Pumpkin and Tempeh-Based Enteral Nutrition as a Supplementary Food for Undernourished Toddlers

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ABSTRACT

In Indonesia, the prevalence of malnutrition among children is 3.9% for severe cases and 13.8% for moderate cases. Pumpkin, rich in β-carotene, enhances immunity, while tempeh, high in protein, supports growth and development in children. This study aimed to evaluate the physical and sensory characteristics of an enteral formula based on pumpkin and tempeh as a high-energy and high-protein (HEHP) supplementary food for malnourished children. A descriptive method was used to analyze the formula's flow rate, viscosity, osmolality, and acceptability. A total of 24 panelists assessed the sensory quality of the enteral formula. Results showed a flow rate of 1.5 ml/second, viscosity of 60.47 cp, and osmolality of 325 mOsm/kg H2O. Panelists rated the formula's color (6, liked), aroma (5, slightly liked), taste (5, slightly liked), texture (4, neutral), and overall acceptability (5, slightly liked). This enteral formula shows potential as an alternative therapy for malnourished children due to its high nutrient density and physical properties that meet the criteria for enteral feeding.

Keywords: *Enteral, malnutrition, pumpkin, physical properties, tempeh*

INTRODUCTION

Nutritional status is a critical indicator in assessing the success of meeting children's nutritional needs, as reflected in weight according to age. Malnutrition is a long-term nutritional deficiency condition that leads to a decline in health status, particularly among children aged 12–59 months, who are at high risk of experiencing nutritional issues. At this age, children require higher nutrient intake for growth and development. They are heavily dependent on their parents to meet their nutritional needs, and a failure to do so could increase the risk of malnutrition, which in turn reduces immune resilience and heightens susceptibility to infections (1).

The 2018 Basic Health Research (Riset Kesehatan Dasar) data reported a prevalence of severe malnutrition at 3.9% and undernutrition at 13.8%. Severe malnutrition is characterized by weight-for-height or length less than 70% of the median value or a z-score below -3 SD, with or without accompanying edema (2). Children with acute severe malnutrition can be treated with WHO formulas (F-75 or F-100) as part of a stabilization therapy (3). Enteral formulas, delivered via feeding tubes, are an alternative for individuals unable to eat orally, including those with severe nutritional problems. There are two types of enteral foods: homemade liquid formulas and commercial powders, both of which can be adjusted to meet the specific nutritional needs of patients (4).

Although WHO formulas have been implemented, many children reject them during recovery due to their low calorie and energy content. Research has shown that involving families in supplementary feeding (PMT) programs is more effective in increasing children's weight compared to solely hospital-based care. PMT with high-energy and protein-modified formulas, made from affordable and accessible ingredients, also supports meeting children's nutritional needs (5). Studies indicate that 85% of children fail to meet their protein intake, which is linked to maternal education and protein adequacy in children (6). There is also a correlation between eating habits, hygiene, and environmental sanitation with the prevalence of stunting in children aged 24–59 months in Sukoharjo Regency (7). These findings highlight the importance of managing children's eating habits to achieve optimal nutritional status.

Yellow pumpkin and tempe are highly nutritious local food ingredients that have the potential to be used as alternatives in enteral formula production. Enteral foods based on tempe flour offer equivalent nutritional value to commercial formulas but at a more economical price and with easily obtainable ingredients. Tempe is a traditional Indonesian food made by fermenting soybeans with Rhizopus sp., which removes antinutritional compounds and enhances soybean digestibility. Every 100 grams of tempe contains approximately 19 grams of protein. Adding tempe to the formulation helps meet the nutritional requirements of enteral food (8). Yellow pumpkin is another local ingredient with significant nutritional value for the body (9). It contains provitamin A or β-carotene, which accelerates nutritional recovery. The β-carotene content in 100 grams of yellow pumpkin is approximately 1,569 µg. A study (10) found that β-carotene levels in enteral formulas processed at three different blending times (30, 60, and 90 seconds) reached 4.75, 4.32, and 4.11 mcg/100 g, respectively. Among vegetables, yellow pumpkin has the highest β-carotene content (11). β-carotene plays a vital role in enhancing the immune response, thereby helping the body combat infections (12).

MATERIAL AND METHODS

This research was carried out in the Food Science Laboratory and Food Quality Analysis Laboratory of the Nutrition Science Program, Faculty of Health Sciences, Universitas Muhammadiyah Surakarta. The study employed a descriptive research design as it focused on describing results from laboratory testing data. The samples used in this study were enteral formulas made from yellow pumpkin and tempe. The enteral formulas were analyzed for their nutritional value, flow rate, viscosity, osmolality, and acceptability.

The ingredients used to prepare the enteral formula included:

- 100 g of yellow pumpkin
- 40 g of tempeh
- 48 g of duck eggs
- 20 g of skim milk
- 8 g of coconut oil
- 12 g of granulated sugar
- 20 g of maltodextrin
- 4 g of vanilla extract
- 388 ml of water

The step-by-step procedure for making the enteral formula is presented in **Figure 1**.

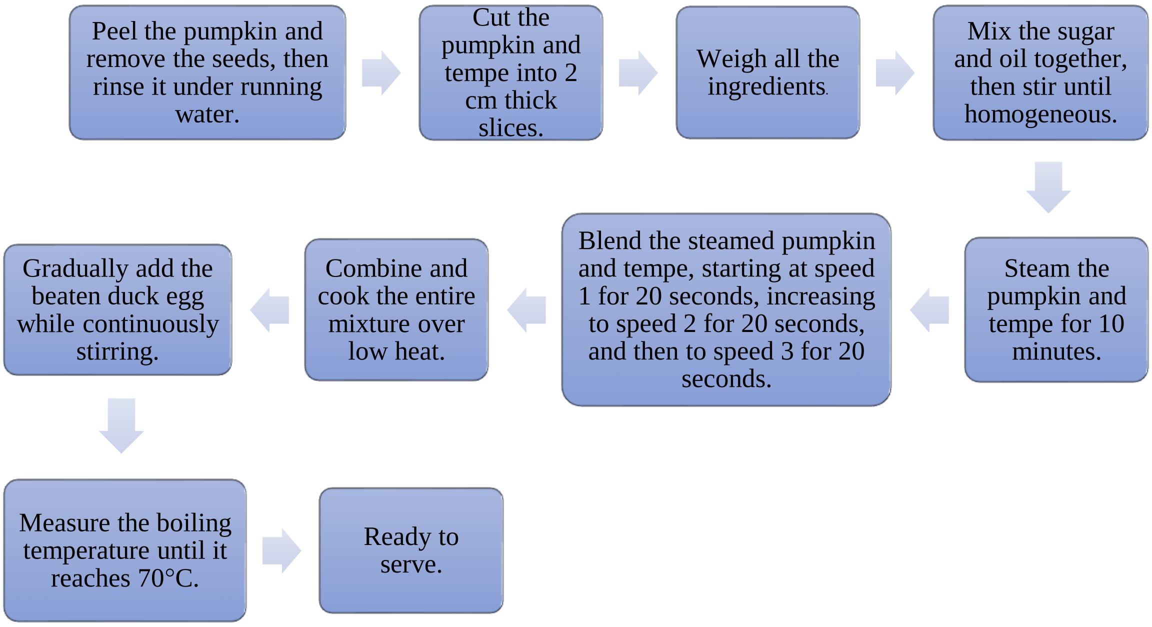

Figure 1. Enteral Feeding Procedure

The nutritional value of the prepared enteral formula was analyzed using the Nutrisurvey application, which had been translated into Indonesian. The analysis included key nutrients such as energy (kcal), protein (g), fat (g), and carbohydrates (g).

The flow rate testing of the enteral formula required the formula itself as the primary material. The equipment used for the flow rate test included:

- Timer
- Enteral feeding bottle
- 16 French feeding tube
- Basin

The procedure for testing the flow rate of the enteral formula is illustrated in **Figure 2**.

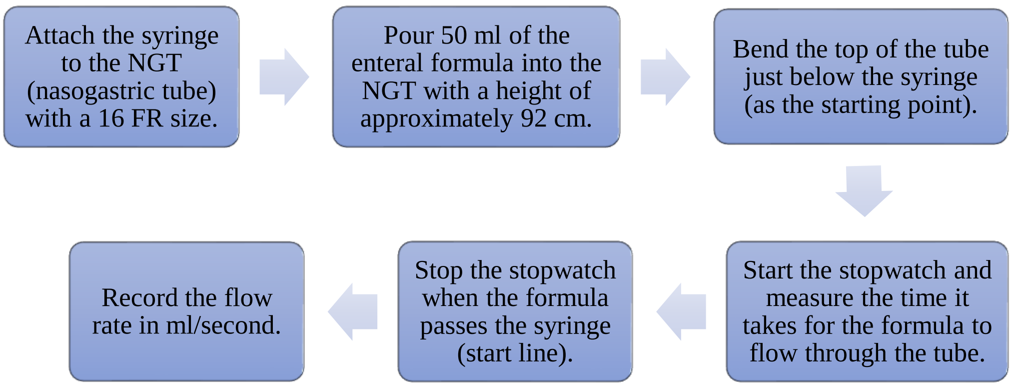

Figure 2. Enteral Flow Test

The viscosity of the enteral formula was measured using a Brookfield viscometer. Prior to testing, the device was calibrated and adjusted according to the specific characteristics of the enteral formula. The viscosity value of the enteral formula was recorded and expressed in centipoise (cP).

Table 1. Viscometer Settings During Viscosity Measurement of Enteral Formula

Parameter	Setting
Alat	Brooksfield Viscometer DV-II+ Pro
Spindle Type	61
Speed (RPM)	60rpm
Torque	62,5%
Temperature (°C)	28,7°C

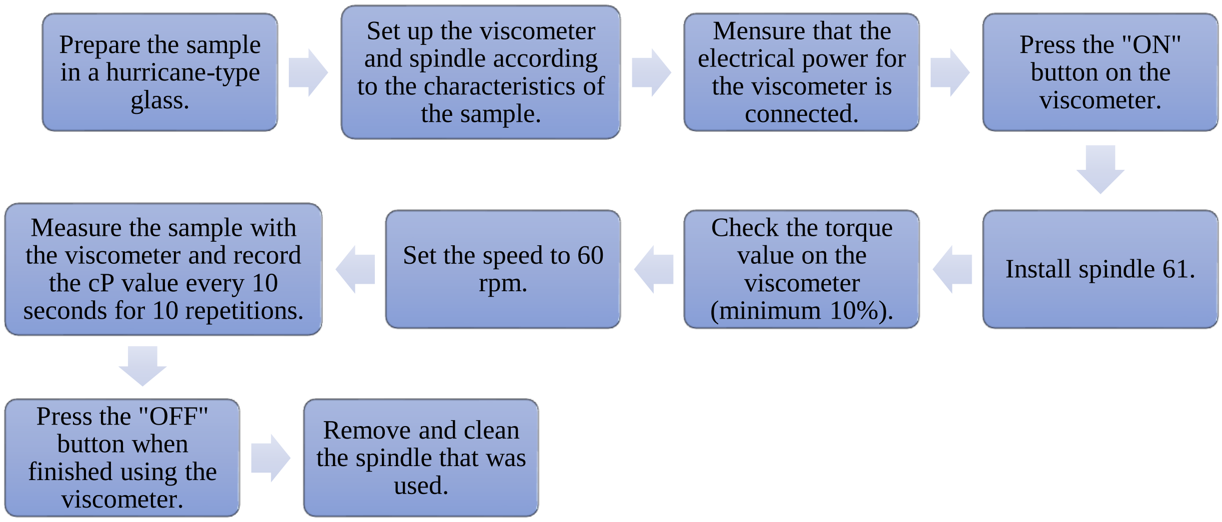

Figure 3. Viscosity Testing Procedure

The osmolality of the enteral formula was tested using the Osmotech Advanced Instrument. A sample volume of 20 µL was taken for the osmolality measurement. The step-by-step procedure for the osmolality testing is illustrated in **Figure 4**.

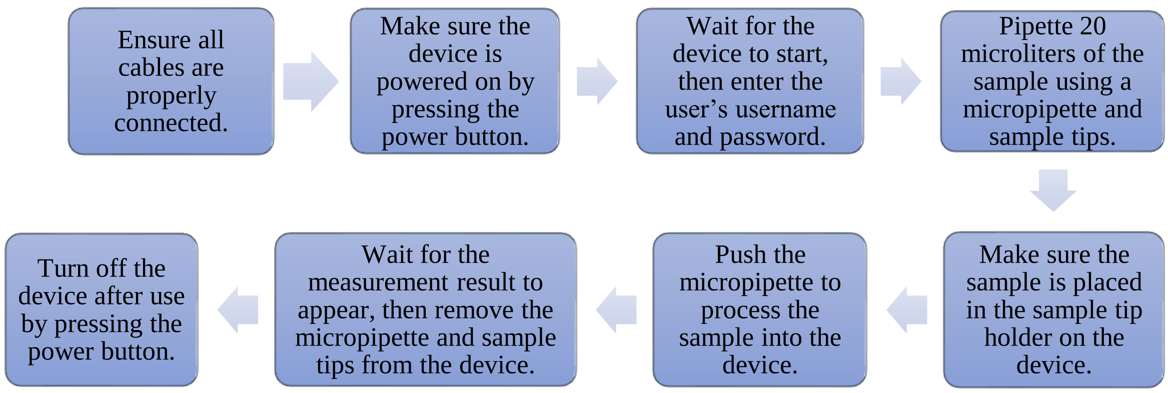

Figure 4. Osmolality Test

The final test conducted was a hedonic (preference) test, involving 24 trained panelists. The panelists evaluated the enteral formula using a 7-point odd-numbered scale to measure their level of preference:

7: Very much like
6: Like
5: Somewhat like
4: Neutral
3: Somewhat dislike
2: Dislike
1: Strongly dislike

The hedonic test assessed five attributes of the enteral formula: color, aroma, taste, texture, and overall acceptability.

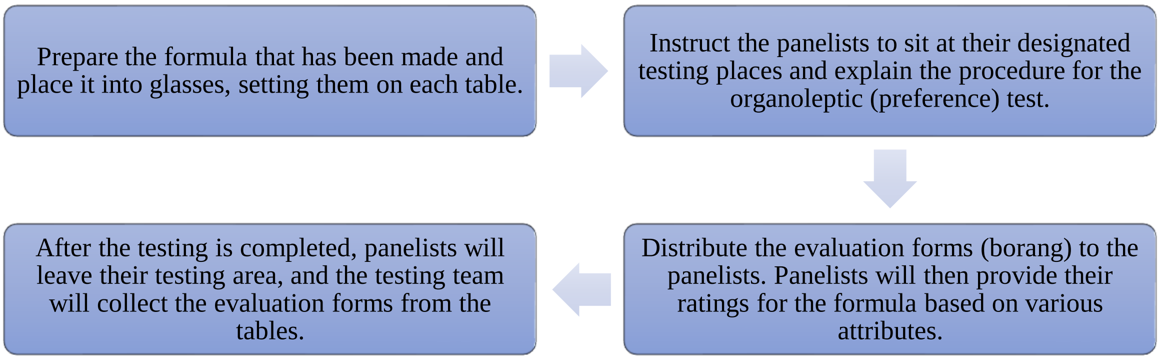

Figure 5. Hedonic/Preference Test

The data analysis technique used in this study was descriptive analysis. The method involved calculating the mean and percentage of the data, followed by presenting the results in descriptive form to provide a clear representation of the findings.

RESULT

Table 2. Macronutrient Content in Enteral Formulations

Ingredients	Weight (g)	Energy (kkal)	Protein (g)	Fat (g)	Carbohydrate (g)
Yellow pumpkin	100	68,88	2,28	0,64	13,48
Tempeh	40	80,4	8,32	3,44	5,6
Duck eggs	48	99,72	5,8	6,6	4,2
Skim milk	20	72	7,08	0,2	10,4
Coconut oil	8	69,6	0,08	7,84	0
Granulated sugar	12	47,28	0	0	11,28
Maltodextrin	20	238,8	0	0	58,2
Vanilla extract	4	12	0	0	0,52
Water	388	0	0	0	0
Total	**600**	**688,68**	**23,56**	**18,72**	**103,68**
1 ml of formula contains 1.1 kcal					

Table 3. Results of Enteral Formula Flow Test

Volume (ml)	Long Time Flow (per second)	Flow Power (ml/second)
50	33.39	1.5

Table 4. Results of Enteral Formula Viscosity Test

Time (s)	Viscosity Value (cP)
10	62.3
20	59.4
30	59.2
40	59.5
50	59.9
60	60.1
70	60.5
80	60.8
90	61.3
100	61.8
Average	60.7 cP

Table 5. Results of Enteral Formula Osmolality Test

Sample	Test Result
Enteral Formula	325 mOsm/kgH_2O

Table 6. Results of Enteral Formula Preference Test

Attribute / Preference Scale	Color	Aroma	Taste	Texture	Overall
Very much like	0	0	0	0	0
Like	3	2	1	2	2
Somewhat like	1	0	3	0	2
Neutral	0	2	0	0	0
Somewhat dislike	0	0	0	2	0
Dislike	0	0	0	0	0
Strongly dislike	0	0	0	0	0
Average	**6**	**5**	**5**	**4**	**5**
Description	Like	Somewhat like	Somewhat like	Neutral	Somewhat like

DISCUSSION

The enteral formula was prepared in a total volume of 600 ml, containing the following nutritional components: 688.68 kcal of energy, 23.56 g of protein, 18.72 g of fat, and 103.68 g of carbohydrates, making the formula energy-dense at 1.1 kcal per ml. The formula was made using real food ingredients to ensure that the materials are easily accessible in the market, affordable, and simple to prepare. The ingredients used include yellow pumpkin, tempe, duck eggs, skim milk, coconut oil, granulated sugar, maltodextrin, vanilla extract, and water. The addition of vanilla extract was intended to minimize the fishy odor from the duck eggs. Duck eggs were chosen for their higher protein content compared to regular chicken eggs, which supports the formulation of a high-energy, high-protein enteral diet. The fat source in the formula comes from coconut oil, which belongs to the category of medium-chain triglycerides (MCTs), known for being easily digestible and absorbed. The carbohydrate sources are maltodextrin and granulated sugar, which provide quick energy (13).

The composition of the ingredients in the enteral formula plays a significant role in the nutritional recovery of infants with malnutrition or undernutrition. Yellow pumpkin contains β-carotene, which is a precursor of vitamin A, essential for accelerating nutritional recovery. The β-carotene content in 100 grams of yellow pumpkin is 1569μg, which is the highest compared to other β-carotene sources like carrots (11). β-carotene is crucial in boosting the immune response, thus helping to protect the body against infections (12). Tempe, as a base ingredient in the enteral formula, plays an important role in preventing and treating malnutrition. As a high-quality protein source, tempe contains complete essential amino acids. It is also rich in various minerals such as calcium, phosphorus, potassium, iron, magnesium, manganese, zinc, and copper. Additionally, tempe is low in saturated fats, high in unsaturated fatty acids, and contains various B vitamins, particularly B12, riboflavin, and niacin. With its low cholesterol content, high fiber, and reduced levels of stachyose, raffinose, and phytic acid, tempe is easily digestible. It also provides antioxidants such as isoflavones, probiotics, and natural antibiotics. Tempe can help boost the immune system, prevent degenerative diseases, reduce the risk of cardiovascular disease, prevent anemia, protect against osteoporosis, and improve bone and dental health (14).

The inclusion of duck eggs in the enteral formula offers numerous benefits as they are a high-quality, easily digestible source of animal protein with a rich nutritional profile. Duck eggs contain 13% protein, 12% fat, and various vitamins and minerals. They are especially high in vitamin B6, pantothenic acid, vitamin A, vitamin E, and vitamin B12 (15). Compared to other poultry eggs, duck eggs have the highest protein content, about 80%. Moreover, the yolks of duck eggs are rich in antioxidants and omega-3 fatty acids, making them beneficial for children with malnutrition or nutritional deficiencies (16).

The energy density of the enteral formula refers to the ratio between the number of calories and the volume of the enteral formula, analyzed in kcal/ml (17). Generally, the energy density of enteral formulas ranges from 0.5 to 2.0 kcal/ml (18). A higher energy density in an enteral formula means less fluid content. For this real food-based formula, the energy density was found to be 1.1 kcal/ml, which meets the energy density standard for enteral formulas, making it suitable for patients who require high energy without fluid restrictions (7). In the flow rate test of the enteral formula, a 16 French tube yielded a flow rate of 1.5 ml/sec. This means that 50 ml of formula can flow through a 16Fr tube in 33.39 seconds. According to theoretical guidelines, enteral formulas with volumes of 250-500 ml generally require 5-10 minutes for administration (19). In this study, the enteral formula flowed in 2.78 to 5.57 minutes, indicating that the flow rate met the standard for enteral formulas.

The viscosity test of the real food-based enteral formula, composed of yellow pumpkin and tempe, using spindle 61, yielded an average viscosity of 60.7 cP. This viscosity falls into the "nectar-like" category, which ranges from 51 to 350 cP (20). Viscosity is an important characteristic of liquid foods in food processing. In this study, the viscosity of the enteral formula decreased over time, showing a steady reduction every ten seconds. According to Pratiwi & Noer (2014), the viscosity of liquid foods can change during heating or cooling processes. Factors such as temperature, solute concentration, molecular weight, and pressure affect viscosity. As temperature decreases, particle movement slows down, increasing viscosity. Conversely, as solid concentration increases, viscosity tends to decrease. Therefore, it can be concluded that in real food-based formulas, viscosity tends to increase over time, influenced by the concentration of dissolved substances (21). Higher viscosity indicates greater internal resistance to flow, making it harder for fluids to move or for objects to pass through (22).

In the osmolality test, the real food-based enteral formula yielded a result of 520 mOsm/kg. The recommended osmolality range for enteral formulas in the treatment of malnutrition is between 300 and 500 mOsm/kg, to ensure good tolerance by patients, especially those with swallowing or digestion issues (23). The result of 325 mOsm/kg falls within this recommended range, indicating that the concentration of dissolved particles in the formula is appropriate for treating malnutrition. Osmolality is an important factor in determining the solubility of enteral formulas. High osmolality can lead to irritation of the digestive tract or nutrient absorption issues.

Figure 6. Enteral Formula Made from Pumpkin and Tempe

The purpose of the hedonic/acceptance test is to assess the acceptance of the enteral formula using a questionnaire with 24 panelists, which includes attributes such as color, aroma, taste, texture, and overall acceptance. The results for each attribute are as follows: the color parameter received an average score of 6 (like), indicating that the panelists generally liked the color; the aroma parameter received an average score of 5 (somewhat like), meaning the panelists somewhat liked the aroma; the taste parameter also received an average score of 5 (somewhat like), suggesting that the taste was somewhat liked; the texture parameter received a neutral score of 4, indicating that the texture was neither liked nor disliked; and the overall acceptance score was 5 (somewhat like), suggesting that the panelists were generally somewhat fond of the formula.

The overall evaluation of the enteral formula showed that it had a yellowish color, a typical milk aroma, a plain milk-like taste, and a thin texture. Most of the panelists gave a "somewhat like" rating, indicating that the formula was generally accepted with mild approval in terms of color, aroma, taste, and texture.

CONCLUSION

The enteral formula made from pumpkin and tempe contains the following nutritional values per 600 ml: 688.68 kcal of energy, 23.56 g of protein, 18.72 g of fat, and 103.68 g of carbohydrates. The energy density of the enteral formula is 1.1 kcal/ml. The formula shows a flow rate of 1.50 ml/second, a viscosity of 60.47 cP, and an osmolality of 325 mOsm/kg H_2O. The formula has a yellowish color, a plain milk-like taste, a milk-like aroma, and a thin texture, which does not result in any sediment even after being left standing for a long period. The hedonic test results show that, overall, the formula is somewhat liked by the panelists. This enteral formula can be an alternative option for patients requiring a high-energy and high-protein diet (TETP).

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