

## Development and Acceptability Test of Enteral Food Formulation Based on Local Foods “*KarotenPe*” Tempeh Flour and Carrot Flour High in BCAA for Cancer Disease

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### Abstract

**Introduction:** Cancer can impair nutritional status due to alterations in the metabolism of energy, protein, fat, and micronutrients, which may lead to malnutrition and require nutritional support through enteral formulas. The development of enteral nutrition based on local food ingredients offers a potential alternative to improve accessibility and nutritional quality for patients. **Objective:** This study aimed to develop an enteral formula based on tempeh flour as a source of plant protein and carrot flour as a source of beta-carotene, and to evaluate its physical characteristics and sensory acceptability. **Method:** A completely randomized design with three formulations was employed, analyzing viscosity, osmolarity, flow rate, moisture content, color parameters, and sensory evaluation. **Result and Discussion:** All formulations met viscosity and flow rate standards. Formula 2 demonstrated the closest flow rate to the commercial product and achieved the highest sensory scores. However, osmolarity across all formulations exceeded recommended ranges, and moisture content surpassed the ideal limit, potentially affecting product stability. No significant differences were found among formulations in sensory parameters. **Conclusions:** Formula 2 was identified as the most preferred formulation with characteristics closest to the commercial product. However, improvements are required in terms of osmolarity and moisture content to meet the standard requirements for enteral nutrition products.

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### **Introduction**

Cancer is one of the most prevalent diseases worldwide and remains a leading cause of mortality, posing a major burden on global health systems (Islami *et al.*, 2022). The increasing incidence and mortality rates highlight the urgency of comprehensive management strategies, including adequate nutritional support for patients (Awuchi *et al.*, 2020). One of the most important issues in cancer care is malnutrition, which arises due to metabolic alterations affecting energy, protein, fat, and micronutrient utilization. Cancer patients often experience reduced food intake, increased basal metabolic rate, and enhanced gluconeogenesis driven by tumor metabolism (Masi & Patel, 2021). Additionally, decreased protein synthesis contributes to progressive nutritional decline and worsens clinical outcomes. Cancer cachexia, characterized by weight loss, muscle wasting, anemia, and weakness, further emphasizes the importance of effective nutritional interventions (Clemente-Suárez *et al.*, 2022).

To overcome malnutrition in cancer patients, enteral nutrition has become an important therapeutic approach because it provides nutrients directly through the gastrointestinal tract in a controlled and efficient manner. However, the availability of enteral formulas is often limited by high costs and dependence on imported commercial products, especially in developing countries. This condition creates a strong need for alternative enteral formulas based on locally available food ingredients that are affordable and nutritionally adequate. Plant-based protein sources such as soybeans are considered a promising option due to their accessibility and nutritional value (Qin *et al.*, 2022). Tempeh, a traditional Indonesian fermented soybean product, has advantages in terms of enhanced digestibility and bioavailability of nutrients. Its fermentation process improves protein quality and makes it suitable for patients with compromised nutritional status (Rizzo, 2024). Thus, the development of local enteral formulas using tempeh represents a strategic solution to improve accessibility and sustainability of nutritional support.

Tempeh is not only a rich source of plant-based protein but also contains bioactive compounds such as isoflavones that act as antioxidants (Ahmed & Saeed, 2026; Ahnan-Winarno *et al.*, 2021). In addition, tempeh flour has been reported to contain high levels of branched-chain amino acids (BCAA), including valine, leucine, and isoleucine, which play an essential role in muscle maintenance and recovery (Yanti *et al.*, 2023). These amino acids are particularly important for cancer patients who are at risk of muscle wasting due to cachexia. On the other hand, carrots are a rich source of beta-carotene, an antioxidant that supports immune function and helps counteract oxidative stress caused by cancer (Medina-García *et al.*, 2025). Carrots also provide essential nutrients such as vitamin C, iron, and calcium that contribute to hemoglobin formation and immune response (Varshney & Mishra, 2022). The combination of tempeh and carrots therefore offers a balanced nutritional profile, integrating protein, BCAA, and antioxidant components.

Despite the known nutritional benefits of tempeh and carrots, studies focusing on their application in enteral nutrition formulations are still limited. Most existing enteral formulas rely on imported ingredients or animal-based protein sources, which may not be affordable or accessible for all patients. In addition, previous studies have primarily focused on general nutritional content without comprehensive evaluation of physical characteristics such as viscosity, osmolarity, and flow rate, which are critical for enteral feeding tolerance. There is also limited research examining the sensory acceptability of local enteral formulations, which is important for patient compliance. Furthermore, challenges such as high osmolarity and moisture content in locally developed formulas

## **Development and Acceptability Test of Enteral Food Formulation Based on Local Foods “*KarotenPe*” Tempeh Flour and Carrot Flour High in BCAA for Cancer Disease**

have not been adequately addressed. These gaps show the need for further research to develop and evaluate enteral formulas based on local ingredients with both optimal nutritional and physical properties. Therefore, a more focused investigation is required to bridge the gap between nutritional potential and practical application.

Based on these considerations, this study aims to develop an enteral formula based on tempeh flour and carrot flour as sources of BCAA and antioxidants. The study also evaluates the physical characteristics, including viscosity, osmolality, flow rate, and moisture content, as well as sensory acceptability. By utilizing locally available ingredients, this research seeks to provide an alternative enteral nutrition product that is affordable and nutritionally beneficial for cancer patients. In addition, this study contributes to addressing the research gap related to the limited development of local enteral formulas with comprehensive evaluation parameters. The findings are expected to support the advancement of functional clinical nutrition products in developing countries. Ultimately, this research aims to improve the quality and accessibility of nutritional support for cancer patients through innovative use of local food resources.

### **Method**

This study employed an experimental research design using a Completely Randomized Design (CRD) with three different treatment formulations. The research was conducted in August 2025 at several laboratory facilities of Universitas Muhammadiyah Surakarta. The flow rate and viscosity tests were carried out in the Food Science Laboratory, while osmolality analysis was conducted in the Food Quality Analysis Laboratory. In addition, organoleptic evaluation was performed in the Sensory (Organoleptic) Laboratory. The sensory test involved 15 trained panelists who were students from the Dietitian Professional Program at Universitas Muhammadiyah Surakarta. These panelists were selected based on their prior experience and training in sensory evaluation to ensure the reliability of the results.

The materials used in this study included tempeh flour as a plant-based protein source and carrot flour as a source of beta-carotene. Additional ingredients consisted of skim milk powder, maltodextrin, granulated sugar, and canola oil, which were used to enhance the nutritional profile and energy content of the enteral formula. All ingredients were food-grade and prepared according to standard laboratory procedures. The selection of these materials was based on their nutritional value, availability, and suitability for enteral feeding formulations. The combination of these ingredients aimed to produce a balanced nutritional formula rich in protein, energy, and antioxidants.

The preparation of the enteral formula began with weighing each ingredient according to the predetermined formulation ratios. All dry ingredients were then mixed thoroughly until a homogeneous powder mixture was obtained. Afterward, canola oil was added and mixed evenly into the formulation. The mixture was then reconstituted using warm water and stirred continuously until the total volume reached 1000 mL. The final solution was homogenized to ensure uniform consistency and prevent sedimentation.

## Development and Acceptability Test of Enteral Food Formulation Based on Local Foods “*KarotenPe*” Tempeh Flour and Carrot Flour High in BCAA for Cancer Disease

**Table 1**  
KarotenPe Enteral Formula Composition

Ingredients	F <sub>1</sub> (g)	F <sub>2</sub> (g)	F <sub>3</sub> (g)
Tempeh flour	75	85	75
Carrot flour	20	20	20
Skim milk powder	95	85	95
Maltodextrin	60	60	60
Sugar	15	15	15
Canola oil	25	25	25
<b>Total</b>	<b>290</b>	<b>290</b>	<b>290</b>

Each formulation (F<sub>1</sub>, F<sub>2</sub>, and F<sub>3</sub>) was subjected to several physical and chemical analyses, including flow rate, viscosity, osmolarity, and moisture content. Flow rate was measured by recording the time required for a specific volume of the formula to flow under standardized conditions. Viscosity was measured using a viscometer and expressed in centipoise (cp). Osmolarity was determined to evaluate the solute concentration of the formula, which is an important parameter for enteral nutrition tolerance. Moisture content analysis was conducted to assess the stability and shelf-life potential of the powdered formulation.

In addition to physical and chemical tests, an organoleptic (sensory) evaluation was conducted to assess consumer acceptability. The parameters evaluated included color, aroma, taste, texture, and overall acceptance. A 7-point hedonic scale was used, where 1 = strongly dislike, 2 = dislike, 3 = slightly dislike, 4 = neutral, 5 = slightly like, 6 = like, and 7 = strongly like. The evaluation was conducted under controlled conditions to minimize bias, and each panelist assessed all three formulations independently. The results were recorded and tabulated for further statistical analysis.

Data obtained from the organoleptic tests were analyzed using One-Way Analysis of Variance (ANOVA) to determine whether there were significant differences among the three formulations. If significant differences were found, further analysis was conducted using the Tukey post hoc test to identify specific differences between groups. For data that were not normally distributed, non-parametric statistical tests were applied, including the Kruskal-Wallis test followed by the Mann-Whitney test for pairwise comparisons. All statistical analyses were performed to ensure the validity and reliability of the conclusions drawn from the study.

## Result and Discussion

### 1. Results

The results of the physical, chemical, and organoleptic analyses of the KarotenPe enteral formulations (F<sub>1</sub>, F<sub>2</sub>, and F<sub>3</sub>) are presented in Table 2. The three formulations exhibited varying characteristics in terms of viscosity, osmolarity, flow rate, moisture content, color parameters, and sensory acceptance. Comparisons with a commercial product were also included for selected parameters to provide a reference standard.

Khantsa Mastura, An-nisa Visi Asmara, Dwi Sarbini/KESANS  
**Development and Acceptability Test of Enteral Food Formulation Based on Local Foods “KarotenPe” Tempeh Flour and Carrot Flour High in BCAA for Cancer Disease**

**Table 2**  
 Results of Physical, Chemical, and Organoleptic Tests

Test	Parameter	F1	F2	F3	Commercial	Remarks
Viscosity	cp (10-100 sec)	27.37	35.61	24.43	<10	Average P1 & P2
Osmolarity	mOsm/kg	580	586.5	687	425	Average P1 & P2
Flow Rate	seconds	30.02	22.65	39.41	22.24	50 mL
	mL/second	1.666	2.207	1.016	2.248	50 mL
Moisture	%	6.83	6.17	6.26	-	-
Color	L	49.8	52.6	53.4	-	Average P1 & P2
	a	1.15	0.9	1.3	-	
	b	12.6	9.2	9.35	-	
Organoleptic	Color	5.8 ± 0.6	5.9 ± 0.7	5.4 ± 1.1	-	p = 0.065
	Aroma	5.2 ± 1.2	5.2 ± 1.2	5.4 ± 0.8	-	p = 0.298
	Taste	4.7 ± 1.2	4.8 ± 1.1	4.1 ± 1.0	-	p = 0.723
	Texture	5.2 ± 0.9	5.2 ± 0.9	4.8 ± 1.2	-	p = 1.000
	Overall	4.9 ± 1.1	5.0 ± 0.9	4.4 ± 1.3	-	p = 0.377

**2. Discussion**

Viscosity is one of the important factors in the development of enteral formulas because it influences the method of administration, whether through a feeding tube or oral consumption. The table 2 shows that all formulations (F<sub>1</sub>-F<sub>3</sub>) have average viscosity values in centipoise (cp) ranging from 24.43 to 35.61 cp. Referring to the standard viscosity range for enteral formulas, which is 1-50 cp, all formulations meet the required criteria. This shows that the developed formulas are suitable for enteral feeding applications. Proper viscosity is essential to ensure smooth administration and prevent clogging of feeding tubes. From a clinical perspective, appropriate viscosity is particularly important for cancer patients who often require long-term enteral feeding, as improper viscosity may increase the risk of tube blockage and compromise nutrient delivery efficiency (Shen *et al.*, 2022).

Osmolarity is an important parameter in enteral formula development. Based on the osmolarity test results, the normal osmolarity range for enteral formulas is 300-500 mOsm/kg. However, all three locally developed formulations showed values above this standard. This condition may be caused by the presence of particles in the formula that are not fully homogeneous or not completely dissolved. The osmolarity of enteral formulas is determined by the concentration of sugars, amino acids, and electrolytes. Osmolarity will increase as the content of amino acids, monosaccharides, disaccharides, and electrolytes rises (Andry, H., 2012). High osmolarity may affect gastrointestinal tolerance in patients receiving enteral nutrition. Clinically, hyperosmolar enteral formulas can lead to adverse gastrointestinal effects such as diarrhea, nausea, abdominal cramping, and delayed gastric emptying, particularly in cancer patients with compromised digestive function (Andreyev *et al.*, 2025). This condition may reduce nutrient absorption and worsen malnutrition status, thereby limiting the effectiveness of nutritional therapy. Therefore, despite meeting physical characteristics, the elevated osmolarity observed in all formulations represents a significant limitation that must be addressed before clinical application.

In the flow rate test of the enteral formulas based on local food ingredients, it was found that the formulation closest to the commercial product (22.24 seconds) was Formula 2, with a flow time of 22.65 seconds and a flow velocity of 2.207 mL/second. The difference was only about 0.41 seconds. In contrast, the formulation with the longest

## **Development and Acceptability Test of Enteral Food Formulation Based on Local Foods “*KarotenPe*” Tempeh Flour and Carrot Flour High in BCAA for Cancer Disease**

flow time was Formula 3, with a flow duration of 39.41 seconds. All formulations were still within the acceptable standard for flow rate testing, which is less than one minute. Therefore, the products were considered to meet the requirements for enteral feeding applications (Church & Zoeller, 2023). These findings show that the developed formulas, particularly F2, have suitable flow characteristics comparable to commercial products. However, from a clinical standpoint, optimal flow rate must also be balanced with osmolarity and viscosity to ensure safe administration and minimize gastrointestinal complications in cancer patients.

The results of moisture content analysis in the six enteral formulations showed values ranging from 6.17% to 6.83%. Referring to the standards recommended by Codex Alimentarius and the study by Ojo *et al.* (2020), the ideal moisture content for dry enteral formula products is less than 5% to maintain physical, chemical, and microbiological stability during storage. Thus, all of the developed local food-based formulations have moisture content exceeding the ideal limit. This condition may increase the risk of product quality deterioration, such as accelerated lipid oxidation, clumping, and reduced solubility during storage. Physically, powdered products with high moisture content are more prone to caking and decreased solubility, making rehydration more difficult when served (Jiang *et al.*, 2020). From a practical and clinical, high moisture content can significantly shorten shelf life, increase the risk of microbial growth, and compromise product safety, especially for immunocompromised cancer patients (De Bock *et al.*, 2023).

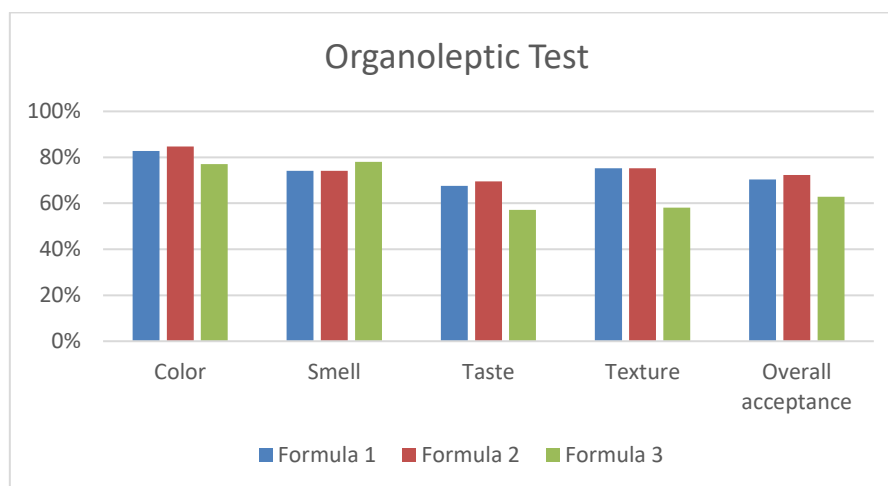
In addition to physical characteristics, the nutritional adequacy of the formula is an important consideration for cancer patients. Although this study shows the presence of plant-based protein and BCAA from tempeh flour, there is no quantitative evaluation of whether the formulations meet clinical requirements for energy and protein intake in cancer patients. Clinically, cancer patients generally require higher protein intake (approximately 1.2-2.0 g/kg body weight/day) and sufficient energy to prevent muscle wasting and cachexia (Gupta & Ghosh, 2023). Without detailed nutritional analysis, it is difficult to determine whether the developed formulas can fully support these needs. Therefore, further analysis of macronutrient composition and clinical testing is necessary to confirm the suitability of this enteral formula as a comprehensive nutritional therapy.

Based on the color analysis using L, a, and b values for the three different formulations, the L value shows brightness, where higher values correspond to brighter colors. The a value represents the red-green intensity, where positive values show a tendency toward red and negative values show green. The b value represents the yellow-blue intensity, where positive values show a tendency toward yellow. Formula 1 had L (49.8), a (1.15), and b (12.6), showing a relatively darker color with slight reddish and noticeable yellowish tones. Formula 2 had L (52.6), a (0.9), and b (9.2), showing a paler and less intense color. Meanwhile, Formula 3 had L (53.4), a (1.3), and b (9.35), which was similar to Formula 2 but brighter and less yellowish.

The results of the organoleptic test with parameters (color, aroma, taste, texture, and overall acceptance) using the category “1 = strongly dislike, 2 = dislike, 3 = slightly dislike, 4 = neutral, 5 = slightly like, 6 = like, 7 = strongly like” showed that all three formulations had relatively similar acceptance levels across all parameters. The panelists’ ratings ranged from “neutral” to “like.” Formula 2 tended to obtain the highest average scores for most parameters, especially color and overall acceptance, showing that it was slightly more preferred compared to the other formulations. However, based on statistical

## Development and Acceptability Test of Enteral Food Formulation Based on Local Foods “*KarotenPe*” Tempeh Flour and Carrot Flour High in BCAA for Cancer Disease

analysis ( $p > 0.05$  for all parameters), that there were no significant differences among the three formulations in all tested parameters. Although sensory acceptance is important, especially for oral consumption, in clinical settings for cancer patients particularly those using feeding tubes nutritional adequacy and safety parameters such as osmolarity and microbiological stability are more critical than organoleptic properties. Therefore, high acceptability alone does not guarantee clinical suitability.



**Figure 1.** Preference Level of KarotenPe Enteral Formula

Figure 1 show the comparison of panelists' preference levels for the three formulations across five organoleptic parameters (color, aroma, taste, texture, and overall acceptance) in percentage form. In general, Formula 2 had the highest percentage in most parameters, particularly color (approaching 85%) and overall acceptance (around 72%), showing that this formulation was more preferred by the panelists. The color parameter showed that Formula 2 obtained the highest score compared to Formula 1 and Formula 3. Formula 1 still received fairly good ratings, while Formula 3 tended to score lower due to its darker appearance compared to the other formulations. This shows that panelists preferred the visual appearance of Formula 2. The characteristics of the three enteral formulas ranged from yellowish-white to cream, influenced by the addition of carrot flour. This is consistent with the study by Faidah *et al.* (2019), which stated that the white color in milk is produced by the reflection of fat globules, calcium caseinate, and phosphate colloids. Meanwhile, the yellowish color is caused by soybeans, which serve as an initial indicator of the presence of isoflavone compounds.

The aroma parameter showed that all three formulations had relatively balanced acceptance levels, although Formula 2 and Formula 3 were slightly superior to Formula 1. Thus, the aroma of all formulations was acceptable to the panelists without significant differences. Tempeh flour has a characteristic beany or unpleasant odor caused by the activity of the lipoxygenase enzyme in soybeans present in tempeh. This occurs because the lipoxygenase enzyme hydrolyzes or breaks down soybean fats into compounds such as hexanal and hexanol, which produce the off-flavor (Kadek *et al.*, 2024).

In addition, this study used tempeh flour obtained directly from a producer, so the production process of the flour could not be controlled. A recommended method to reduce the beany odor is the blanching process. However, this is not consistent with the findings

## **Development and Acceptability Test of Enteral Food Formulation Based on Local Foods “*KarotenPe*” Tempeh Flour and Carrot Flour High in BCAA for Cancer Disease**

of Wibowo (2016), which stated that the addition of tempeh flour still produces a distinctive slightly beany aroma, even after blanching treatment has been applied.

For the taste parameter, Formula 2 was again the most preferred, followed by Formula 1, while Formula 3 received the lowest score due to the presence of a bitter aftertaste. This finding is consistent with the study by Lestari *et al.* (2024), which reported that panelists' preference for instant corn rice products with added tempeh flour tended to decrease due to a bitter aftertaste. The bitterness is caused by amino acid hydrolysis occurring during the Maillard reaction. Amino acids that contribute to bitterness include lysine, arginine, proline, phenylalanine, and valine. Among these, lysine is known to produce a stronger bitter taste compared to other amino acids.

Regarding the texture parameter, Formula 2 had the most preferred texture with the highest score of  $5.2 \pm 0.9$  (liked) compared to the other two formulations. Based on the hedonic quality test, the texture of F2 was categorized as slightly thick, while F1 and F3 were categorized as liquid. However, there was no statistically significant difference among them. The differences in texture were influenced by the proportion of tempeh flour used in each formulation. A higher proportion of tempeh flour resulted in a thicker texture and slightly grainy sensation due to its fiber content. Conversely, a lower proportion of tempeh flour combined with carrot flour resulted in a more liquid consistency.

In terms of overall acceptance, Formula 2 consistently obtained the highest score, showing that panelists preferred it over Formula 1 and Formula 3. Formula 1 ranked in the middle with fairly good acceptance, while Formula 3 tended to be less preferred. Overall, these results confirm that Formula 2 is the formulation with the best level of acceptance across almost all organoleptic aspects.

### **Conclusion**

The development of an enteral formula based on tempeh flour and carrot flour resulted in three formulations, all of which met the standard requirements for viscosity (24.43-35.61 cp) and flow rate (<1 minute), showing that they are physically suitable for enteral product applications. Among the three formulations, Formula 2 exhibited characteristics most comparable to the commercial product, particularly in terms of flow rate (22.65 seconds vs. 22.24 seconds), and achieved the highest organoleptic scores in color, taste, texture, and overall acceptance. However, statistical analysis showed no significant differences among the formulations ( $p > 0.05$ ). Despite these positive findings, the osmolarity values of all formulations (580-687 mOsm/kg) exceeded the standard range for enteral formulas (300-500 mOsm/kg), and the moisture content (6.17-6.83%) also surpassed the ideal limit of <5%, which may affect product stability and safety. Therefore, Formula 2 can be recommended as the most promising formulation, although improvements are still required in terms of osmolarity and moisture content to comply with established enteral formula standards.

Further improvements in formulation composition are necessary to reduce osmolarity so that it meets enteral standards. Additional processing techniques, such as optimized drying methods, are also recommended to reduce moisture content below 5%, thereby enhancing product quality and shelf life. Preliminary treatment of tempeh, such as blanching, is suggested to reduce the beany or undesirable odor, while the use of natural additives may help mask the bitter aftertaste. Furthermore, future studies involving clinical trials on cancer patients are essential to evaluate the safety, tolerance, and effectiveness of the formula in supporting nutritional status.

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**Development and Acceptability Test of Enteral Food Formulation Based on Local Foods “*KarotenPe*” Tempeh Flour and Carrot Flour High in BCAA for Cancer Disease**

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