



Functional cookies formulation based on red ginger by- products (juice) for diabetes mellitus patients: approach zero waste in Micro, Small Medium Enterprise (MSMEs)

Formulasi cookies fungsional berbasis hasil samping (perasan) jahe merah untuk penderita diabetes mellitus: pendekatan zero waste di Usaha Mikro, Kecil dan Menengah (UMKM)

Isti Istianah¹, Ratnayani², Mia Srimati^{3*}, Ni'ma Ghaida⁴, Meyra Sakura⁵, Sarah Salsabila⁶

¹ Nutrition Study Program, Binawan University, East Jakarta, Indonesia.

E-mail: isti@binawan.ac.id

² Nutrition Study Program, Binawan University, East Jakarta, Indonesia.

E-mail: ratnayani@binawan.ac.id

³ Nutrition Study Program, Binawan University, East Jakarta, Indonesia.

Email: mia@binawan.ac.id

⁴ Nutrition Study Program, Binawan University, East Jakarta, Indonesia.

E-mail:

nima.042111068@student.binawan.ac.id

⁵ Nutrition Study Program, Binawan University, East Jakarta, Indonesia.

E-mail:

meyra.042111028@student.binawan.ac.id

⁶ Nutrition Study Program, Binawan University, East Jakarta, Indonesia.

E-mail:

sarah.042111030@student.binawan.ac.id

*Correspondence Author:

Nutrition Study Program, Binawan University, East Jakarta, Indonesia.

E-mail: mia@binawan.ac.id

Article History:

Received: January 13, 2025; Revised: April 15, 2025; Accepted: July 22, 2025;

Published: September 08, 2025.

Publisher:



Politeknik Kesehatan Aceh
Kementerian Kesehatan RI

© The Author(s). 2025 **Open Access**

This article has been distributed under the terms of the *License Internasional Creative Commons Attribution 4.0*



Abstract

Diabetes mellitus is one of the major health issues in Indonesia, and Diabetes mellitus is a significant health issue in Indonesia, and consuming low-glycemic index foods can help manage blood sugar levels. This study aimed to develop a cookie formula incorporating red ginger by-products and analyze its proximate composition, fiber content, antioxidant activity, and glycemic index. The research methods included an organoleptic test involving 30 panelists, chemical composition analysis, and a glycemic index test on 20 subjects. Organoleptic test results showed that cookies with red ginger by-products had a more preferred color and taste than control cookies. Chemical analysis revealed an increase in dietary fiber content and antioxidant activity in cookies containing red ginger byproducts. The glycemic index test indicated that these cookies contributed to a more stable reduction in the blood sugar levels. The study concludes that incorporating red ginger by-products into cookie formulations can provide additional nutritional benefits for patients with diabetes mellitus while supporting sustainability through a zero-waste approach. These findings highlight the potential of red ginger by-products as a functional food ingredient that benefits both health and environmental sustainability, encouraging further exploration of food by-product utilization in functional food development.

Keywords: Diabetes, functional, ginger, glycemic

Abstrak

Diabetes melitus merupakan salah satu masalah kesehatan utama di Indonesia, dan mengonsumsi makanan dengan indeks glikemik rendah dapat membantu mengatur kadar gula darah. Penelitian ini bertujuan untuk mengembangkan formula cookies yang mengandung produk samping jahe merah, menganalisis komposisi proksimat, kandungan serat, dan aktivitas antioksidan, serta mengukur indeks glikemiknya. Metode penelitian yang dilakukan meliputi uji organoleptik yang melibatkan 30 panelis, analisis komposisi kimia, dan uji indeks glikemik pada 20 subjek. Hasil uji organoleptik menunjukkan cookies dengan produk samping jahe merah mempunyai warna dan rasa yang lebih disukai dibandingkan cookies kontrol. Analisis kimia menunjukkan peningkatan kandungan serat makanan dan aktivitas antioksidan pada cookies yang mengandung produk samping jahe merah. Uji indeks glikemik menunjukkan bahwa cookies dengan produk samping jahe merah memberikan penurunan kadar gula darah yang lebih stabil. Studi ini menyimpulkan bahwa penggunaan produk samping jahe merah dalam formulasi kue dapat memberikan manfaat nutrisi tambahan bagi pasien diabetes melitus dan mendukung keberlanjutan melalui pendekatan tanpa limbah.

Kata Kunci: Diabetes, fungsional, jahe, glikemik

Introduction

Diabetes mellitus is one of the main health problems in Indonesia and its prevalence continues to increase. Currently, there are around 19,47 million diabetes sufferers in Indonesia (the most) fifth in the world, (IDF, 2019) and DKI Jakarta has prevalence of diabetes mellitus the highest in Indonesia, namely by 3,4 % (Arablou et al., 2014). Impact negative from height prevalence of diabetes mellitus in Indonesia including is improvement risk complications serious health problems, such as disease heart, failure kidney, blindness, amputation, cancer, and mortality related infection including COVID-19 (Topka et al. 2023; Istianah et al., 2020). In addition, diabetes also increases burden economy that requires an integrated intervention strategy (International Diabetes Federation, 2019; Kanter, 2016). Therefore, innovation in the development of foods that maintain blood sugar levels is required. Consumption of food with an index glycemic low can help lower blood glucose levels in patients with diabetes (Tomic & Shaw, 2022).

Ginger is known to be a potential bioactive component for the prevention and treatment of various diseases through modulation of biological activities, such as antioxidant and anti-inflammatory activities (Gopisetty et al., 2018). Red ginger contains gingerol, shogaol, and paradol which are known own effect antioxidant and anti-inflammatory compounds. This can help increase insulin sensitivity and reduce stress-related oxidative stress and the complications of diabetes. Research shows that the consumption of ginger red can lower blood sugar levels, fasting, and HbA1c. Consumption of ginger can significantly lower fasting sugar levels, HbA1c, Apo B, Apo B/Apo AI, and MDA, as well as increase Apo AI levels in type 2 diabetes patients (Zawudie et al., 2022). Therefore, the use of ginger shows potential in controlling glucose term length in patients with type 2 diabetes.

In 2020, Indonesia became one of the countries exporting ginger the biggest fifth in the world, with rhizome ginger white and ginger red as the two main types. Ginger can also be processed as a base material for various products (Almasri et al., 2020). Example processed ginger among them is herbal drink ginger dry for spice or industry pharmaceutical, powder ginger instant, candy, and tea ginger which is rich in benefits (Istianah et al., 2020;

Rahmani & Al shabirmi, 2014; Arablou et al., 2014). The production process drinks ginger and its extract often produces dregs, which, although still possess potential properties, are usually not utilized optimally. Red ginger pulp can actually become a beneficial product through development. Red ginger pulp not only enriches the sensory characteristics of food, such as cake rise, but also offers nutritional benefits (FAOSTAT, 2024). Research has shown that the addition of powdered ginger red to products such as Swiss roll cake and cakes can increase organoleptic characteristics, such as aroma and texture, as well as give a distinctive taste (Hamsidar & Widysusanti, 2021).

The utilization of red ginger pulp also supports draft *zero waste* and sustainability, which have become global attention at the moment. In line with this, UMKM, which operates in the field of food production, has the potential to increase the mark economy of red ginger pulp through the formulation of innovative functional food products. Cookies based on red ginger pulp will not only provide a healthy alternative food for diabetes mellitus sufferers but also become an example of an environmentally friendly production environment. The use of red ginger pulp in food formulations can also increase nutritional benefits such as high fiber and antioxidant content (Fauzan et al., 2020).

In the development of functional cookies, besides using red ginger pulp, we will also explore the use of flour mocaf as a replacement flour wheat and stevia as a substitute for granulated sugar, to ensure that products produced low index glycemic and are suitable for diabetes sufferers. In addition, it is hoped that it can evaluate the potential pilot production of dregs cookies ginger red in UMKM and identify the impact to subtraction results side, with the hope of increasing the welfare UMKM economy and contributing to the effort of the sustainability environment.

This study aimed to develop functional cookies made with red ginger pulp to support blood sugar management in patients with diabetes mellitus. This includes analyzing the proximate composition, fiber content, and antioxidant activity of the best formula based on organoleptic evaluation (color, aroma, taste, and texture), measuring the glycemic index of the cookie product, implementing a pilot production project in MSMEs to gather practical input and refine production methods, and assessing the

market acceptance and economic feasibility of red ginger pulp-based cookie production.

Methods

This study consists of a number of stages, namely making powdered ginger red (from dregs). Dregs ginger obtained from the side products in MSMEs in this study was obtained from PT Blooming Seven. The manufacturing process of powder dregs ginger was conducted in the Laboratory Culinary and Dietetics of Binawan University. Red ginger pulp, which becomes a powder, is then formulated into cookies. The formulation was prepared by adding 2,5%, 5%, 7,5%, and 10% of flour wheat to each formula (F1, F2, F3, F4).

The control formula did not add powder from dregs ginger. The formulation process will be conducted at the Laboratory Culinary and Dietetics of Binawan University. Organoleptic tests conducted include hedonic and hedonic quality tests, involving as many as 30 panelists (semi-trained). The analyzed aspects included color, aroma, taste, and texture. Organoleptic tests were conducted in the laboratory of Binawan University. The highest average hedonic test results were stated as the product selected.

Selected *cookies* (based on the results of the hedonic test assessment) and control cookies were then analyzed for proximate levels (water content, acidity content) ash, protein, fat, and carbohydrates), fiber food content, fiber roughness, and antioxidant activity. This study aimed to determine the impact of adding red ginger pulp to cookies. All activity analyses will be conducted at PT. Vicmalab Indonesia.

The index test glycemic at stage will be conducted on 20 healthy subjects fulfilling the inclusion and exclusion criteria for the known marker index glycemic index in dregs cookies ginger red. This test was conducted on 20 subjects who were previously requested to fast for 12 h and then checked for blood glucose levels. Subjects were given a glucose solution of as much as 50 g, and blood samples were taken from subjects at 15, 30, 45, 60, 90, and 120 min after eating. The same results were obtained for the control and selected formula cookies with red ginger pulp.

After determining the best formula and characterizing it as well as the counted mark

index glycemic, the next stages are the production process experiments in MSMEs. This study will be conducted at PT Blooming Seven, which is located in eastern Jakarta. Cookies that will be produced are selected based on the results of the hedonic test. Dregs of ginger were obtained from the results of garlic juice production at PT Blooming Seven, which uses ginger red as one of the material defaults. Cookies that have been made then analyze the eligibility economy, which includes aspects such as technical, market, management and organization, finance, law, and environment.

The data analysis techniques used in this study included several methods. Organoleptic testing was conducted using a hedonic test with 30 panelists, and the data were analyzed using the Kruskal-Wallis test. If significant differences were found, the Mann-Whitney test was performed as a post-hoc analysis. Chemical composition analysis included proximate analysis, fiber content, and antioxidant activity, comparing the control formula (without red ginger by-product) and the selected formula (with red ginger by-product). The glycemic index test involved measuring blood glucose levels in 20 subjects at different time points (0, 15, 30, 45, 60, 90, and 120 min) after consuming the glucose solution, control cookies, and treatment cookies. Statistical analysis was applied to evaluate the organoleptic test results using the Kruskal-Wallis and Mann-Whitney tests, while glycemic index data were compared between the treatment groups to observe blood glucose trends. Additionally, an economic feasibility analysis is conducted to assess the cost efficiency and profitability of the product. These analytical techniques aim to comprehensively evaluate the characteristics of functional cookies made from red ginger by-products, in terms of sensory attributes, chemical composition, blood sugar regulation, and economic viability.

Result and Discussion

This research began with the manufacture of red ginger powder (from dregs) obtained as a by-product of the production of UMKM PT. Blooming Seven. After being dried and ground into a powder, ginger dregs were used as ingredients in making cookies. The cookies included a formula of cookies, both control (F0) and formulas with the addition of red ginger

dregs (F1, F2, F3, and F4). For F0, the control formula, it did not contain red ginger dregs, while for F1 it contained 2,5% red ginger dregs as a substitute for wheat flour, F2 contained 5% red ginger dregs, F3 contained 7,5% red ginger dregs and F4 contained 10% red ginger dregs.

The composition of the ingredients in each formula uses one recipe of wheat flour, which is 400 g, and each formula of wheat flour grammage is the same; therefore, for F1, it is 10 g, F2 is 20 g, F3 is 30 g, and F4 is 40 g. The process of making cookies is carried out in the Culinary and Dietetics Laboratory of Binawan University by focusing on the balance between the main ingredients, such as flour, sugar, and fat, to ensure consistency of texture.

Based on the results of organoleptic tests carried out by 30 panelists, related data on color, taste, and texture were obtained from various cookie formulations containing red ginger pulp. In general, the color of cookies with added red ginger pulp was more positive compared to control cookies (F0), which did not contain ginger. Panelists tend to produce a color in the formulation with red ginger pulp, especially in formulations with a higher percentage of ginger, such as F4. This color is rated as more attractive and natural, which makes the cookies appear more appealing.

In terms of taste, cookies that used red ginger pulp gave different impressions compared to the control. The distinctive taste of ginger was felt by the panelists in formulations F1 to F4, with the intensity of spicy taste ginger varying. Most panelists state that they like spicy taste light until currently from the ginger contained in F1 and F2. However, in formulations F3 and F4, the taste is spicy from ginger start felt too strong by some panelists, who suggested that spiciness can balance more effectively. However, ginger has different characteristics and is preferred by panelists looking for a more intense taste complex.

In terms of texture, cookies on each formulation rated their own crispiness, with variation in the crispness felt between formulas. Panelists generally give a positive evaluation to texture, and mention that formulations with percentage dregs ginger more red tall like F3 and F4 feels a little more crispy compared to the control. In addition, formulated cookies with red ginger pulp get better assessment compared to control cookies, particularly in terms of color and taste. Based on organoleptic test results 2 formulas were obtained which will be

intervened namely F0 (without dregs ginger) and F1 (with dregs ginger).

After obtaining two formulas from the organoleptic test results, F0 (without ginger dregs) and F1 (with ginger dregs), an analysis of the chemical composition was carried out, as shown in the table below.

Table 1. Comparison of F0 and F1 analysis

Types of Analysis	F0	F1
Water content (%)	3,74	2,73
Ash Content (%)	2,78	2,8
Fat Content (%)	31,11	31,22
Protein Content (%)	5,77	5,33
Carbohydrates (%)	56,6	57,92
Crude Fiber (%)	20,81	15,45
Dietary Fiber (%)	42,49	49,36
Actv Antioxidants (%)	5,93	7,93
Total Energy (kcal)	530,0	530,0
Energy from Fat (kcal)	280,0	280,0

Based on analysis of composition chemistry, there are a number of differences between F0 (without dregs ginger) and F1 (with dregs ginger). Formula F0 has water content is 3,74%, while F1 is more low, namely 2,73%. From the side-level ash, both formulas have almost the same value, with F0 of 2,78% and F1 of 2,8%. For fat content, the differences were also very small, that is, 31,11% in F0 and 31,22% in F1. However, the protein content in F0 was slightly higher (5,77%) than that in F1 (5,33%).

In contrast, F1 had a higher carbohydrate content (57,92%) than F0 (56,6 %). However, the formula without dregs ginger (F0) showed a rougher high-content fiber (20,81 %) than F1 (15,45 %). On the other hand, the formula with dregs ginger (F1) had a higher fiber content (49,36%) compared to F0, which was only 42,49%. In addition, F1 also showed higher antioxidant activity, with a level of inhibition of 7,93%, while F0 was only 5,93%.

Even though the total energy of both formulas is the same, reaching 530 kcal, with a contribution energy from fat of 280 kcal, the difference composition shows that addition of dregs ginger in the F1 formula provides a number of profit nutrients, especially in matter fiber food and antioxidant activity.

From the proximate results analysis that can be seen in the table above, cookies containing red ginger pulp show improvement in fiber content. The formula with added red

ginger pulp (F1) had a higher fiber content than the control formula (F0). The higher dietary fiber height was caused by the fiber content in the red ginger pulp. Increased fiber content is very useful, especially for diabetes mellitus sufferers, because fiber helps in controlling blood sugar levels and slows down the absorption of glucose.

The addition of red ginger pulp also increased the antioxidant activity of cookies (IDF, 2019). Based on the resulting data, the formula with red ginger pulp (F1) showed higher antioxidant activity than the control formula (F0). Red ginger possesses its own bioactive components, such as gingerols and shogaols, which have strong antioxidant properties. Antioxidants are important because they can help avoid free radicals in the body, which contributes to the reduction of chronic disease risk, including complications of diabetes mellitus (Arablou et al., 2014).

The addition of red ginger pulp tends to lower the water content in cookies. This is visible from the water content data in the formula with dregs ginger being redder compared to the control formula. The decrease in water level contributes to a more textured crispy cookie, as it feels in organoleptic tests, where cookies with concentration dregs are considered more crispy by panelists.

The data showed that the addition of red ginger pulp slightly increased the content of carbohydrates in the cookies. This may be because the composition of red ginger pulp still contains carbohydrates. However, this increase was not significant and was still balanced with the beneficial improvement of fiber and antioxidants (Topka et al., 2023). The addition of red ginger pulp slightly reduced the protein content of the cookies. This is possible because red ginger pulp is richer in fiber compared to protein, so substitution of flour with dregs ginger lowers protein levels. However, the decline is not too significant and does not affect the overall nutritional quality of the product.

In this study, this intervention was performed for three days (August 12, 2024) for solution glucose, cookies F0 on August 14, 2024, and cookies F1 on August 16, 2024. The effect of two formulas, F0 (without dregs ginger) and F1 (with dregs ginger) and solution glucose, on blood sugar levels (Table 2).

Based on table on before consumption solution glucose, average blood sugar level

respondent with F0 was 82,25 mg/dL, while in the F1 group it was 77,05 mg/dL. After 15 min, blood sugar levels in the F0 group increased to 95,4 mg/dL, while in group F1 it became 94,4 mg/dL. At the 30th minute, the blood sugar levels continued to increase, with F0 reaching 106,3 mg/dL and F1 reaching 102,55 mg/dL. After 45 min, the blood sugar levels in the F0 group decreased to 100,75 mg/dL, while in group F1, it decreased to 97,65 mg/dL.

Table 2. Average blood sugar of respondents

Time	Solution Glucose	F0	F1
GDP	82,8	82,25	77,05
15'	116,5	95,4	94,4
30'	133,95	106,3	102,55
45'	136,3	100,75	97,65
60'	120,2	97,45	99,5
90'	108,45	94,3	92,6
120'	94,55	84,4	90,35

At the 60th minute, blood sugar levels in the F0 group were recorded of 97,45 mg/dL, while in group F1, it was slightly more high, namely 99,5 mg/dL. At the 90th minutes, the blood sugar level at F0 returned decrease to 94,3 mg/dL, while in F1 it decreased more low, namely 92,6 mg/dL. After 120 min, blood sugar levels in the F0 group fell to 84,4 mg/dL, while in group F1 it was at 90,35 mg/dL. In general, the F1 formula with dregs ginger showed a decline in higher blood sugar levels compared to F0, which does not use dregs ginger.

The average blood sugar results of the respondents in this study showed variations influenced by several factors, such as cookies with red ginger pulp content fiber more food tall compared to the control cookies. Fibers, especially fibers, dissolve and play an important role in slowing down digestion and absorption of carbohydrates in the small intestine. This causes high blood sugar levels, which are slower and steadier after consumption. In the formula with red ginger pulp, more fiber tall helps to arrange the release of glucose into the blood flow, which explains why blood sugar levels tended to be lower and more stable after consuming cookies with dregs ginger.

Red ginger is known to possess bioactive components such as gingerol and shogaol, which have antioxidant and anti-inflammatory effects. These substances can help increase insulin sensitivity and reduce oxidative stress, which

often affects the regulation of blood sugar levels in patients with diabetes (Arablou et al., 2014). Consumption of cookies containing red ginger pulp can help lower blood glucose levels.

Cookies containing fiber with higher height and antioxidant activity from ginger red tended to have a higher glycemic index (GI) than the control cookies. Food with a low glycemic index causes a further increase in blood sugar slowly and steadily. Because glucose absorption occurs gradually, this influences the blood sugar profile of respondents, who tend to be lower and more stable after consuming cookies with red ginger pulp compared to control cookies (Istianah et al., 2020).

Conclusion

This study concludes that the use of red ginger pulpin cookies can provide nutritional benefits for diabetes mellitus sufferers as well as support draft sustainability through a zero-waste approach.

Implications for practice, incorporating red ginger pulp into cookie formulations offers a sustainable food innovation with dual benefits: enhancing dietary fiber and antioxidant intake while reducing waste. For individuals with diabetes mellitus, such functional snacks may contribute to improved glycemic control. Small enterprises can adopt this approach to develop healthier value-added products

Acknowledgment

Saying thank you to the Ministry of Education, Culture, Research, and Technology as a grant under study lecturer beginner this is Binawan University, which has facilitated researchers to study this until the end.

References

- Arablou, T., Aryaeian, N., Valizadeh, M., Sharifi, F., Hosseini, A., & Djalali, M. (2014). The effect of ginger consumption on glycemic status, lipid profile and some inflammatory markers in patients with type 2 diabetes mellitus. *International Journal of Food Sciences and Nutrition*, 65(4), 515–520
- https://doi.org/10.3109/09637486.2014.880671.
- Dewati, R., Harinta, Y. W., & Setyarini, A. (2021). Pengembangan produk olahan jahe di Kecamatan Jenawi Kabupaten Karanganyar (studi kasus kelompok wanita tani Desa Sidomukti). *Jurnal Ekonomi Pertanian dan Agribisnis (JEPA)*, 5(4), 1107–1114. https://doi.org/10.21776/ub.jepa.2021.05.04.13.
- Fauzan, S., Rahmadani, D. F., Devi, L. S., Akyun, Q., & Aulia, W. (2020). Pemberdayaan masyarakat Desa Seketi melalui inovasi olahan jahe merah. *Sinergi: Jurnal Pengabdian*, 2(2), 65–68.
- Gopisetty, D., Levine, B., Liu, N., Younge, P., Brown, A., Close, K. L., & Wood, R. (2018). How does diabetes affect daily life? A beyond-A1C perspective on unmet needs. *Clinical Diabetes*, 36(2), 133–137. https://doi.org/10.2337/cd17-0093
- Hamsidar, Widysusanti, A. K., & Nur Ain, T. (2021). Pengembangan tanaman jahe menjadi produk olahan sehat sebagai alternatif pencegahan Covid-19 di Desa Ilotunggula. *Jurnal Sibermas (Sinergi Pemberdayaan Masyarakat)*, 10(1). https://doi.org/10.37905/sibermas.v10i1.10382
- International Diabetes Federation. (2019). *IDF diabetes atlas* (9th ed.). International Diabetes Federation.
- Istianah, I., Septiani, & Dewi, G. K. (2020). Mengidentifikasi faktor gizi pada pasien diabetes mellitus tipe 2 di Kota Depok tahun 2019. *Jurnal Kesehatan Indonesia*, X(2), 72–78.
- Kanter, J. E., & Bornfeldt, K. E. (2016). Impact of diabetes mellitus. *Arteriosclerosis, Thrombosis, and Vascular Biology*, 36(6), 1049–1053. https://doi.org/10.1161/ATVBAHA.116.307302
- Kementerian Kesehatan Republik Indonesia. (2018). *Laporan nasional Risesdas 2018*. Kementerian Kesehatan Republik Indonesia.
- Putri, A. P. (2018). Uji organoleptik Swiss roll cake dengan penambahan bubuk jahe merah (*Zingiber officinale* var. *rubrum* rhizome) [Tugas akhir, Program Studi

- Diploma III Tata Boga, Jurusan Perhotelan, Politeknik Negeri Balikpapan].
- Rahmani, A. H., Al Shabrmi, F. M., & Aly, S. M. (2014). Active ingredients of ginger as potential candidates in the prevention and treatment of diseases via modulation of biological activities. *International Journal of Physiology, Pathophysiology and Pharmacology*, 6(2), 125–136.
- Rahmadhia, S. N., Aditya, P. R., & Febrianti, N. (2021, Oktober 23). Pemanfaatan ampas jamu menjadi kue kering di kelompok wanita tani Desa Wareng Gunungkidul. *Prosiding Seminar Nasional Hasil Pengabdian kepada Masyarakat Universitas Ahmad Dahlan*, 353–357.
- Tomic, D., Shaw, J. E., & Magliano, D. J. (2022). The burden and risks of emerging complications of diabetes mellitus. *Nature Reviews Endocrinology*, 18(9), 525–535. <https://doi.org/10.1038/s41574-022-00690-7>
- Topka, P., Poliński, S., Sawicki, T., Szydłowska-Czerniak, A., & Tańska, M. (2023). Effect of enriching gingerbread cookies with elder (*Sambucus nigra* L.) products on their phenolic composition, antioxidant and anti-glycation properties, and sensory acceptance. *International Journal of Molecular Sciences*, 24(2), 1493. <https://doi.org/10.3390/ijms24021493>
- Zawudie, A. B., Daka, D. W., Teshome, D., & Ergiba, M. S. (2022). Economic burden of diabetes mellitus among patients on follow-up care in hospitals of Southwest Shewa Zone, Central Ethiopia. *BMC Health Services Research*, 22, 1398. <https://doi.org/10.1186/s12913-022-08819-0>