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Article

Development of Hospital Enteral Formula for Diabetes Using Tempeh Flour with Dragon Fruit and Tomato Addition

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Abstract: This study aimed to develop a novel enteral formula for diabetes patients using tempeh flour with dragon fruit and tomato additions. An experimental design was employed to formulate and evaluate the nutritional content, viscosity, and organoleptic properties of the developed formula. Results showed that the formula had a high energy content of 926.1 kcal/100ml, with 41.6g/100ml of protein, 26.8g/100ml of fat, and 131.4g/100ml of carbohydrates. Viscosity testing indicated appropriate flow properties for enteral feeding, with 7ml of 10ml flowing in 10 seconds. However, organoleptic evaluation by seven panelists revealed low acceptance scores on a 4-point scale: color (mean 1.71), aroma (1.43), taste (1.43), and texture (2.29). While the formula demonstrates potential in terms of nutritional content and viscosity, significant improvements are needed to enhance its sensory acceptability. This research contributes to the development of plant-based enteral formulas for diabetes management, highlighting the challenges in balancing nutritional requirements with organoleptic qualities. The high carbohydrate content, while potentially beneficial for energy provision, raises concerns about glycemic control in diabetic patients. Further optimization of the formula's composition and clinical trials are recommended to assess its efficacy in diabetes care and to address the sensory and nutritional challenges identified in this study.

Keywords: enteral formula; diabetes; tempeh flour; dragon fruit; tomato; organoleptic properties

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1. Introduction

Diabetes mellitus is a global health concern with increasing prevalence. This disease results from impaired insulin secretion or decreased tissue sensitivity to insulin, leading to disruptions in carbohydrate, fat, and protein metabolism. Diabetes is characterized by random blood glucose levels exceeding 200 mg/dL or fasting blood glucose above 126 mg/dL. In 2021, diabetes affected 537 million people worldwide, with projections reaching 783 million by 2045 [1].

Various therapies are employed in diabetes management, including enteral formula therapy. This approach involves delivering nutrients through the digestive tract using a specialized tube or feeding tube to meet patients' nutritional requirements [2]. Several studies have explored the development of enteral nutrition formulas using more cost-effective alternative ingredients. Faidah et al. (2019) developed a tempeh flour-based enteral nutrition formula as an alternative high-protein enteral food. Another study by Rampengan et al. (2020) investigated tempeh flour-based enteral nutrition formulations with varying ratios of tempeh flour to skim milk [3].

While these studies demonstrate the potential for using plant-based proteins like tempeh to create cost-effective enteral nutrition options, limitations persist, particularly regarding osmolality exceeding recommended limits for enteral nutrition. Furthermore, no studies have combined alternative ingredients while considering the specific needs of diabetic patients, especially in terms of using low glycemic index ingredients rich in antioxidants.

This study investigated the effect of dragon fruit juice on blood sugar levels in diabetes mellitus (DM) clients. Using a quasi-experimental design with pre and post-tests and a control group, 38 DM clients were divided into intervention and control groups. The intervention group received 400 ml of dragon fruit juice twice daily for 7 days. Blood sugar levels were measured before and after the intervention. Results showed a statistically significant difference in blood sugar levels before and after intervention in both groups (p=0.000). The study concluded that dragon fruit juice had a significant effect on reducing blood sugar levels in DM clients (p=0.000). The researchers suggest that DM clients could consume dragon fruit juice as an independent intervention to lower blood sugar levels, and that this intervention could be integrated into public health efforts through existing programs for non-communicable diseases [4], and tomatoes (*Solanum lycopersicum L.*), which are rich in bioactive components such as carotenoids, vitamin C, and B vitamins [5]. The novelty of this research lies in combining these ingredients to create an enteral formula with enhanced organoleptic properties while maintaining appropriate nutritional content for diabetes management. Specifically, this study will analyze the energy, protein, fat, and carbohydrate content, as well as flow properties and organoleptic qualities of the developed homemade enteral formula for diabetes patients.

2. Materials and Methods

This research employed an experimental design to develop and evaluate an enteral formula based on tempeh flour with the addition of dragon fruit and tomato. Conducted in August 2024 at the Nutrition Installation Room of Sleman Regional Hospital, the study involved formula development, sample preparation, nutritional analysis, viscosity assessment, and organoleptic evaluation.

The enteral formula was prepared using 50 grams of tempeh flour as the main ingredient, supplemented with 50 grams of dragon fruit, 50 grams of tomato, 15 ml of coconut oil, 10 grams of sugar, and 325 ml of water. The preparation process began with ingredient preparation, fruit juice extraction, ingredient mixing, cooking, blending, straining, and packaging. Dragon fruit and tomato were washed, cut, and blended with 100 ml of water, then strained. Tempeh flour was mixed with 225 ml of water, then combined with the fruit juice, coconut oil, and sugar. This mixture was cooked until boiling and thickened, then blended again and strained to ensure smoothness. The final formula was packaged in sterile containers and could be stored in a refrigerator.

A 500 ml sample of the developed formula was prepared for various analyses. The nutritional content of the formula was estimated using Nutrisurvey software, providing data on energy, protein, fat, and carbohydrate content. Viscosity was measured using a simple flow rate test with a 10 ml sample in a syringe, recording the flow time with a stopwatch. Organoleptic evaluation involved seven panelists who assessed the taste, aroma, texture, and color of the formula using a 4-point Likert scale on a 350 ml sample.

Data analysis included processing nutritional data with Nutrisurvey and descriptive statistical analysis for organoleptic test results, including calculation of mean, maximum, and minimum values for each sensory parameter. This research did not require ethical approval as it did not involve intervention studies on animals or humans. This comprehensive approach allowed for a thorough evaluation of the newly developed enteral formula, covering nutritional composition, physical properties, and sensory acceptance.

3. Results and Discussion

3.1. Nutritional Content Analysis

The nutritional content analysis of the developed enteral formula for diabetes mellitus patients showed the following results:

Table 1. Analysis of Nutritional Content of the Formula

Nutrient	Amount per 100 ml
Energy	926,1 kcal
Protein	41,6 g
Fat	26,8 g
Carbohydrate	131,4 g

Table 1 presents the analysis of the nutritional content of the formula, showing the amount of key nutrients per 100 ml of the product. The table consists of two columns: "Nutrient" and "Amount per 100 ml". The formula provides 926.1 kilocalories (kcal) of energy per 100 ml, indicating a high energy density. It contains 41.6 grams of protein per 100 ml, which is a substantial amount and contributes significantly to the formula's nutritional value. The fat content is 26.8 grams per 100 ml, providing an important source of energy and essential fatty acids. Carbohydrates form the largest macronutrient component of the formula, with 131.4 grams per 100 ml.

This nutritional profile reveals that the formula is highly concentrated in terms of energy and macronutrients. The high carbohydrate content, followed by protein and fat, suggests that this formula is designed to provide a substantial amount of energy and nutrients in a relatively small volume. This composition could be beneficial in situations where high-calorie, nutrient-dense nutrition is required, such as for individuals with increased nutritional needs or those who have difficulty consuming large volumes of food. The balance of macronutrients and the high energy content indicate that this formula might be used for specific medical or nutritional purposes, rather than as a regular dietary supplement. It's important to note that the appropriate use of such a concentrated formula should be determined by healthcare professionals based on individual nutritional requirements and health conditions.

The enteral formula developed in this study, which incorporates tempeh flour along with dragon fruit and tomato additions, presents a distinctive nutritional composition that warrants thorough examination in the context of diabetes management. This innovative formulation offers a high energy density of 926.1 kcal per 100 ml, which could potentially address the elevated energy requirements of certain patients. However, this substantial caloric content also raises important considerations regarding its impact on glycemic control, a critical factor in diabetes care [6]. The formula's protein content, measured at 41.6 g per 100 ml, is in line with current recommendations for high-protein nutritional approaches in clinical settings [7]. This elevated protein level may prove particularly beneficial for diabetic patients, as it could support their increased protein needs. This is especially relevant for individuals requiring enhanced wound healing, a common concern in diabetes management [8]. The protein composition of this formula may contribute to improved tissue repair and maintenance of lean body mass, both of which are crucial aspects of overall health in diabetic patients.

The carbohydrate content of 131.4 grams per 100 ml in this mixture warrants special attention due to its notably high level. While dragon fruit and tomato likely contribute beneficial fibers and micronutrients, this elevated carbohydrate level has the potential to pose challenges in blood sugar management [9]. This aspect requires careful consideration, particularly for individuals who need strict glucose regulation. The macronutrient distribution in this mixture, consisting of approximately 17.9% protein, 26.0% fat, and 56.1% carbohydrates of total calories, demonstrates a significant departure from the high-protein, low-carbohydrate dietary approach. This approach has shown benefits in glycemic control according to recent research [7]. This discrepancy underscores the importance of further evaluation regarding the suitability of this mixture for individuals requiring optimal blood glucose management.

Glycemic response studies play a crucial role in assessing the impact of the formula on blood glucose levels in diabetic patients [6]. These studies not only provide insights into the formula's effectiveness in managing blood sugar but also help optimize the nutritional composition for the specific needs of diabetics. Glycemic response testing typically involves monitoring patients' blood glucose levels after consuming the formula, with periodic measurements over several hours to determine how the formula affects glucose fluctuations.

Further analysis of the amino acid profile and protein digestibility would be highly beneficial, especially considering recent findings on the nutritional benefits of tempeh [10]. Tempeh, as a rich plant-based protein source, has shown potential in improving metabolic health. An in-depth evaluation of the amino acid composition in the formula could reveal an optimal nutritional balance to support muscle health and metabolic function in diabetic patients. Additionally, understanding

protein digestibility will help ensure that the nutrients contained can be effectively absorbed and utilized by the body.

Although not detailed in the provided nutritional information, the inclusion of dragon fruit and tomato in the formula likely contributes valuable micronutrients and antioxidants [9]. Dragon fruit is known to be rich in vitamin C, fiber, and various phytochemicals, while tomatoes are a good source of lycopene - a powerful antioxidant that has been associated with various health benefits. The combination of these ingredients could potentially enhance the overall antioxidant capacity of the formula, which is crucial in reducing oxidative stress often experienced by diabetics.

Comprehensive clinical trials are necessary to evaluate the formula's effectiveness in managing blood glucose levels, lipid profiles, and overall nutritional status in diabetic patients [7].

Guidelines for appropriate dosing and administration should be developed to prevent overfeeding and ensure optimal glycemic control. The formula's composition should be evaluated against local diabetes management guidelines, such as PERKENI 2021 [11].

While this formula offers a novel approach with potential benefits from its high protein content and functional ingredients, its high carbohydrate and overall calorie content necessitate careful clinical evaluation. Further research is needed to optimize the macronutrient ratio and assess its efficacy in real-world diabetes management scenarios. The unique composition of this formula underscores the importance of personalized nutrition approaches in diabetes care, highlighting the need for continued innovation and rigorous scientific evaluation in developing specialized enteral formulas for diabetic patients.

3.2. Viscosity

The viscosity test was conducted to measure the formula's ability to flow using a 10 ml syringe. The test results showed that after flowing for 10 seconds, the volume of formula remaining in the syringe was 3 ml.

This result indicates that the formula has appropriate viscosity to flow through a feeding tube. In 10 seconds, 7 ml of formula (70% of the total volume) was able to flow out of the syringe, demonstrating a suitable level of thickness for an enteral formula.

Table 2. Viscocity Test Result for Enteral Formula

Parameter	Result
Initial volume	10 ml
Flow time	10 seconds
Remaining volume	3 ml
Flowed volume	7 ml

Table 2 presents the results of a viscosity test conducted on an enteral formula. The table is composed of two columns: "Parameter" and "Result". It provides key measurements related to the flow characteristics of the formula, which are crucial for determining its suitability for enteral feeding. The test began with an initial volume of 10 ml of the enteral formula. This volume was allowed to flow for a set duration of 10 seconds, which represents the flow time. After this period, the remaining volume in the testing apparatus was measured at 3 ml. By subtracting the remaining volume from the initial volume, we can determine that the flowed volume was 7 ml. These results offer valuable insights into the viscosity and flow properties of the enteral formula. The fact that 7 ml out of 10 ml flowed within 10 seconds suggests that the formula has a relatively low viscosity, allowing for easy flow. This characteristic is particularly important for enteral nutrition, as it affects the ease with which the formula can be administered through feeding tubes. The low remaining volume (3 ml) further supports the conclusion that the formula flows well, which is a desirable trait for enteral formulas. A formula that flows easily reduces the risk of clogging feeding tubes and ensures more accurate delivery of nutrients to the patient. Understanding these viscosity characteristics is crucial for healthcare professionals when selecting appropriate enteral formulas for patients. The flow properties can impact the choice of feeding tubes, the rate of administration, and the overall effectiveness of nutritional support. This data can also be valuable for formula

manufacturers in quality control processes and product development efforts aimed at optimizing the physical properties of enteral nutrition products.

Enteral formula viscosity is crucial for successful administration and patient care effectiveness. A study developing a hospital enteral formula for diabetes using tempeh flour with dragon fruit and tomato additions employed a simple flow test to assess viscosity. Results showed that from an initial 10 ml volume, 7 ml flowed in 10 seconds, leaving 3 ml.

This viscosity profile aligns with the International Dysphagia Diet Standardization Initiative (IDDSI) framework's 'slightly thick' category (Level 2). Liquids in this category typically leave 1-4 ml when 10 ml flows for 10 seconds. This consistency is generally suitable for enteral feeding, allowing smooth flow through standard tubes while minimizing risks associated with excessively thin or thick formulas [12].

Appropriate viscosity is vital in enteral nutrition. Excessive thickness can impede nutrient delivery, causing slow flow rates or tube blockages, potentially compromising feeding effectiveness. This emphasizes the importance of maintaining proper viscosity for adequate nutrient delivery [13].

While not explicitly discussed, overly thin formulas may increase regurgitation and aspiration risks in patients with impaired swallowing reflexes [14], highlighting the need for balanced formula viscosity.

Formula energy density, stirring time, and time since preparation significantly influence thickened enteral formula (TEF) viscosity. These findings underscore the importance of controlling these factors in clinical settings [15]. Given the wide viscosity variation among formulas and the need to select appropriate viscosity based on individual patient needs, this study's formula appears to achieve a balance suitable for various patients [16]. However, further testing and validation are necessary before widespread clinical implementation.

The simple flow test method used may have limitations compared to advanced rheological measurements. Future research could benefit from more precise techniques and in vivo testing to validate the formula's suitability for different patient populations and feeding regimens.

This research contributes to enteral nutrition formula knowledge, particularly in diabetes management. The developed formula's viscosity characteristics align with established standards and theoretical expectations, suggesting potential clinical suitability. However, regular assessment and potential adjustment of formula viscosity may be necessary to ensure optimal feeding outcomes [17]. This study paves the way for further research into the complex interplay between formula composition, preparation methods, and patient-specific needs in determining optimal viscosity for various clinical scenarios.

3.3. Organoleptic Test

The organoleptic test results are presented in Table 3 below.

Table 3. Results of Organoleptic Test

Preference	Color		Aroma		Taste		Texture	
	N	%	N	%	N	%	N	%
Dislike	2	28,5	4	57,1	4	57,1	1	14,2
Slightly Dislike	5	71,5	3	42,9	3	42,9	3	42,9
Like	0	0	0	0	0	0	3	42,9
Very Like	0	0	0	0	0	0	0	0
Total	7	100	7	100	7	100	7	100

Table 3 presents the results of an organoleptic test conducted on a product, likely a food or beverage item. The table provides a comprehensive breakdown of sensory evaluations across four key attributes: color, aroma, taste, and texture. A total of seven participants (N=7) were involved in this sensory analysis, offering their preferences on a scale ranging from "Dislike" to "Very Like" for each attribute. For the color attribute, the majority of participants (71.5% or 5 out of 7) slightly disliked the color, while 28.5% (2 out of 7) disliked it. No participants liked or very much liked the color. The aroma and taste attributes showed identical results, with 57.1% (4 out of 7) of participants disliking these aspects, and 42.9% (3 out of 7) slightly disliking them. Again, no participants rated the aroma or taste favorably. The texture attribute received the most varied responses. While 14.2% (1 out of 7) disliked the texture, 42.9% (3 out of 7) slightly disliked it, and interestingly, an equal percentage (42.9% or 3 out of 7) liked the texture. This makes texture the only attribute that received any positive feedback. Notably, none of the attributes received a "Very Like" rating from any participant across all four sensory categories. These results suggest that the product under evaluation was generally not well-received by the test group, with texture being the only attribute that garnered some positive responses. The data indicates that improvements may be necessary, particularly in the areas of color, aroma, and taste, to enhance overall consumer acceptance. This type of sensory analysis is crucial in product development and quality control processes, providing valuable insights for potential reformulation or refinement of the product to better meet consumer preferences.

The organoleptic test evaluated four sensory attributes: color, aroma, taste, and texture. Table 3 shows the frequency distribution of preferences for each attribute, while Table 4 presents the mean, minimum, and maximum scores for each attribute.

Table 4. Average Results of Organoleptic Test

Preference	Color	Aroma	Taste	Texture
Mean	1,71	1,43	1,43	2,29
Minimum	1	1	1	1
Maximum	2	2	2	3

Table 4 presents the average results of an organoleptic test, summarizing the sensory evaluation of a product across four key attributes: color, aroma, taste, and texture. The table provides three statistical measures for each attribute: mean, minimum, and maximum scores. The scoring system appears to use a scale where lower numbers indicate less favorable responses and higher numbers indicate more favorable responses. Based on this assumption, color received a mean score of 1.71, with a minimum of 1 and a maximum of 2. This suggests that participants generally rated the color between "dislike" and "slightly dislike," with some variation in opinions. Aroma and taste both received identical mean scores of 1.43, with minimum scores of 1 and maximum scores of 2. These lower mean scores indicate that participants generally disliked the aroma and taste of the product, with responses ranging from "dislike" to "slightly dislike." Texture stands out with the highest mean score of 2.29, and is the only attribute with a maximum score of 3. The minimum score for texture is still 1, indicating a wider range of opinions. This suggests that texture was the most positively received attribute, with some participants potentially rating it as "like," while others still disliked it. Overall, these results indicate that the product under evaluation was not particularly well-received in terms of sensory attributes. Texture appears to be the most positively perceived aspect, while aroma and taste were the least favored. The color fell somewhere in between. This data is valuable for product developers and quality control teams, as it clearly identifies areas for potential improvement. Focusing on enhancing the aroma and taste, while maintaining or improving the relatively better-received texture, could be key strategies for improving overall product acceptance. The consistent minimum score of 1 across all attributes also

suggests that there's significant room for improvement in all sensory aspects of the product.

This study aimed to develop a tempeh and dragon fruit-based enteral formula for diabetic patients. The organoleptic test results indicate that significant improvements are needed in various sensory aspects of the developed formula.

Data analysis from the organoleptic test revealed relatively low acceptance of this enteral formula. Mean scores for color (1.71), aroma (1.43), taste (1.43), and texture (2.29) were all below the midpoint of the rating scale, indicating general dislike. This suggests substantial adjustments are necessary to enhance the formula's acceptability.

The formula's unusual color, likely due to dragon fruit's betacyanin pigments, was a major concern. This contrasts with typical enteral formulas, which are usually white or yellowish-white. Interestingly, research on red dragon fruit betacyanins' bioaccessibility has shown significant stability during simulated digestion, particularly in fermented form [18]. These findings raise questions about potential health benefits of the persisting pigments, while also warranting further investigation into their use in enteral formulas for patients with specific gastrointestinal conditions.

Low scores for taste and aroma may be related to using tempeh as a base ingredient. Previous studies on white bean tempeh burgers have shown that tempeh-based products can have a residual beany flavor affecting acceptance [19]. Despite tempeh's good nutritional potential, these sensory challenges need addressing to improve formula acceptance.

The formula's texture, while scoring slightly higher than other aspects, still requires improvement. Research on plant-based milk substitutes has shown texture's importance in consumer acceptance [20]. Although this study didn't specifically address enteral formulas, the same principles about pleasing texture can apply.

Notably, while this formula was developed for diabetic patients, organoleptic testing was conducted on a general panel, not diabetic patients. Further research involving diabetic patients in sensory evaluations would provide more relevant insights into the target population's acceptance, given the importance of nutritional management in type 2 diabetes [21].

Based on these findings, it's concluded that while the tempeh and dragon fruit-based enteral formula has good nutritional potential for diabetic patients, further modifications are needed to enhance its sensory acceptance. Future research could focus on formula optimization, such as adjusting ingredient proportions, exploring alternative processing techniques to reduce undesirable tastes and aromas, and potentially using natural additives to improve the overall sensory profile.

Study limitations include the relatively small number of panelists and absence of testing on actual diabetic patients. Therefore, future research with a larger, more diverse panel, including diabetic patients, would be valuable for further validation and formula development.

4. Conclusions

This study successfully developed an enteral formula based on tempeh flour with the addition of dragon fruit and tomato for diabetic patients. The main findings of this research are noteworthy. The formula demonstrated a high energy content of 926.1 kcal/100ml, with a composition of 41.6g/100ml protein, 26.8g/100ml fat, and 131.4g/100ml carbohydrates. While nutrient-rich, the high carbohydrate content requires further evaluation for glucose management in diabetic patients. The formula exhibited appropriate flow properties for enteral administration, with 7ml out of 10ml flowing in 10 seconds, indicating suitable viscosity for feeding tube use. However, organoleptic evaluation by seven panelists resulted in low acceptance scores on a 4-point scale for color (mean 1.71), aroma (1.43), taste (1.43), and texture (2.29), suggesting significant improvements are needed to enhance sensory acceptance. The success indicators of this research include the creation of a locally-sourced enteral formula with adequate

nutritional content and appropriate viscosity for enteral administration. Nevertheless, this study also revealed areas requiring improvement, particularly in organoleptic properties and optimization of carbohydrate content for better diabetes management. Further research, including clinical trials, is recommended to fully assess the formula's efficacy in diabetes care and to address the identified challenges.

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