

**“ATemp”, A Tempe-based product with High Nutritional Value and Low Glycemic Index
(Alternative Plant-Based Protein Sources for Diabetic Patients)**

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ABSTRACT

Diabetes Mellitus (DM) is a metabolic endocrine disease with the identical symptom of hyperglycemia. One of the main pillars in DM management is nutrition therapy through limiting the intake of carbohydrates and high simple sugar (monosaccharides). The availability of foods with low glucose levels has become one of the crucial needs of DM patients in controlling blood glucose levels. Tempeh is a soy-fermented local food that has been known widely by Indonesian Society. Tempeh-based food products with high nutritional value and low sugar are still scarcely found in society. Thus, this research aims to develop a tempeh-based product with high nutrition value (protein), low Glycemic Index (GI) level and adequate fibre content. Research and Development Design method was used in this research with the selecting, sorting and processing done with respecting the standard of food processing. The yield product was tested on 40 panellists for organoleptic tests, analyzed in the laboratory to measure the nutrient content, and calculated for glycemic index. The results show that “ATemp” (a tempeh floss) has a result of organoleptic test with the panellist who stated like and very like for colour of the product 65%, for the aroma 67,5%, for the texture 58% and for the taste of the product 50%. Laboratory analysis has shown that 100 g of ATemp contains 23 g of fat, 19 g of protein, 45 g of carbohydrate, 1 g of sugar, 257 mg of sodium, 12 g of fibre and 465 kcal of total energy. The result of GI test shows that ATemp has a GI level of 12 (low) and GL level of 2,7 (low). ATempt has a high potential to be an alternative food for diabetes or for those who are doing low-sugar diet.

Keywords: ATemp, Floss, Tempeh, Glycemic Index, Diabetes Mellitus

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INTRODUCTION

Diabetes Mellitus (DM) is a metabolic endocrine disease with the identical symptom of hyperglycemia¹. One of the main pillars in DM management is nutrition therapy through limiting the intake of carbohydrates and high simple sugar (monosaccharides)². Increased levels of blood glucose or hyperglycemia are a major sign of diabetes accompanied by polyuria, polydipsy and polyphagia³.

Medical nutrition therapy (MNT) is one of the main interventions in treating DM². In MNT planning for DM patients, it is crucial to consider glycemic index (GI) and glycemic load (GL) of the food in controlling blood glucose level^{4,5}. The food glycemic index indicates the speed of a food increases blood glucose levels. Whilst glycemic load is a value that shows how much carbohydrates in a portion of food can increase blood glucose levels^{6,7}. Thus, food with high GI and or GL will increase the occurrence of hyperglycemia⁸.

In addition to GI and GL, MNT planning for DM patients should also be developed with the consideration of protein content. It is because food with high protein content could bring benefit for glycemic control⁹. Therefore, it is important to provide food with high protein content for DM patients.

One of the local foods in Indonesia that can provide the aforementioned properties in MNT planning for DM patients is tempeh. A hundred gram of tempeh contains 201 kcal, 20.8 g protein, 8.8 g fat, and 13.5 g carbohydrate¹⁰. Hence, it is most likely that tempeh can be utilized in making food for DM patients.

Various research had studied about the utilization of tempeh for DM patients. There was a study found that, tempeh could contribute to the making of nugget with low IG and GL which would be suitable for DM patients¹¹. There was also a study that used tempeh to develop a low GI biscuit. Besides, its high fiber content also contributed to gastric emptying which eventually lead to low GI level¹². Furthermore, there were studies that found that interventions with tempeh-based product resulting in improvement of hyperglycemic control and wound healing^{13,14}.

Even though there had been some development of tempeh-based products for DM patients, most of them are still in *in vivo* study or in product development phase. Another point to consider is, the forms of the developed

product were deemed not attractive enough for Indonesian people. Therefore, it is still a challenge to form a tempeh-based product that is more familiar to society.

Various types of animal floss are widely known in society and are relatively preferred by many people such as cow meat floss, chicken floss, fish floss, and so forth. Thus, a tempeh-based floss could be a promising product for DM patients. In addition to that, there is also another local food, which is oyster mushroom that will be added to tempeh-based floss to increase its hedonic score. Therefore, this study aimed to develop a tempeh floss. The product was named Atemp to reflect the main ingredient of it, which is tempeh.

METHOD

Research and Development Design method was used in this research with the selecting, sorting, and processing were done with respecting the standard of food processing.

Atemp product was made with the main ingredient of high quality of tempeh (100 g) and Oyster Mushroom (*Pleurotus ostreatus*) (100 g). Those two main ingredients were then added with spices and seasonings to obtain the desired mixture. The well mixed pre-cooked Atemp then cooked by deep-frying method. After the frying process, the oil spinner was used to extract the excessive oil from the cooked Atemp.

An organoleptic test was performed to determine the assessment of the panel against the Atemp. The test covered the colors, aroma, texture, and taste. The 7-point hedonic scale was used by the panelists to indicate their preferences start from dislike very much (point 1) to like very much (point 7). The evaluation was given by 40 panelists with the inclusion criteria: healthy with normal BMI (20-24) and normal blood glucose, as well as no history of DM in family¹⁵. Those healthy young adults were selected to reduce the bias due to impairment in blood glucose which eventually could alter the results. To test the content and nutritional value of atemp performed testing by the same laboratory with sni method 01-2891-1992 section 8.1.

Glycemic index tests and glycemic load are performed with methods explained by Brouns et al¹⁵. All responders who will follow glycemic index testing protocols are required to fast for 8-10 hours before the blood sugar

check begins. After performing the fasting, a sample is measured in blood sugar before it consumes an Atemp or sugar solution as a reference. The sugar solution consumed was 25 g of sugar along with 200 millimetres of water and the tempeh-based product consumed was 56 g to fill the load of 25 g carbs to be the same. There was six days prior to the exchange of consumption of tested materials. After consuming product or sugar solution, blood sugar was measured every 15 minutes for the first hour and then every 30 minutes until it reaches 2 hours. Following the interval of the blood sample taken in minutes: 0, 15, 30, 45, 60, 90, 120.

RESULTS

Organoleptic Test

The Atemp product have been tested for the level of preference among 40 panelists who comprised of 75% women and 25% men, aged range between 18 to 80 years and 48% work as students; 25% private employees; housewives 20% and workers 7%. The results of the organoleptic test shown that most of the panelist chose like and very like for all the parameter. The presentation of those values are displayed in table 1.

Table 1. Organoleptic Test Results

Parameter	Like Moderately	Like Very Much	Total
Color	45.0	25.0	70.0
Aroma	35.0	32.5	67.5
Texture	42.5	15.0	57.5
Taste	17.5	32.5	50.0
Overall	42.5	20.0	62.5

As shown on table 1, there were 70.0% and 67.5% of 40 panelists that stated like moderately and like very much for the color and the aroma of Atemp, respectively. There were also 57.5% and 50.0% of the panelists who stated like moderately and like very much for the texture and taste of Atemp. Moreover, after calculated the total collected organoleptic data, we managed to identify the overall value of the product and the data shown that there were 42.5% and 20.0% who stated like moderately and like very much for overall Atemp with the total percentage of acceptance at 62.5%.

Nutrition Value Analysis

Nutrition value analysis was done in proximate analysis of food. The results of this

analysis are shown on table 2.

Table 2. Nutrition Value Analysis of ATemp

Nutrition Value	Result
Total Energy	465 kcal
Fat	23 g
Protein	19 g
Carbohydrate	45 g
Sugar	1 g
Sodium	257 mg
Fiber	12 g

As shown in table 2, the nutrition value was displayed according to 100 g of Atemp. The findings confirm that the total calories of Atemp is 465 kcal, with the macronutrients value are 23 g, 19 g, and 45 g for fat, protein and carbohydrate, respectively. There were also 1 g and 12 g of sugar and fiber content, with 257 mg of sodium.

Glycemic Index and Glycemic Load

Glycemic index of Atemp was analyzed based on the blood sample of 10 healthy young adults. The results of the blood glucose increment after consuming Atemp and Sugar (Reference) are shown in figure 1.

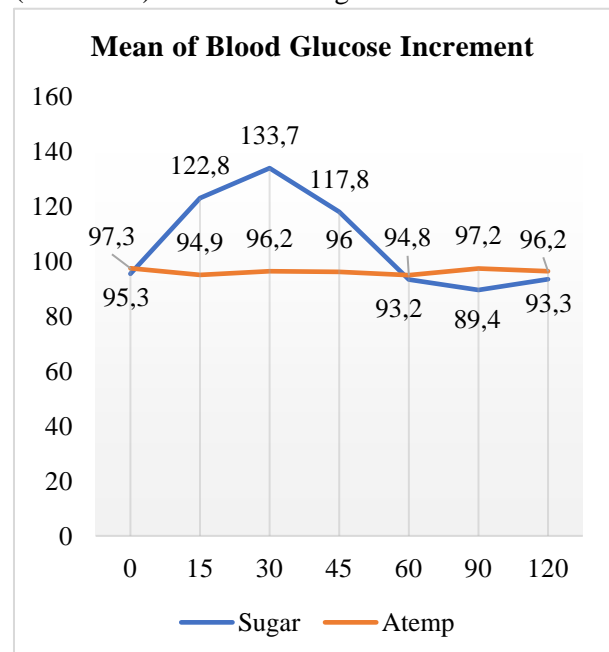


Figure 1. The Differences of Blood Glucose Increment in consuming Atemp and sugar.

As displayed in figure 1, the mean blood glucose level at 0 minutes (fasting plasma glucose) were 95.3 mg/dL for sugar and 97.3% for Atemp. Fifteen minutes after the consumption, the mean blood glucose level when the respondents consuming sugar was exponentially increased to 122.8 mg/dL. The

mean blood glucose level for consuming sugar was at its peak after 30 minutes with the blood glucose level of 133.7 mg/dL. Contradictively, the results of consuming Atemp shown that there were mild changes in mean blood glucose level. We can hardly even point out the peak level of mean blood glucose after consuming Atemp.

These results of mean blood glucose increment then used in calculation to decide the glycemic index (GI) of Atemp. The GI level was obtained after comparing the AUC for Atemp against the AUC for Atemp. The obtained GI level was then used to calculate the Glycemic Level (GL) of Atemp. The results of GI and GL analysis are shown in table 3.

Table 3. The GI and GL of Atemp

Item	AUC	GI (Category)	GL (Category)
Atemp	125.8	12	2,7
Sugar	1087.7	(Low)	(Low)

Based on the table above, it can be seen that the glycemic index (GI) of Atemp products is still relatively low (<55) as well as the glycemic load (GL) which is also low (<10)(15).

DISCUSSION

The findings in the organoleptic test as shown in table 1 indicate that most of the panelists stated like moderately and like very much in all parameters, except in taste which was still 50:50. Moreover, this study used oyster mushroom to enhance the texture and the taste of the product. This also confirmed that oyster mushroom could be utilised as the additional ingredient in making floss. This also could add the alternatives that had been mentioned elsewhere for plant-based ingredients with similar texture to the animal based such as unripened jackfruit¹⁶, unripened sukun¹⁷, and banana blossom¹⁸.

The overall results confirmed that Atemp can be well accepted by the panelists. Even though the overall value is not as high as similar product but different form elsewhere¹⁹, this result still can be a supportive finding if this product was about to be given to the targeted population.

The results in the organoleptic test was in alignment with the results in nutrition value analysis which was shown in table 2. This proves that, beside acceptable, Atemp also can

offer a good nutrients content, especially protein. Protein content in Atemp even higher than plant-based high protein snack which was done elsewhere, with the protein content of the product ranging from 12-14 g per 100 g²⁰.

The result from nutrition value analysis also confirms that this product can be utilized as a nutritional support in certain diseases such as those with pulmonary TB patients or DM patients. There was a study that found that giving two nutritional support products with a protein content of 8.5 g per serving (17 g per day) could affect the healing of post-surgical wounds in patients¹⁴. The provision of nutritional support products like this is based on the standard provision of nutritional support in hospitals by providing 2 x 40 g of extra egg white which contains 8 g of protein (16 g of total protein)²¹.

In addition to its high protein content, Atemp also possesses a predominantly low GI compared to its classification²². With the GI of 12, Atemp can even provide better GI compared to other tempeh-based products which were also low GI^{12,11}. This GI of Atemp also lower than tuber-based snack bar developed for DM patients in other study⁴.

The soybean as the only main ingredient in tempeh contain the starch that could contribute to higher GI^{23,24}. Nevertheless, fermentation process in making tempeh makes the rapidly digestible starch (RDS) decrease while increases the resistance starch (RS)²⁵. For this reason, tempeh used in Atemp could contribute to the yield product with low GI.

Potential limitations of this product are the sources of the main ingredients. The way that tempeh was fermented could not be controlled, yet it still can influence the end product²⁵. Nevertheless, in this study, the used tempeh was obtained from a reputable vendor which marked by its brand awareness.

CONCLUSION

The overall acceptance according to the organoleptic test indicates that the Atemp product can be well accepted by society. The nutrition value, GI level, as well as GL level can confirm that Atemp is a potential product for those who need high protein food with low GI and GL level. Therefore, Atemp could be utilized in MNT planning for DM patients. For further research in product development, it is important to put more concern regarding the taste of the product.

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