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MODIFICATION ENTERAL FORMULA BASED ON LOCAL FOOD AS A KETOGENIC DIET FORMULA FOR EPILEPSY PATIENTS

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ABSTRACT
Epilepsy is a neurological disorder that commonly occurs in children and can affect cognitive development, nutritional status, and quality of life. The ketogenic diet has been widely used as a nutritional therapy to help reduce seizure frequency in children with refractory epilepsy. This study evaluated the organoleptic characteristics, flow rate, and nutritional content of a local food-based ketogenic enteral formula for epilepsy patients using tempeh, cheddar cheese, and coconut oil. This study using a trial-and-error design. The ingredients are using tempeh, cheddar cheese, and coconut oil with three modification formulation tested on 35 panelists for organoleptic test, flow testing using an NGT tube, and proximate testing. Organoleptic testing showed that formulation F2 (57% tempeh and 37% cheese) had the highest acceptability in color, taste, and texture due to its balanced flavor, creamy mouthfeel, and homogeneous consistency. Flow rate testing using a 12-Fr enteral tube showed F1 had the lowest flow rate (2.2 cc/s), indicating higher viscosity, while F2 and F3 had better flow properties. Nutritional analysis of F2 showed a fat content of 8.40%, meeting ketogenic diet requirements. Coconut oil provided medium-chain triglycerides (MCTs) that support ketone production, while tempeh contributed moderate protein and potential gut health benefits. Overall, F2 was identified as the best formulation with good sensory acceptance, suitable viscosity, and appropriate nutritional composition for ketogenic enteral feeding in epilepsy patients. Modification of the ketogenic enteral diet formula for epilepsy patients resulted in the best formula, F2. F2 and F3 had better flow capacity than F1. Proximate analysis of F2 showed that its fat content met the ketogenic diet standard, which is 70% of total calories.

Keywords: enteral formula; epilepsy; ketogenic diet; local food

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INTRODUCTION

Epilepsy affects approximately 50 million people worldwide, and nearly half of cases begin in childhood. It significantly impacts an individual's quality of life from an early age and can even potentially disrupt cognitive development, behavior, and nutritional status (World Health Organization, 2019). The prevalence of epilepsy in children and adolescents in Indonesia is estimated to range from 0.5–1%, with an incidence rate of 45–50 cases per 100,000 children per year (Kemenkes RI, 2023). These data indicate that epilepsy remains a public health problem that requires a comprehensive and sustainable therapeutic approach. Uncontrolled seizures can increase energy needs due to excessive muscle activity and the body's metabolic response, while food intake often decreases due to impaired consciousness, nausea, or side effects of antiepileptic medications (Neal et al., 2024). This condition can worsen a child's nutritional status and impact long-term growth and development (Ballaban-gil et al., 2018). Therefore, management of epilepsy in children cannot focus solely on seizure control but must also include appropriate nutritional interventions as part of an integrated therapy (Al-beltagi et al., 2025).

The ketogenic diet is a high-fat, moderate-protein, and very low-carbohydrate diet (Lane & Fontaine, 2021). The classic ratio commonly used is 4:1, the ratio of fat to protein and carbohydrates combined. However, in clinical practice, especially in pediatric patients, a 3:1 ratio is often used to improve tolerability without significantly reducing therapeutic effectiveness (Martin-McGill et al., 2020). Several studies have shown that the ketogenic diet can reduce seizure frequency by more than 50% in most children with refractory epilepsy, and even achieve seizure-free status in a small proportion of patients (Muthmainah, 2019). This confirms the important role of nutritional therapy in the management of epilepsy that is difficult to control with pharmacotherapy alone (Sancheti et al., 2016). Furthermore, administering epilepsy medication to children can lead to significant resistance, which can significantly impact activity disruption (Lestari et al., 2025).

Modification of the ketogenic enteral diet formula with local tempe food ingredients is attempted to achieve a 3:1 ketogenic ratio while considering nutritional value, food safety, sensory acceptability, and cost efficiency in the hospital food service system. Tempeh as the main ingredient is a fermented soybean product by Rhizopus oligosporus which can increase the bioavailability of protein, iron, and zinc due to the fermentation process and produce bioactive peptides and isoflavone aglycones that have antioxidant and anti-inflammatory activities (Astuti et al., 2010). The addition of cheese ingredients is based on its very low carbohydrate content (<2 g per 100 g), making it very suitable for ketogenic diet formulations (Mahan & Raymond., 2020). Coconut oil is the main source of fat because it is rich in medium chain triglycerides (MCT), especially lauric acid (C12), capric (C10), and caprylic (C8). MCTs are metabolized directly in the liver without requiring the carnitine system, thus producing ketone bodies more rapidly than long-chain triglycerides (Ballaban-gil et al., 2018). Based on these issues, nutritional therapy for epilepsy patients receiving a ketogenic enteral diet formula requires strict adherence. This study aims to develop and evaluate a local food-based enteral formula as a ketogenic diet formula for epilepsy patients by organoleptic characteristics, flow rate, and nutritional content to identify the most suitable formulation.

METHOD

Research Design

This research was an experimental study using a trial-and-error design, involving modifications to the composition of ingredients to achieve nutritional content consistent with the 3:1 ketogenic diet formula. The study was conducted from January to March 2026 at two locations: the Nutrition Installation of Dr. Mohammad Hoesin General Hospital, Palembang, and the Food Technology Laboratory of the Lampung State Polytechnic. Activities included the creation of a ketogenic enteral formula, organoleptic testing involving 25 trained panelists, flow testing using an NGT tube, and proximate testing.

Materials

The tools and materials used in the research for the formula making process include local tempeh, cheddar cheese, and Barco coconut oil with the ratios listed in table 1. The tools used include food scales, pans, stainless steel bowls, knives, sieves, measuring cups, and spoons. The flow smoothness test consists of a 12-Fr NGT tube.The organoleptic test uses hedonic quality with an organoleptic form of color, taste, aroma, and texture parameters with a rating scale of 1 (very dislike), 2 (dislike), 3 (somewhat like), 4 (like), 5 (very like) (Linangsari et al., 2022).

Table 1.
Modification of the Ingredient Ratio of Ketogenic Enteral Formula

Ingredients	Amount (%)		
	F1	F2	F3
Coconut Oil	6.2	6.2	6.2
Soy Tempeh	28.8	57	51
Cheese	65	37	42

Enteral Formula Preparation

The manufacturing process began with weighing the ingredients, steaming the tempeh, mixing it with oil, then blending and filtering it. Afterward, grated cheese and hot water were added to the tempeh and oil mixture until it reached 1500 ml. The mixture was boiled until boiling, and then filtered again.

Data Analysis
The data were analyzed descriptively. Panelists preference ratings are presented in percentage format (Goss-Sampson, 2019).

RESULT

Table 1.
Organoleptic Test Results

Criteria	Category	F1 (f, %)	F2 (f, %)	F3 (f, %)
Color	1	0 (0)	0 (0)	0 (0)
	2	0 (0)	0 (0)	0 (0)
	3	12 (48)	10 (40)	14 (56)
	4	13 (52)	15 (60)	11 (44)
	5	0 (0)	0 (0)	0 (0)
Taste	1	1 (4)	0 (0)	0 (0)
	2	11 (44)	9 (36)	10 (40)
	3	8 (32)	11 (44)	13 (52)
	4	3 (12)	5 (20)	2 (8)
	5	2 (8)	0 (0)	0 (0)
Aroma	1	0 (0)	0 (0)	0 (0)
	2	4 (16)	3 (12)	4 (16)
	3	15 (60)	12 (48)	15 (60)
	4	6 (24)	10 (40)	6 (24)
	5	0 (0)	0 (0)	0 (0)
Texture	1	0 (0)	0 (0)	0 (0)
	2	1 (4)	0 (0)	1 (4)
	3	14 (56)	14 (56)	16 (64)
	4	9 (36)	10 (40)	7 (28)
	5	1 (4)	1 (4)	1 (4)
		25 (100%)	25 (100%)	25 (100%)

Note: 1 (Strongly Dislike), 2 (Dislike), 3 (Somewhat Like), 4 (Like), 5 (Strongly Like)

Based on the organoleptic test of the keto enteral formula on the aspects of color, aroma, taste and texture to determine the acceptability and level of preference for the formula, it was carried out on 25 trained panelists Table 1. The results of the organoleptic test showed that in terms of color, 60% liked F2. The taste criteria were obtained for 20% of panelists liked F2 compared to F1 12% and F3 8%. Both formulas F1 and F3 for color were 60% panelists liked somewhat and the texture of F2 obtained a 40% higher level of liking compared to F1 (36%) and F3 (28%).

Table 2.
Flow Power Test Results

Parameter	Ketogenic Enteral Formula		
	F1	F2	F3
Volume (ml)	50	50	50
Time (Second)	23	17.8	17.1
Flow Power (ml/second)	2.2	2.8	2.9

Table 3.
Proximate Analysis Results

Parameter	F2
Water (%)	82,42
Ash (%)	1,05
Protein (%)	2,32
Fat (%)	8,40
Fiber (%)	1,26
Carbohydrate (%)	5,78

The flow rate test measures the ability of a liquid to flow within a specified time through a medium or channel with a specific diameter. According to Yudiyanti et al. (2023), the flow rate test is performed on an NGT tube to determine the speed or time required for liquid food to flow through the tube when administered to a patient. Based on the results of the flow rate test using a 12-Fr pediatric enteral tube, the flow rate of F1, at 2.2 ml/s, was the lowest compared to the flow rates of F2 and F3, at 2.8 ml/s and 2.9 ml/s, respectively. This can be interpreted as F1 having a thicker consistency than the other two formulations. Proximate testing was performed on the selected formulation, F2, with the organoleptic results shown in table 3. This indicates that the formulation obtained had a high fat content, making it suitable for use as a ketogenic diet formula.

DISCUSSION

The organoleptic test of the keto enteral formula on the aspects of color, aroma, taste and texture to determine the acceptability and level of preference for the formula. The results of the organoleptic test showed that in terms of color, 60% of panelist liked. The difference in color preference is thought to be influenced by the proportion of tempeh and cheese in each formulation, while the use of the same coconut oil at 6.2% resulted in a relatively uniform color effect. In F1, the use of higher cheese (65%) resulted in a more intense yellow color due to the natural pigments and fat content in the cheese, while in F3, increasing the proportion of tempeh can cause a cloudier or brownish color because tempeh from fermented soybeans has a natural brownish cream color. Formulation F2 with a balance of 57% tempeh and 37% cheese produced a brighter and more homogeneous color, making it more preferred by panelists. This is in line with research that the addition and ratio of food ingredients can affect the color of the final product due to the content of pigments, proteins, fats, and browning reactions during processing, such as the Maillard reaction that occurs due to heating (Hosry et al., 2025).

The taste criteria obtained for 20% of panelists liked F2 compared to F1 12% and F3 8%. The F2 formulation with a combination of 57% tempeh and 37% cheese is thought to produce a balance of savory, creamy, and not too dominant flavors, making it more acceptable. This indicates that the addition and ratio of food ingredients affect the taste of the final product because each ingredient has different flavor-forming compounds, such as protein, fat, and fermentation products that can affect the product's sensory characteristics. In addition, the fat content in cheese plays a role in improving mouthfeel, creating a more stable texture, and improving taste through a flavor binding effect, thereby increasing the acceptability of high-fat enteral formulas (Lawless & Heymann, 2010).

Both formulas F1 and F3 were 60% panelists liked somewhat and the texture of F2 obtained a 40% higher level of liking compared to F1 (36%) and F3 (28%). The organoleptic test results showed that the color of both F1 and F3 formulations was rated as slightly liked by 60% of the panelists, while the texture of F2 formulation had the highest preference rating at 40% compared to F1 at 36% and F3 at 28%. The color acceptance rate of F1 and F3 is thought to be influenced by the different proportions of tempeh and cheese that produce different color intensities, where a higher cheese content produces a more intense yellow color, while tempeh can produce a brownish cream color due to the fermentation and heating process. Meanwhile, the texture of F2 was preferred because the more balanced combination of tempeh and cheese was able to produce a more homogeneous, soft consistency, and was neither too thick nor too runny. The protein content in tempeh and the fat and milk protein in cheese are known to affect the viscosity and stability of enteral product emulsions, thus affecting the final texture of the product. Research states that the addition of food ingredients with different protein and fat compositions can affect physical and sensory characteristics, especially color and texture, due to changes in emulsion structure, water content, and interactions between components during processing. (Suryani et al., 2018; Putri & Widjanarko, 2020).

The flow rate test is performed on an NGT tube to determine the speed or time required for liquid food to flow through the tube when administered to a patient. Based on the results of the flow rate test using a 12-Fr pediatric enteral tube, the flow rate of F1, at 2.2 cc/s, was the lowest compared to the flow rates of F2 and F3, at 2.8 cc/s and 2.9 cc/s, respectively. This can be interpreted as F1 having a thicker consistency than the other two formulations. High-fat formulas tend to have higher viscosity due to their high lipid and protein content, resulting in more pronounced flow resistance, especially in small-diameter hoses (Liu et al., 2025). In this formulation, viscosity is influenced by tempeh as a source of protein and fiber, cheddar cheese as a source of protein and fat, and coconut oil as the primary fat source. High protein and fat content can increase viscosity through the interaction of protein-fat molecules and the ingredients' ability to bind water. Heating during processing can also cause protein denaturation, which impacts the final consistency of the formula (Yalcin et al., 2021).

The nutritional content of the ketogenic enteral formula includes fat, protein, carbohydrates, water, ash, and fiber in Table 3. The formula was developed as an alternative enteral formula for the ketogenic diet in epilepsy patients. The ingredients used were from local food sources, namely tempeh as a source of vegetable protein, and cheese and coconut oil as sources of fat. The formulation was created to determine the nutritional content based on the principles of a high-fat ketogenic diet. Nutritional content testing was carried out on the best formulation, F2, with a fat content of 8.40% BB, which means it has met the fat requirement in a ketogenic diet, which reaches 70% of total calories (Bachar & Birk, 2025). This is also related to the ingredient used, namely coconut oil as the main source of fat because it is rich in medium-chain triglycerides (MCT), especially lauric acid (C12), capric (C10), and caprylic (C8). MCT is metabolized directly in the liver without requiring the carnitine system, so it produces ketone bodies more quickly than long-chain triglycerides (Fern et al., 2023). The goal of the ketogenic diet is to produce ketone bodies as a parameter that the body has successfully metabolized fat as an energy source (Shaaban et al., 2023).

Tempeh's moderate protein content allows for protein regulation to maintain a 3:1 ratio, thus supporting ketone body production without excessively increasing gluconeogenesis (Kossoff et al., 2018). With these considerations, tempeh serves not only as an economical protein source but also as a functional food component that supports metabolic and gastrointestinal health in ketogenic diet patients. Consumption of fermented vegetable protein can have a positive effect on the gut microbiota (Galena et al., 2022). The balance of the gut microbiota plays a crucial role in regulating the gut-brain axis, which is known to contribute to seizure control mechanisms on a ketogenic diet (Olson et al., 2018).

CONCLUSION

Modification of the ketogenic enteral diet formula for epilepsy patients resulted the best formula, F2. F2 and F3 had better flow capacity than F1. Proximate analysis of F2 showed that the fat content met the ketogenic diet standard, which is 70% of total calories.

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