

Dietary Modification Of Egg White Smoothies As A High-Protein Snack For Patients With Type 2 Diabetes Mellitus, Diabetic Foot Ulcers, And Hypoalbuminemia

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Abstract. Background: Diabetic foot ulcers are chronic complications of diabetes mellitus (DM) and are frequently associated with hypoalbuminemia, which may impair wound healing. Continuous dietary management, including the selection of appropriate snacks, is important to help meet protein requirements and support glycemic control and wound healing. Egg white smoothies were developed as a modified dietary product containing egg whites and selected fruits, with the potential to serve as a high-protein snack for patients with DM. **Objective:** This study aimed to develop and evaluate egg white smoothies as an alternative snack for outpatients with type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia at Dr. Soedomo Regional General Hospital, Trenggalek. **Methods:** This product development study used a quantitative descriptive approach and was conducted from June 26 to July 16, 2026. Four outpatients with type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia participated in the study. Three smoothie formulations were developed and evaluated for nutritional composition using NutriSurvey and acceptability using a 5-point hedonic test. Dietary intake, consumption compliance, product tolerance, random blood glucose levels, and wound condition were monitored during the intervention. **Results:** The smoothies provided an average of 155.1 kcal, 11.7 g of protein, 4.8 g of fat, and 9.3 g of carbohydrates per serving. All three formulations were well accepted based on the hedonic evaluation. Participants demonstrated high compliance with smoothie consumption, with no reported gastrointestinal complaints. During the intervention period, protein intake increased by 63.3%, accompanied by a decrease in random blood glucose levels in all participants and a reduction in PUSH scores ranging from 2 to 4 points, indicating improvement in wound condition. **Conclusion:** Egg white smoothies show potential as a high-protein snack option for outpatients with type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia. However, the findings are descriptive and do not establish a causal relationship between the intervention and the observed changes. Further analytical or controlled studies involving larger samples and longer intervention periods are needed to confirm these findings.

Key-Words: *diabetic foot ulcer; egg white; hypoalbuminemia; high-protein snack; dietary modification; smoothies.*

1. Introduction

Diabetes mellitus (DM) is a metabolic disorder characterized by chronic hyperglycemia resulting from impaired insulin secretion, insulin action, or both. Persistent hyperglycemia may lead to various metabolic abnormalities and chronic complications affecting multiple organs, including the eyes, kidneys, nerves, and blood vessels [1]. DM is one of the major non-communicable diseases and remains an important public health concern because of its increasing prevalence and its potential to cause serious chronic complications.

Diabetic foot ulcers are among the major complications of DM. In Indonesia, diabetic foot ulcers represent an important clinical problem among patients with diabetes and may significantly affect quality of life and healthcare needs [2]. Wound healing in patients with DM and diabetic foot ulcers is influenced by multiple factors, including nutritional status, glycemic control, infection, tissue perfusion, and serum albumin levels. Hypoalbuminemia is frequently observed in patients with chronic wounds and may reflect inadequate nutritional intake, inflammation, or increased metabolic demands. Inadequate protein intake may impair collagen synthesis, angiogenesis, granulation tissue formation, and epithelialization, thereby contributing to delayed wound healing.

Nutritional therapy is an important component of diabetes mellitus management. Dietary management in patients with diabetes mellitus and diabetic foot ulcers should not focus solely on limiting sugar intake but should also ensure adequate protein intake to meet nutritional requirements and support tissue repair and wound healing [3]. Food selection should consider both glycemic impact and protein content, particularly when selecting snacks for patients with diabetes. Snacks can contribute to overall nutritional intake and may help patients meet daily energy and protein requirements when appropriately planned. Therefore, the development of nutrient-dense snacks that provide adequate protein and dietary fiber while maintaining a favorable glycemic profile may be a relevant approach to support nutritional therapy in patients with diabetes mellitus and diabetic foot ulcers.

Egg white is a high-quality protein source with high digestibility and a favorable profile of essential amino acids that are important for protein synthesis and tissue repair. Egg white also contains branched-chain amino acids

(BCAAs), including leucine, isoleucine, and valine, which are involved in protein metabolism and may contribute to the regulation of hepatic protein synthesis. Therefore, adequate consumption of high-quality protein from egg white may help support nutritional adequacy and tissue repair. However, its potential role in supporting serum albumin levels requires further investigation [4].

The development of egg-white-based products may expand the variety of nutritionally appropriate food options and provide alternative snacks that meet patients' nutritional needs. In the dietary management of patients with DM, diabetic foot ulcers, and hypoalbuminemia, egg white can be combined with selected fruits to develop a snack that provides high-quality protein and dietary fiber while maintaining a favorable glycemic profile. Such a combination may provide a nutritionally appropriate snack option while also considering sensory acceptability, including taste and texture [5].

Based on this rationale, Egg White Smoothies were developed as a modified dietary product consisting of egg whites combined with selected fruits. The product was designed as an alternative snack for outpatients with type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia, while considering appropriate dietary principles, the utilization of locally available food ingredients, and patient acceptability. Therefore, this study aimed to develop and evaluate Egg White Smoothies as an alternative high-protein snack for outpatients with type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia [6].

2. Materials and Methods

2.1 Research Design

This study employed a dietary product development design with a quantitative descriptive approach. The product developed was Egg White Smoothies, consisting of egg whites and selected fruits, as an alternative high-protein snack for outpatients with type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia.

2.2 Time and Place of the Study

The study was conducted from June 26 to July 16, 2026, at Dr. Soedomo Regional General Hospital, Trenggalek, Indonesia. The dietary intervention was administered from July 2 to July 9, 2026.

2.3 Study Population and Sample

The study population consisted of outpatients with type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia. Four eligible outpatients who met the inclusion and exclusion criteria were recruited as study participants.

2.4 Sampling Method

A total sampling technique was used in this study. All patients who met the predetermined inclusion and exclusion criteria during the study period were recruited as study participants. A total of four eligible patients were included in the study.

2.5 Inclusion and Exclusion Criteria

The inclusion criteria were: (1) patients diagnosed with type 2 diabetes mellitus by a physician; (2) patients with a diabetic foot ulcer that was still undergoing the healing process; (3) patients with hypoalbuminemia, defined as a serum albumin level of <3.5 g/dL; (4) patients with hyperglycemia, indicated by a random blood glucose (RBG) level of ≥ 200 mg/dL or based on the results of a medical examination; (5) aged ≥ 18 years; (6) receiving outpatient care; (7) able to consume food orally; (8) willing to receive the egg white smoothie dietary intervention throughout the study period; and (9) willing to participate as a study respondent and provide written informed consent.

The exclusion criteria were: (1) a history of allergy to eggs or egg whites; (2) conditions that impaired oral food intake, such as severe dysphagia or persistent vomiting; (3) severe comorbid conditions that could substantially affect serum albumin levels, such as severe liver failure, nephrotic syndrome, or end-stage renal disease; (4) receiving other specialized nutritional interventions, such as high-protein supplementation or albumin administration, that could potentially influence the study outcomes; (5) inability to complete the intervention or all stages of data collection; or (6) withdrawal of consent or refusal to continue participation at any point during the study.

2.6 Variables Studied

The study variables included the Egg White Smoothies formulation, nutritional composition, organoleptic acceptability, product consumption, dietary adherence, product tolerance, and clinical condition of the participants. Nutritional composition was assessed in terms of energy, protein, fat, and carbohydrate content. Organoleptic acceptability was evaluated based on color, aroma, taste, and texture using a 5-point hedonic scale. Product tolerance was assessed based on the presence or absence of gastrointestinal complaints following consumption.

Dietary adherence was evaluated using an adherence scoring system ranging from 21 to 32, with higher scores indicating greater adherence. The clinical condition of the participants was assessed based on random blood glucose levels and changes in diabetic foot ulcer condition during the monitoring period.

2.7 Tools and Materials

The equipment used in the preparation of the Egg White Smoothies included a digital kitchen scale, knife, cutting board, blender, steamer, stove, mixing bowl, serving glasses, and spoon. *NutriSurvey* software was used to analyze the nutritional composition of the product. The ingredients used in the formulation are presented in Table 1.

Table 1. Basic Ingredients for Preparing Egg White Smoothies for One Recipe (One Serving)

Ingredient	Amount per Serving
Egg whites	150 g
Frozen fruit (Strawberry, Dragon Fruit, Avocado)	100 g
Skim milk	150 mL
Natural sweetener (stevia)	1–2 drops
Vanilla extract	5 mL
Ice cubes	As needed

2.8 Research Procedure

The study began with the collection of participant characteristics, including demographic information, medical diagnosis, dietary habits, anthropometric measurements, biochemical data, and clinical findings. Body weight and height were measured to determine nutritional status based on body mass index (BMI). Subsequently, the Egg White Smoothies were prepared by cooking the egg whites, preparing the fruit, weighing all ingredients according to the predetermined formulation, and blending the ingredients until a homogeneous consistency was obtained. The nutritional composition of the product was then analyzed, and the smoothies were provided as a snack according to the meal schedule specified in each participant's dietary plan. During the intervention period, monitoring was conducted to assess smoothie consumption, dietary adherence, product tolerance, clinical condition, random blood glucose levels, and changes in diabetic foot ulcer condition. Wound healing was evaluated using the Pressure Ulcer Scale for Healing (PUSH) Tool.

2.9 Data Analysis

Data were analyzed descriptively. Nutritional composition of the egg white smoothies was calculated using *NutriSurvey* and presented as energy, protein, fat, and carbohydrate content per serving. Sensory acceptability was assessed using a 5-point hedonic scale and summarized using mean scores for color, aroma, taste, texture, and overall acceptability. Dietary intake was assessed using 24-hour dietary recalls and compared before and during the intervention. Changes in random blood glucose levels and wound condition were described based on the observed values during the intervention. Wound progression was assessed using the Pressure Ulcer Scale for Healing (PUSH) Tool. Data were tabulated and presented as frequencies, percentages, means, and changes from baseline, as appropriate. Data were processed and tabulated using Microsoft Excel. No inferential statistical tests were performed because of the small sample size and descriptive nature of the study.

2.10 Research Ethical Approval

This study received ethical approval from the Research Ethics Committee of Dr. Soedomo Regional General Hospital, Trenggalek, under approval number 000.9/397/406.010.001/18.00/2026. The approval was issued on June 25, 2026, and was valid until December 25, 2026. All participants provided written informed consent before participating in the study.

2.11 Conflict of Interest

The authors declare that there are no conflicts of interest related to the conduct, analysis, or publication of this study.

2.12 Funding

This study was funded by the authors' personal resources. No external funding was received from public, commercial, or non-profit organizations.

3. Results

3.1 Subject Characteristics

A total of four outpatients with type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia participated in this study. The baseline characteristics of the respondents included age, sex, educational level, body

Subject Category: Medical and Health Science

Received: August 03, 2026. Revised: September 01, 2026.

mass index (BMI), random blood glucose (RBG) level, and serum albumin level. The detailed characteristics of the respondents are presented in Table 1.

Table 1. Characteristics of Respondents at Baseline

Patient	Age (years)	Sex	Education	BMI (kg/m ²)	Random Blood Glucose (mg/dL)	Serum Albumin (g/dL)
Patient 1	50	Male	Junior high school	21.87	251	2.9
Patient 2	44	Female	Senior high school	27.08	380	2.7
Patient 3	49	Female	Junior high school	23.63	232	3.2
Patient 4	53	Male	Junior high school	24.69	321	2.6

The study involved four outpatients with type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia. The respondents were aged 44–53 years, consisting of two males and two females. Three respondents had completed junior high school, while one had completed senior high school. Body mass index ranged from 21.87 to 27.08 kg/m². Baseline random blood glucose levels ranged from 232 to 380 mg/dL, while serum albumin levels ranged from 2.6 to 3.1 g/dL. All respondents had serum albumin levels below the normal range, indicating hypoalbuminemia at baseline.

3.2 Energy and Nutrient Content

Based on calculations using *NutriSurvey*, the nutritional composition of the three modified Egg White Smoothies formulations, consisting of egg whites and selected fruits, was determined in terms of energy, protein, fat, carbohydrate, and dietary fiber content. The nutritional composition of each formulation is presented in Table 2.

Table 2. Energy and Nutrient Content of Egg White Smoothies

Nutrient	Strawberry Formula/ 1 serving	Dragon Fruit Formula/ 1 serving	Avocado Formula/ 1 serving
Energy (kcal)	115.6	124.7	225
Protein (g)	11.2	11.5	12.6
Carbohydrate (g)	8.5	11.3	8.1
Fat (g)	0.35	0.4	13.8
Fiber (g)	2.1	3.2	6.1

Among the three formulations, the avocado formulation had the highest energy and protein contents and the lowest carbohydrate content. The strawberry and dragon fruit formulations had lower fat contents than the avocado formulation. The energy content of the three formulations ranged from 115.6 to 225 kcal per serving.

3.3 Organoleptic Quality

Table 3. Mean Hedonic Scores of Outpatient DM Patient Panelists

Attribute	Strawberry Formula	Dragon Fruit Formula	Avocado Formula
Aroma	4.1	4.0	4.2
Taste	4.0	4.0	4.1
Texture	4.1	4.0	4.3
Color	4.0	4.1	4.4
Mean	4.05	4.02	4.25

The outpatient participants with diabetes mellitus showed the highest preference for the avocado formulation, particularly in terms of texture. Based on the mean scores across all sensory attributes, the avocado formulation received the highest overall score of 4.25 on the 5-point hedonic scale and was therefore identified as the most preferred formulation among the three formulations.

3.4 Monitoring of Intake, Tolerance, and Adherence

Table 4. Summary of Patient Monitoring During the Intervention

Patient	Product Intake	Tolerance	Adherence
Patient 1	Egg White Smoothies consumed as scheduled	No gastrointestinal complaints	27/32 (84.37%); High
Patient 2	Egg White Smoothies consumed as scheduled	No gastrointestinal complaints	28/32 (87.5%); High
Patient 3	Egg White Smoothies consumed as scheduled	No gastrointestinal complaints	27/32 (84.37%); High

Patient 4	Egg White Smoothies consumed as scheduled	No gastrointestinal complaints	26/32 (81.25%); High
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Overall, all participants consumed the Egg White Smoothies according to the scheduled intake and prescribed portion. No gastrointestinal complaints, including nausea, vomiting, abdominal pain, bloating, or diarrhea, were reported during the intervention period. Based on the predetermined adherence criteria, all participants demonstrated high dietary adherence, with adherence scores exceeding 80% [7].

3.5 Monitoring of Random Blood Glucose and Ulcer Progression

Table 5. Changes in Random Blood Glucose and Diabetic Foot Ulcer Status Before and After Intervention

Patient	Random Blood Glucose (mg/dL)		PUSH Score		Interpretation
	Before	After	Before	After	
Patient 1	251	198	7	4	Decreased blood glucose and improved wound condition
Patient 2	380	276	12	8	Decreased blood glucose and improved wound condition
Patient 3	232	176	4	2	Decreased blood glucose and improved wound condition
Patient 4	321	241	15	11	Decreased blood glucose and improved wound condition

Overall, random blood glucose levels decreased during the monitoring period, although two participants continued to have elevated levels. The random blood glucose levels recorded during monitoring were 198, 276, 176, and 241 mg/dL, respectively. Assessment using the Pressure Ulcer Scale for Healing (PUSH) Tool showed improvement in diabetic foot ulcer condition in all participants, with PUSH scores decreasing during the monitoring period.

4. Discussion

This study demonstrated that Egg White Smoothies can be developed as an alternative snack for outpatients with type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia. All three formulations provided relatively moderate energy content, ranging from 115.6 to 225 kcal per serving. Based on their nutritional composition and overall organoleptic evaluation, the avocado formulation was identified as the most preferred formulation because it provided the highest protein content, the lowest carbohydrate content, and the highest overall hedonic score. In addition, monitoring indicated that the participants were able to consume the product according to the scheduled intake, no gastrointestinal complaints were reported, and dietary adherence was categorized as high.

These findings are consistent with the principles of medical nutrition therapy for patients with diabetes mellitus, which emphasize individualized management of food type, portion size, energy intake, and meal timing to support glycemic management [8]. For patients with type 2 diabetes mellitus accompanied by diabetic foot ulcers and hypoalbuminemia, snack selection should consider energy and macronutrient composition, particularly protein and carbohydrate content, as well as dietary fiber. The strawberry formulation provided 115.6 kcal of energy, 11.2 g of protein, 8.5 g of carbohydrates, 0.35 g of fat, and 2.1 g of dietary fiber per serving. The dragon fruit formulation provided 124.7 kcal of energy, 11.5 g of protein, 11.3 g of carbohydrates, 0.4 g of fat, and 3.2 g of dietary fiber per serving. The avocado formulation provided 225 kcal of energy, 12.6 g of protein, 8.1 g of carbohydrates, 13.8 g of fat, and 6.1 g of dietary fiber per serving. These nutritional characteristics indicate that the formulations provide a combination of protein, carbohydrates, fat, and dietary fiber within a relatively moderate energy range, making them potentially suitable as snack options within an individualized dietary plan.

The use of egg white as the main ingredient is an important nutritional characteristic of the product. Egg white is a high-quality protein source with high digestibility and a favorable essential amino acid profile. It is particularly rich in ovalbumin and provides amino acids that contribute to protein synthesis and tissue maintenance. Adequate protein intake is important in patients with chronic wounds because protein is required for collagen synthesis, tissue regeneration, and other processes involved in wound healing. However, the present study did not directly assess changes in serum albumin or protein synthesis; therefore, the potential contribution of Egg White Smoothies to protein status should be interpreted cautiously.

The fruit component also contributes dietary fiber to the product. Dietary fiber, particularly soluble fiber, may delay gastric emptying and reduce the rate of glucose absorption, thereby attenuating postprandial glucose responses [9]. This finding is supported by previous research showing that increased dietary fiber intake may

improve glycemic control in patients with type 2 diabetes mellitus, including reductions in glycated hemoglobin and fasting blood glucose levels [10]. Therefore, the combination of egg white and fruit provides a potentially useful approach for developing a snack that combines a substantial protein contribution with dietary fiber and a relatively favorable carbohydrate profile.

The avocado formulation was the most preferred formulation based on the overall hedonic evaluation, particularly for texture. Its higher energy and fat content compared with the strawberry and dragon fruit formulations may have contributed to its smoother and creamier texture, which could explain the higher sensory acceptance. However, the higher fat and energy content of the avocado formulation should also be considered when incorporating the product into an individualized meal plan, particularly for patients with specific energy requirements or metabolic goals.

During the monitoring period, a decrease in random blood glucose levels and improvement in diabetic foot ulcer condition were observed. However, these findings should be interpreted as descriptive observations rather than evidence of a causal effect of Egg White Smoothies. The study involved only four participants, had a short intervention period, and did not include a control group. In addition, wound healing and glycemic control may have been influenced by other factors, including diabetes medication, wound care, infection status, dietary intake from other meals, and individual clinical conditions. Therefore, the observed changes cannot be attributed solely to the consumption of Egg White Smoothies.

The PUSH Tool was used in this study to monitor changes in wound condition during the intervention. However, its use has several limitations. The PUSH Tool primarily evaluates wound healing based on wound surface area, exudate amount, and tissue type, and therefore does not comprehensively capture other clinically important aspects of diabetic foot ulcers, such as wound depth, infection status, perfusion, neuropathy, pain, and tissue oxygenation. In addition, changes in PUSH scores may be influenced by factors other than dietary intake, including wound care procedures, glycemic control, medication, infection management, and the patient's overall nutritional and clinical condition. Therefore, the reduction in PUSH scores observed during the intervention should be interpreted as a descriptive indication of wound improvement rather than evidence that the egg white smoothies directly caused wound healing. Future studies should consider combining the PUSH Tool with more comprehensive wound assessment methods and longer follow-up periods.

Nevertheless, the high level of product consumption adherence, absence of reported gastrointestinal complaints, and favorable sensory acceptance indicate that Egg White Smoothies are feasible as an alternative snack option for this patient population. Further studies involving larger samples, longer intervention periods, and controlled or analytical research designs are needed to evaluate their effects on protein status, serum albumin, glycemic control, and diabetic foot ulcer healing.

5. Conclusion and Recommendations

5.1 Conclusion

Egg White Smoothies made from egg whites and fruit can be developed as an alternative snack for outpatients with type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia. The product demonstrated good sensory acceptability and was well tolerated by the participants, with no gastrointestinal complaints reported during the intervention period. The Egg White Smoothies are consistent with the principles of diabetes dietary management by considering appropriate food selection, moderate energy content, and protein and dietary fiber content. Therefore, Egg White Smoothies may be considered as an example of a modified-diet product for nutritional education and as an alternative snack that can be prepared and consumed at home.

5.2 Recommendations

Patients and their families should continue to receive nutritional education regarding appropriate snack selection, meal scheduling, and limiting foods high in added sugar, saturated fat, and sodium to support dietary adherence. The findings of this study represent preliminary observations from a small-scale study involving only four participants. The observed decreases in random blood glucose levels and PUSH scores indicate potential improvements during the intervention period. However, these findings cannot be interpreted as evidence of a causal effect of the Egg White Smoothies intervention because the study did not include a control group and the intervention period was relatively short. Further research involving larger sample sizes, longer intervention periods, and controlled study designs is needed to confirm these preliminary findings and evaluate the potential effects of Egg White Smoothies on glycemic control, nutritional status, serum albumin levels, and diabetic foot ulcer healing.

6. Acknowledgments

The authors would like to express their sincere gratitude to Dr. Soedomo Regional General Hospital, Trenggalek, particularly the Nutrition Clinic, for granting permission and providing the facilities and support necessary for the implementation of this study. The authors also extend their appreciation to the outpatients with

type 2 diabetes mellitus, diabetic foot ulcers, and hypoalbuminemia who willingly participated in the study as participants and provided valuable contributions to the data collection process.

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