, and brown sugar were 87 mg/dL, 91.4 mg/dL, and 83.71 mg/dL, respectively. After consumption, the average blood glucose levels of respondents experienced a peak increase in the 30th minute, reaching 119.5 mg/dL for gulo puan, 136.73 mg/dL for granulated sugar, and 134.78 mg/dL for brown sugar, followed by a gradual decline from the 60th to the 120th minute.

Gulo puan exhibits a lower glycemic index and load than brown sugar, accompanied by a statistically significant mean difference (p-value 0.004, < 0.05). Proximate composition analysis reveals that gulo puan boasts an energy content of 417.44 kcal/100 g, with 153.36 kcal attributed to fat. The ash and water content of gulo puan is recorded at 1.64% and 15.03%, respectively. Furthermore, gulo puan manifests higher levels of fat (16.65%) and protein (10.25%), coupled with lower carbohydrate content (55.93%) than brown sugar. Consequently, it emerges as a viable alternative sugar for individuals managing diabetes. However, the amount and processing as an alternative sugar must be considered, especially when combined with other high-fat foods.

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All authors declare that they have no conflicts of interest.

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