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Original Research Paper

Characteristics and Acceptability of a Modified High-Energy, High-Protein Enteral Formula Based on Local Foods

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Abstract

Background: Enteral formula is a liquid nutritional preparation administered orally or via tube to patients with a functioning digestive system, and high-energy high-protein (HEHP) diets are essential for patients requiring enhanced nutritional intake. **Objective:** To determine the optimal formulation of HEHP enteral formula based on purple sweet potato flour, tempeh flour, and chicken egg flour in terms of macronutrient composition, viscosity, microbiological quality, acceptability, and food cost. **Methods:** This experimental study used a Completely Randomized Design (CRD) with three formulations tested on 30 panelists for organoleptic evaluation. **Results:** The organoleptic test results (color, aroma, taste, and texture) indicated that Formula 1 (F1) was the most preferred. F1 contained 124.49 kcal energy, 6.75% protein, 7.25% fat, and 8.06% carbohydrates per 100 grams, with a viscosity of 34.0 mPa.s and a Total Plate Count of 1.0×10^5 colonies/ml, meeting the acceptable microbiological standards for enteral nutrition. Among all formulations, F1 demonstrated optimal sensory quality, nutritional balance, and production cost efficiency, making it the most suitable candidate for HEHP dietary use. **Conclusion:** The HEHP enteral formula made from purple sweet potato, tempeh, and chicken egg flour is a feasible and acceptable alternative for conscious patients requiring oral HEHP nutritional support.

Keywords: *Enteral Formula; High energy high protein diet; Local food.*

Introduction

A high energy high protein diet (HEHP) is a diet with higher energy and protein content compared to normal nutritional requirements. This diet is prescribed to address problems and risks of malnutrition in patients with energy and protein deficiencies, which may be caused by increased metabolic stress, reduced immune function, disease factors, inflammation, growth failure in children, and other conditions[1–3]. The HEHP diet can be provided in various forms, both orally and enterally. Generally, an HEHP diet is achieved by adding foods or supplements rich in energy or protein without significantly increasing the total volume of food for example, milk, meat, margarine, enteral formulas, and others[4].

The diet is administered gradually according to the patient's tolerance and digestive capacity. Enteral nutrition is a therapy that delivers nutrients through the gastrointestinal tract using a special feeding tube or catheter[5]. Enteral nutrition can be delivered via the nasogastric route (through the nose to the stomach) or nasoduodenal / nasojejunal route (through the nose to the intestine). Nutrient administration can be performed by bolus feeding or continuous infusion using an enteral feeding pump. Early enteral nutrition provides several benefits, including reducing the catabolic response, lowering the risk of infectious complications, improving patient tolerance, maintaining intestinal integrity, preserving immunological response, being more physiological, and serving as an appropriate source of energy for the gut during illness[6–8].

Local food commodities can be utilized as alternative ingredients for modified enteral formulas. Previous studies have reported the development of enteral formulas based on pumpkin and germinated soybean tempeh[9]. Another example includes enteral food formulations using tempeh flour as an alternative high-protein enteral food. Tempeh, a traditional Indonesian food, is produced by fermenting soybeans with Rhizopus sp. Tempeh has superior nutritional content compared to raw soybeans, which naturally contain anti nutritional factors such as antitrypsin and oligosaccharides that may cause excessive gas production (flatulence)[10,11].

Purple sweet potato is a local carbohydrate source that plays a role in diversifying food products and can be processed into various products. Eggs are considered one of the most complete animal protein sources[10,11]. Chicken eggs are regarded as a nutritionally complete food, containing about 12.8% protein and 11.8% fat. Other research has developed specialized formulas based on tempeh flour, corn flour, and catfish flour as alternative enteral formulas for patients requiring a high-energy high-protein diet. Previous researchers were interested in formulating specialized HEHP enteral formulas made from purple sweet potato flour, tempeh flour, and chicken egg flour[9,12].

This study aims to assess the acceptability, proximate analysis, osmolarity, viscosity, microbiological safety, and production costs of specialized HEHP formulas made from purple sweet potato flour, tempeh flour, and chicken egg flour[11,13]. This research will demonstrate the characteristics and acceptability of locally sourced, high-energy high-protein modified enteral formulas based on purple sweet potato flour, tempeh flour, and chicken egg flour.

Materials and Methods

Research Design

This research was an experimental study employing a *completely randomized design (CRD)* with three different treatment formulations. The purpose was to develop and assess a modified high energy, high protein enteral formula using local food ingredients. The study was conducted between February and April 2024 at three locations: the Nutrition Campus of the Health Polytechnic of the Ministry of Health (Poltekkes Kemenkes) Palembang, the laboratory of PT Saraswanti Indo Genetech in Bogor, and the laboratory of the Faculty of Agriculture, Sriwijaya University.

Sample

The sample in this study included three variations of enteral food formulations using a combination of purple sweet potato flour, tempeh flour, and chicken egg flour, with additional ingredients such as full cream milk powder, powdered sugar, maltodextrin, and coconut oil. These ingredients were chosen based on local availability and acceptability. The acceptability test involved a panel of nutrition students from Poltekkes Kemenkes Palembang as untrained panelists for organoleptic evaluation.

Data Collection Techniques

Data were collected through organoleptic (sensory) testing using a structured assessment form. The sensory attributes evaluated included color, aroma, taste, and texture. Panelists rated each attribute using a 5-point hedonic scale: 1 = strongly dislike, 2 = dislike, 3 = somewhat like, 4 = like, and 5 = strongly like. The organoleptic test was conducted in a controlled setting to minimize external influences on the panelists' perceptions, and each formulation was coded to ensure unbiased evaluation. Prior to testing, panelists were given instructions to ensure consistent interpretation of the rating scale.

Data Analysis Techniques

Data from the organoleptic tests were edited before entry to reduce errors and processed using computer software. Analysis was conducted descriptively. Panelists' preferences were presented in percentage format, and mode scores were used to determine the most frequently selected rating for each attribute per formulation.

Ethical Consideration

As this study did not involve human subjects in a medical or invasive context, but only required voluntary participation in sensory evaluation by students, formal ethical clearance was not mandatory. Nevertheless, informed verbal consent was obtained from all panelists, and confidentiality of responses was maintained. The research was conducted in accordance with general ethical principles in food product testing.

Results

The organoleptic test was conducted to evaluate the sensory acceptability of three enteral formula treatments (F1, F2, and F3) based on four key parameters: color, taste, aroma, and texture. This sensory evaluation involved a panel of respondents who provided their perceptions using a five-point hedonic scale ranging from "strongly dislike" to "strongly like." The purpose of this assessment was to identify which formulation achieved the most favorable sensory characteristics and overall acceptance among panelists. Statistical analysis using the Friedman test was applied to determine whether there were significant differences among the three formulas for each sensory parameter. The following combined table presents the detailed organoleptic test results, including the frequency and percentage of panelist responses, as well as the corresponding p-values for each parameter.

Table 1. Combined Organoleptic Test Results of Enteral Formulas

Criteria	Category	F1 (N, %)	F2 (N, %)	F3 (N, %)	p-value
Color	SDL	0 (0)	0 (0)	0 (0)	0.004
	DL	0 (0)	0 (0)	0 (0)	
	SWL	5 (16.7)	8 (26.7)	8 (26.7)	
	L	10(33.3)	19(63.3)	19 (63.3)	
	SL	15 (50)	3 (10)	3 (10)	
Taste	SDL	0 (0)	0 (0)	0 (0)	0.142
	DL	2 (6.7)	2 (6.7)	1 (3.3)	
	SWL	7 (23.3)	12 (40)	10 (33.3)	
	L	13(43.3)	11(36.7)	5 (16.7)	
	SL	8 (26.7)	5 (16.7)	14 (46.7)	
Aroma	SDL	0 (0)	0 (0)	0 (0)	0.004
	DL	1 (3.3)	1 (3.3)	1 (3.3)	
	SWL	2 (6.7)	6 (20)	10 (33.3)	
	L	7 (23.3)	16(53.3)	13 (43.3)	
	SL	20(66.7)	7 (23.3)	6 (20)	
Texture	SDL	0 (0)	0 (0)	0 (0)	0.791
	DL	1 (3.3)	1 (3.3)	2 (6.7)	
	SWL	5 (16.7)	5 (16.7)	7 (23.3)	
	L	16(53.3)	21 (70)	11 (36.7)	
	SL	8 (26.7)	3 (10)	10 (33.3)	

*SDL: Strongly Dislike, DL: Dislike, SWL: Somewhat Like, L: Like, SL: Strongly Like. (**Source:** Primary Research Data)*

The combined organoleptic evaluation showed significant differences in color and aroma (p = 0.004 for both), while taste (p = 0.142) and texture (p = 0.791) were not significantly different among the three formulas (Table 1). Formula F1 was most preferred in terms of color and aroma, with 50% and 66.7% of panelists, respectively, expressing strong liking likely due to its lighter appearance and more pleasant scent resembling milk. In contrast, F2 and F3 appeared darker, resulting in lower color preference scores. Regarding taste, F3 was the most favored (46.7% strongly liked), attributed to its higher purple sweet potato content that balanced the dominant tempeh flavor found in F1 and F2. For texture, all formulas were well-accepted, with F1 and F2 showing slightly higher liking rates due to their smoother and more homogeneous consistency. Overall, F1 was rated highest in visual and olfactory attributes, while F3 excelled in taste, indicating that both formulations have the potential for consumer acceptance depending on sensory preference priorities.

Proximate analysis was conducted to determine the chemical composition of the modified local food-based enteral formula (purple sweet potato flour, tempeh flour, and chicken egg flour) resulting from the best treatment formulation in the study. This analysis aimed to assess the quality of the food ingredients, particularly the nutritional standards that should be contained in the enteral formula. The chemical analysis included protein, fat, and carbohydrate levels.

Table 5. Proximate Analysis Results

Parameter	Formula F1
Ash Content (%)	0.94
Moisture Content (%)	77.00
Total Energy (kcal/100 g)	124.49
Protein (%)	6.75
Fat (%)	7.25
Carbohydrate (%)	8.06

Source: Primary research data

The protein content of the modified enteral formula based on selected local food, F1, is 6.75% of total calories. The protein sources in this ETPT enteral formula come from tempeh flour, chicken egg flour, and full cream milk. The fat content of the ETPT enteral formula based on selected local food, F1, is 7.25% of total calories. Tempeh flour, chicken egg flour, coconut oil, and full cream milk contribute to the fat content of the enteral formula. The viscosity of this formula is 34.0 mPa.s with a Total Plate Count of 1.0 x 105 colonies/ml. This indicates that this formula is safe from bacterial colonies.

Discussion

A high energy high protein diet (HEHP) is a diet with energy and protein content exceeding normal requirements. This diet is designed to address problems and risks of malnutrition in patients suffering from energy and protein deficiencies due to increased metabolic stress, reduced immunity, disease factors, inflammation, growth failure in children, and similar conditions.[4] The modified HEHP enteral formula based on local food commodities has a pale yellowish-white color with a slight purplish brown hue[10,13].

The higher the proportion of chicken egg flour, the more yellowish the resulting color.[10] The purplish-brown color is influenced by the presence of tempeh flour and purple sweet potato flour, whereas full cream milk powder, maltodextrin, and powdered sugar contribute to the whiteness of the formula[13,14].

Faidah et al. (2019)[15] reported that the color of enteral food products is affected by the addition of tempeh. The inclusion of tempeh increases the content of isoflavones, which produces a yellowish-brown color. This yellowish-brown tone originates from soybeans and is an indicator of the presence of isoflavone compounds, as flavone compounds are inherently yellow[10,14].

The taste of the modified enteral formula made from local ingredients (purple sweet potato flour, tempeh flour, chicken egg flour) has a balanced sweetness due to the equal proportion of full cream milk powder, maltodextrin, powdered sugar, and coconut oil in formulas F1, F2, and F3.[16] This formula has a distinctive taste derived from purple sweet potato flour, tempeh flour, and chicken egg flour, which are commonly consumed as food but rarely in beverage form.[14] Differences in taste among formulas F1, F2, and F3 are influenced by the varying proportions of purple sweet potato flour, tempeh flour, and chicken egg flour[9,17].

Formula F3 was the most preferred by panelists because it contained a higher proportion of purple sweet potato flour compared to F1 and F2. This finding aligns with previous studies stating that adding tempeh flour and soybean flour significantly alters taste and aroma[18]. Off-flavor compounds that cause beany odor and bitter aftertaste when adding tempeh flour and soybean flour originate from glycosides and saponins, lipoxygenase enzyme activity, and amino acid hydrolysis, particularly lysine[19,20].

The aroma of formula is a blend resulting from purple sweet potato flour, tempeh flour, and chicken egg flour. Formula F1 had a better aroma compared to F2 and F3, which exhibited a slight beany odor from tempeh flour. This difference also reflects panelists' varied perceptions through olfactory senses. The enteral formula combining purple sweet potato flour, tempeh flour, and chicken egg flour has a unique aroma contributed by full cream milk powder, chicken egg flour, and tempeh flour. Formula F1 was favored the most as it contained the least amount of tempeh flour compared to F2 and F3[13,15].

Tempeh flour has a characteristic aroma with a slight beany note; thus, increasing its proportion reduces the panelists' preference. This is consistent with research indicating that tempeh flour composition affects the aroma of enteral food. The beany aroma typical of tempeh arises from lipoxygenase enzyme activity[10,14]. In terms of texture, panelists generally preferred formula F1 due to its more balanced composition compared to formulas F2 and F3. The modified enteral formula made from purple sweet potato flour, tempeh flour, and chicken egg flour is in powder form with medium particle size. When dissolved, it becomes a homogeneous mixture though fine sediment from tempeh flour and purple sweet potato flour remains[10,14]. The texture is also influenced by full cream milk powder, maltodextrin, and powdered sugar[9].

Food processing can lead to protein content reduction. Protein reduction occurs during processing of raw materials into flour. The processing of tempeh and chicken eggs includes two heating steps: boiling tempeh and pasteurizing eggs, followed by drying each ingredient separately. Boiling tempeh contributes to the reduction of product protein content. Research has shown that boiling can dissolve some proteins into the cooking water, reducing the final protein content[21].

This finding aligns with previous studies reporting decreased protein levels after boiling compared to before boiling. Furthermore, high processing temperatures and duration can damage protein structures, leading to reduced protein levels. Drying temperatures used in food processing typically range from 60–80°C, which may hydrolyze proteins through denaturation. Protein denaturation generally occurs during heating at 55–77°C[21].

Processing of tempeh and chicken eggs involves two heating steps boiling and pasteurization followed by separate drying[22]. Boiling tempeh also contributes to reduced fat content. Puspita Sari et al. (2023)[9] found that boiling and pasteurization at high temperatures and in the presence of water can hydrolyze fat into fatty acids and glycerol, which dissolve in water. Hydrolyzed fat results from the combined effects of high temperature and humidity. Beyond boiling and pasteurization, drying also contributes to the reduction of fat content in the enteral formula[10].

Rokayah (2018) observed that fat degradation in food ingredients occurs after processing and that the extent of degradation varies with temperature and duration. The higher the processing temperature, the greater the fat degradation. Fat exposed to high temperatures melts and easily separates from the cell matrix. Additionally, the fat content in the final enteral formula may not meet standard specifications because the initial formula composition targeted the minimal fat requirement for enteral formulas (around 29%), balancing it against other macronutrients[10].

Carbohydrates are essential nutrients that provide energy for the human body[21]. They are a diverse group of organic compounds sharing similar chemical structures and functions, composed of carbon (C), hydrogen (H), and oxygen (O). Beyond being an energy source, carbohydrates add sweetness to food, spare protein, regulate fat metabolism, and aid in bowel movements[22,23].

The carbohydrate content of the selected local food–based HEHP enteral formula, F1, was 8.06% of total calories. Carbohydrate sources in the formula include full cream milk powder, powdered sugar, and maltodextrin. Carbohydrate levels were calculated by difference, subtracting the sum of moisture, ash, protein, and fat content from 100%. The drying process is one factor contributing to the increased carbohydrate percentage in the final product[10,23].

Parents caring for children with intellectual disabilities experience higher levels of stress, anxiety, and depression compared to the general population. Mental health practitioners need to recognize this issue, so appropriate screening and mental health management can be applied for caregivers of children with intellectual disabilities. Moisture content refers to the amount of water in a material, expressed as a percentage. It is an essential characteristic of food, as water affects appearance, texture, and taste[24].

The moisture content of the selected local food based HEHP enteral formula, F1, was 77.00%. Compared to the Indonesian National Standard (SNI_01_2970_2006) for full-fat milk powder, which sets a maximum moisture content of 5%, the formula did not meet quality standards. Moisture content affects texture and flavor, and is closely related to shelf life by influencing microbial growth. Lower moisture content can slow down microbial proliferation, thereby extending product shelf life[21].

Conclusion

This enteral formula made from purple sweet potato flour, tempeh flour, and chicken egg flour can be used as an alternative enteral formula for patients who are conscious of the ETPT diet and through oral administration.

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Conflict of Interest Statement

The author(s) declare no commercial, financial, or personal conflicts of interest related to this research. All authors approved the final manuscript and consented to its publication in *Healthy Tadulako Journal*.

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