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Development of a High BCAA Enkaje Ginger Mung Bean Enteral Formula For Cancer Patients

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Abstract

Introduction: *The development of Enteral Formula with local food ingredients of mung bean flour produces enteral formulation from local food ingredients whose taste, aroma, color, and texture are acceptable to the community, and the osmolality value remains according to the standard to support the recovery of cancer patients.* ***Objective:*** *The purpose of this study was to develop a more economical Enteral Formula with a higher BCAA value than the Commercial Formula.* ***Method:*** *The type of research was quantitative with a Completely Randomized Design (CRD) experimental design.* ***Result and Discussion:*** *The results showed that F1, F2, F3, and Commercial were not readable with a viscometer, while the osmolality test of F2 476.5 mOsm/L, F3 450 mOsm/L and Commercial 400 mOsm/L obtained results according to the standard, while F1 was above the standard at 516 mOsm/L. The selected enteral formula was F2, with a ratio of 65% mung bean flour to 65% skim milk. The organoleptic test for taste, aroma, texture, and overall performance achieved the highest total of 60-79%, indicating a favorable and acceptable level of acceptance.* ***Conclusion:*** *It also had a lower price of Rp 4,868.17 per serving compared to the commercial formula at Rp 29,450. It also had a higher BCAA content than the commercial formula, in line with the research objectives.*

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Introduction

One of the leading causes of death worldwide is cancer, which accounted for nearly 10 million deaths globally in 2020. The incidence of cancer increases drastically with age. This condition is caused by the increasing risk of cancer as individuals grow older, accompanied by a decline in cellular repair capacity with advancing age (WHO, 2022). Based on the 2023 Indonesian Health Survey, the prevalence of cancer in Indonesia reached 1.2%, with the highest prevalence found among individuals aged 55–64 years, at 3.2%, and occurring most frequently among females, at 2.0% (SKI, 2023). Cancer can affect any part of the body. One of the hallmarks of cancer growth is the formation of abnormal cells that proliferate rapidly beyond their normal limits and may subsequently invade surrounding tissues and spread to other organs; this process is referred to as metastasis. Widespread metastasis is the primary cause of cancer-related mortality; therefore, further therapy is required for its treatment (Nisa, 2021).

This study specifically targets adult cancer patients undergoing active treatment, particularly chemotherapy, in the outpatient clinical setting. Chemotherapy-induced adverse effects, including nausea, vomiting, anorexia, taste alterations, and early satiety, frequently reduce oral food intake and increase the risk of malnutrition and cancer cachexia. These patients often require oral enteral nutritional support that is easy to consume, nutritionally dense, and well tolerated (Novitarum, 2026). Therefore, the development of a high-branched-chain amino acid (BCAA) enteral formula using locally available food ingredients is intended to provide nutritional support for ambulatory patients receiving chemotherapy who remain capable of oral intake.

Cancer-associated metabolic alterations, including increased systemic inflammation, insulin resistance, and accelerated muscle protein breakdown, frequently lead to progressive weight loss and cancer cachexia despite adequate nutritional intake. (Shanneisa, 2025). Cancer cachexia is recognized as a multifactorial syndrome characterized by ongoing skeletal muscle loss that cannot be fully reversed through conventional nutritional support alone and is associated with poorer treatment outcomes and survival (Suryani, 2025). Amino acid supplementation, particularly branched-chain amino acids (BCAAs), has been reported to support skeletal muscle protein synthesis through activation of anabolic signaling pathways and may contribute to preserving muscle mass during cancer treatment. BCAAs, consisting of leucine, isoleucine, and valine, are essential amino acids that must be obtained from dietary sources and have been increasingly investigated as functional nutrients for patients with cancer-related malnutrition and cachexia (Arends, 2021).

Clinical studies have demonstrated that nutritional formulas enriched with BCAAs may improve protein metabolism, preserve lean body mass, and support nutritional recovery among patients with cancer, particularly those at risk of cachexia. Leucine is considered the principal anabolic amino acid because it activates the mammalian target of rapamycin (mTOR) signaling pathway, thereby stimulating skeletal muscle protein synthesis and reducing muscle protein degradation (Mardiana, 2022). Mung bean is a type of legume that serves as a source of carbohydrates and protein. Mung bean (Vigna radiata) is a rich source of plant protein containing high levels of essential amino acids, including leucine, valine, and isoleucine (Sulfi, 2021). Recent studies have demonstrated that mung bean contains bioactive peptides and polyphenolic compounds with antioxidant, anti-inflammatory, and immunomodulatory properties that may contribute to suppressing tumor progression and reducing oxidative stress associated with cancer (Masykur, 2025).

In addition to mung bean, soybean is a good source of BCAAs for cancer patients. This study used soy milk, which is a liquid obtained from the extraction of soybeans with water. Soybeans processed into soy milk can serve as an alternative substitute for animal milk fat. In addition to being a source of protein, soy milk also contains carbohydrates, phosphorus, iron, calcium, and nine essential amino acids, but it does not contain lactose (Cindy, 2024). Other additional ingredients, such as ginger, have benefits as a natural antiemetic because ginger contains bioactive compounds. Another benefit of ginger is its ability to relieve nausea, even when administered in small doses (Aini, 2025). Therefore, Ginger (Zingiber officinale) has been extensively studied as a complementary therapy for chemotherapy-induced nausea and vomiting. Its bioactive compounds, including gingerols and shogaols, exert antiemetic effects through modulation of gastrointestinal motility and serotonin receptors (Hasanah, 2025). Recent systematic reviews have shown that ginger supplementation may reduce the severity of chemotherapy-induced nausea when used alongside standard antiemetic therapy (Amalia, 2021). The texture, form, and consistency of food provided to patients influence their subsequent condition. A multicenter analysis conducted among 1,453 patients in palliative care centers in Japan showed that enteral nutrition provides clinical benefits in improving the nutritional status and level of food intake among cancer patients (Amano, 2021). This study therefore developed a high-BCAA powdered enteral formula prepared from locally available ingredients, namely mung bean flour, soy milk, and ginger, specifically intended for adult outpatient cancer patients undergoing chemotherapy who remain able to consume nutrition orally. The formulation was designed to provide acceptable sensory characteristics, appropriate osmolality, and adequate nutritional composition as a potential oral enteral nutritional support for patients at risk of malnutrition and cancer cachexia.

Method

The type of research was quantitative, using an experimental design with a Completely Randomized Design (CRD), conducted from July 2025 to August 2025 at the Food Science Laboratory of Universitas Muhammadiyah Surakarta after obtaining Ethical Clearance (EC) from the Ethics Committee of Dr. Moewardi Hospital. The equipment used in this study included a food processor (Philips HR2115/60, China), an SF400 analytical balance, a whisk, and a stopwatch. The ingredients used for the modification of the enteral formula were mung bean flour, skim milk, coconut oil, maltodextrin, ginger, powdered sugar, and soy milk. The materials used are presented in Table 1.

Table 1
Ingredients of Enkajo Formula

Food Ingredients	Units	F1 (50 : 80)	F2 (65 : 65)	F3 (80 : 50)
Green bean flour	São	50	65	80
Skimmed milk	São	80	65	50
Coconut oil	ml	25	25	25
Ginger	São	5	5	5
Maltodex Train	São	30	30	30
Refined sugar	São	25	25	25
Soy juice	ml	300	300	300
TOTAL		**515 gr**	**515 gr**	**515 gr**
Weight per package		**171.67 gr**	**171.67**	**171.67 gr**

Source: Primary Data, 2025

These ingredients were then weighed according to the specified proportions and mixed until homogeneous, after which they were reconstituted with boiled water at 100°C. The formula was reconstituted until evenly dispersed (Jannah & Kristianto, 2025). Energy content was empirically calculated per 1,000 mL of formula using the NutriSurvey application and TKPI (Indonesian Food Composition Table). Subsequently, flowability, viscosity, osmolarity, moisture content, and color tests were performed. The acceptability of the enteral formula was determined through an organoleptic test using the Hedonic Scale Test method, which included taste, color, aroma, texture, and overall acceptability. The assessment was analyzed using an organoleptic test form and expressed in the categories of strongly like, like, slightly like, less like, and dislike. The test was conducted with 15 semi-trained panelists.

Result and Discussion

Comparison of the Nutritional Values of Enteral Formula and Commercial Formula

In this study, the nutritional values of Formulas F1, F2, and F3 were compared with those of a commercial formula empirically using NutriSurvey and TKPI (Indonesian Food Composition Table), as follows:

Table 2
Comparison of Nutritional Content of Enteral Formula (100 gr)

Food Ingredients	F1	F2	F3	FK
Energy (kcal)	318.16	317.88	317.59	419.75
Protein (gr)	16.18	15.61	15.04	24.69
Fat (gr)	10.33	10.28	10.22	9.88
KH (gr)	43.71	44.34	44.97	59.26
Isoleucine (gr)	1.77	1.98	2.18	1.73
Valin (gr)	2.04	2.30	2.56	1.48
Leusin (gr)	3.23	3.68	4.13	3.09

The enteral formulas had higher nutritional values in terms of energy, protein, fat, and carbohydrates; moreover, in terms of BCAA content, namely isoleucine, valine, and leucine, they also had higher levels. BCAAs are essential amino acids that can only be obtained from food and consist of isoleucine, leucine, and valine. BCAAs are among the functional ingredients that contribute to health improvement, such as reducing negative nitrogen balance in biological systems, preventing muscle loss at all ages, and treating patients with liver cirrhosis and cancer (Siregar, 2022).

Viscosity Test

The instrument used to measure viscosity was a viscometer. A 200 mL sample was placed into a beaker and then stirred until homogeneous. During the viscosity test of enteral formulas F1, F2, and F3, as well as the commercial formula, the viscometer was unable to detect the viscosity; therefore, no results were obtained. The viscosity test of an enteral formula greatly affects whether the enteral nutrition flows smoothly through the feeding tube, influences the method of administration, and determines the size of the tube used. The higher the viscosity of the formula, the more difficult it is to flow, thereby increasing the risk of blockage in the feeding tube. In this case, one of the possible reasons the viscometer could not detect the liquid result was that the type of liquid was too dilute. A liquid that flows more easily has low viscosity; conversely, a liquid that flows with greater difficulty can be interpreted as having high viscosity (Zahra, 2025).

Flow Test

Table 3
Flow Power Test

	F1	F2	F3	FK
Quantity (mL)	50	50	50	50
Time (seconds)	9.24	9.27	9.7	11.15
Speed (mL/sec)	5.41	5.39	5.15	4.48

The flow test is an assessment of the flow rate of liquid enteral formula through an NGT tube, expressed in mL/second. The tube used was size 14, and the enteral formula volume used was 50 mL. The test results showed that all formulas flowed well. The fastest flow time was observed in F1, with a flow rate of 5.41 mL/second, whereas the longest flow time was observed in F3, with a flow rate of 5.51 mL/second. This finding indicates that the enteral formula made from mung bean flour and skim milk powder at a ratio of 80:50 appeared to be thicker than the other formulas. The viscosity of a product may be influenced by several factors, including high protein content in the ingredient, temperature, energy density, liquid concentration, pressure, molecular weight, and holding time (Silviwanda, 2024).

Osmolality Test

Table 4
Osmolarity Test

	F1	F2	F3	FK
1	520	477	447	
2	512	476	453	
	516	**476.5**	**450**	**400**

Osmolarity is a measure of the number of particles in a solution, expressed in mOsm/L. Osmolarity can be used to determine the ability of a solution to draw or retain water through a semipermeable membrane. Osmolarity that exceeds the standard range, when administered rapidly, may cause symptoms such as cramps, nausea, vomiting, and diarrhea (Fitriani, 2024). Excessively high osmolarity can inhibit intestinal emptying and the delivery of food to the small intestine, thereby increasing fluid secretion in the large intestine and triggering diarrhea (Bischoff et al., 2020). An appropriate enteral formula should have an osmolarity ranging from 300 to 500 mOsm/L. Enteral formulas within this range can minimize the risk of gastrointestinal disturbances and diarrhea in patients with sensitive digestive systems (DAA, 2018). The results of this study showed that the osmolarity values of F2 (476.5 mOsm/L) and F3 (450 mOsm/L) met the standard formula criteria, whereas F1 (516 mOsm/kg) had an osmolarity value above the standard range.

Color Test

Table 5
Color Test

	L	a	b
F1	46.3	0.77	13.37
F2	51.93	0.27	15.57
F3	46.8	2.6	13.97

One of the indicators that can attract consumers in selecting a product is color. In this study, color testing was conducted to determine the characteristics of each formula. The test was performed using a colorimeter and produced three color parameters, namely L*, a*, and b*. The L* indicator is a parameter used to determine brightness on a scale of 0–100. A value of 100 indicates white, whereas a value of 0 indicates black. The a* indicator is used to determine redness and has negative and positive values within a scale range of 0–80. Negative values from (-0) to (-80) indicate green, whereas positive values from 0 to 80 indicate red. Meanwhile, the b* indicator is used to determine yellowness and has values ranging from 0 to 70, including negative and positive values. Negative values from (-0) to (-70) indicate blue, whereas positive values from 0 to 70 indicate yellow (Axiomawan, 2024).

Based on the results of the color test using the L* indicator, F2 was found to have the brightest color compared with F1 and F3. Meanwhile, for the a* indicator, the highest degree of redness was observed in F3, as indicated by its higher score compared with F1 and F2. For color measurement using the b* indicator, F2 was identified as the formula with the highest degree of yellowness, as demonstrated by its highest score compared with F1 and F3. The oleoresin content in ginger added to the formula can enhance the yellow color, causing the formula to appear yellow to dark in color (Athaillah, 2021.

Moisture Content Test

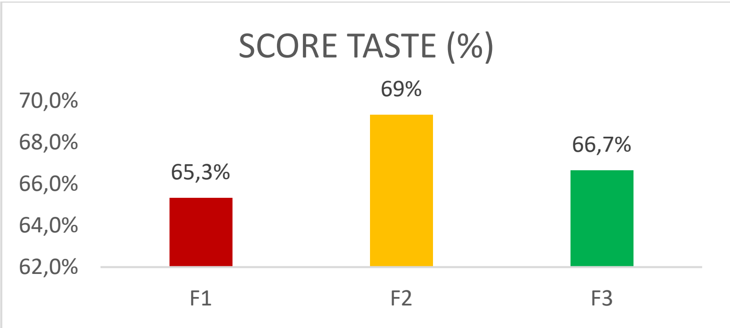
Table 6
Moisture Content Test

	F1 (840)	F2 (136)	F3 (579)
1	7.32	7.75	7.9
2	7.67	6.65	6.39
	7.495	**7.2**	**7.145**

The amount of water present in food ingredients affects the moisture content of a food product. The higher the water content in a food ingredient, the higher its moisture level; consequently, the food deteriorates more rapidly and has a shorter shelf life because water can serve as a medium for microorganism growth, making food ingredients more susceptible to spoilage (Nurfitriyani, 2024). Moisture content testing was performed using a Moisture Analyzer with a gravimetric or weighing method. Based on the results of the moisture content test, the lowest moisture content was found in F3 at 7.145%, whereas the highest moisture content was found in F1 at 7.495%. The moisture content of the Enkaje formula could not be compared with that of the commercial formula because the two were in different forms. The commercial formula was in powdered form, whereas the Enkaje formula had already been mixed with soy milk before reconstitution; therefore, the moisture content obtained was higher due to the addition of liquid, making comparison inappropriate.

Organoleptic Test

a) Taste

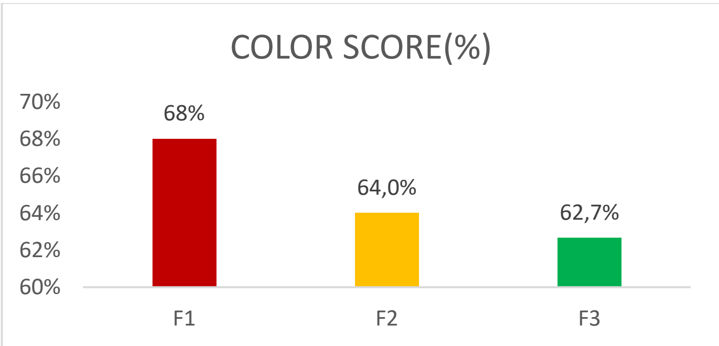


Description: 20–39% (Dislike); 40–59% (Less Like);
60–79% (Slightly Like); 80–99% (Like); 100% (Strongly Like)

Picture 1. Organoleptic Assessment of Taste

Based on the results of the organoleptic taste test conducted by 15 panelists, the average scores obtained were 65.3% for F1, 69% for F2, and 66.7% for F3, indicating that the formulas were slightly liked; however, the highest score was found in F2. The panelists preferred the taste of the formula with a balanced ratio of mung bean flour and skim milk. The Kruskal–Wallis test performed using SPSS 25.0 at a 95% confidence level ($\alpha = 0.05$) yielded a p-value of 0.932 ($p > 0.05$). This result indicates that there was no significant difference in taste among the three formulated products, which may be attributed to the relatively similar composition of the ingredients used.

b) Color

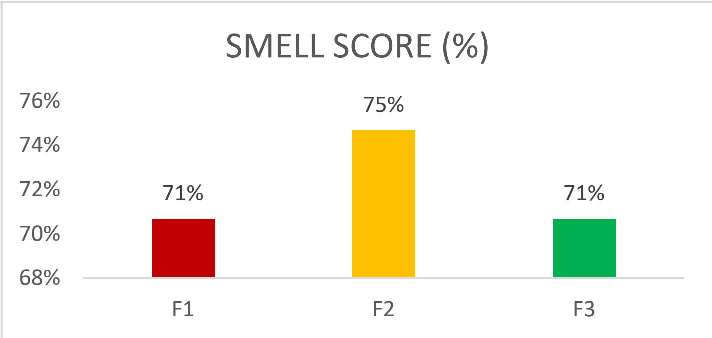


Description: 20–39% (Dislike); 40–59% (Less Like);
60–79% (Slightly Like); 80–99% (Like); 100% (Strongly Like)

Picture 2. Organoleptic Assessment of Color

Based on the results of the organoleptic color test conducted by 15 panelists, the average scores obtained were 68% for F1, 64% for F2, and 62.7% for F3, indicating that the formulas were slightly liked; however, the highest score was found in F1. The panelists preferred a color that was not excessively yellow. F1 had the least yellow color compared with F2 and F3, which tended to have a more intense yellow color. This was supported by the color test, in which the b* score of F1 was the lowest, at 13.37, whereas F2 and F3 had higher scores of 15.57 and 13.97, respectively, indicating a tendency toward a yellow color. The different ratios of skim milk and mung bean flour in the formula, combined with the oleoresin content in ginger added to the formula, may enhance the yellow color, causing the formula to appear yellow to dark in color (Paimin & Murhananta, 1991). The Kruskal–Wallis test performed using SPSS 25.0 at a 95% confidence level ($\alpha = 0.05$) yielded a p-value of 0.527 ($p > 0.05$). This result indicates that there was no significant difference in color among the three formulated products, which may be attributed to the relatively similar composition of the ingredients used.

c) Smell

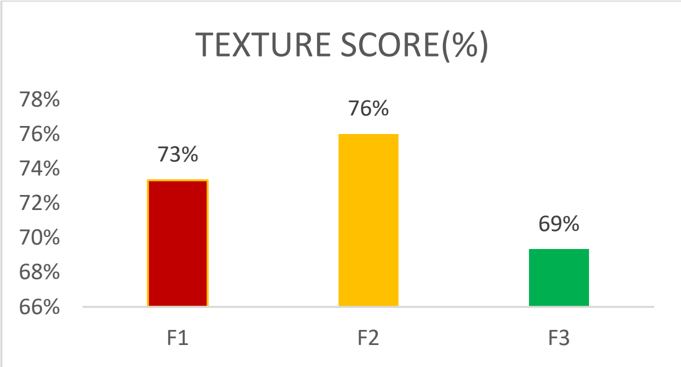


Description: 20–39% (Dislike); 40–59% (Less Like);
60–79% (Slightly Like); 80–99% (Like); 100% (Strongly Like)

Picture 3. Organoleptic Assessment of Aroma

Based on the results of the organoleptic aroma test conducted by 15 panelists, the average scores obtained were 71% for F1, 75% for F2, and 71% for F3, indicating that the panelists slightly liked the formulas; however, the highest score was found in F2. The Kruskal–Wallis test performed using SPSS 25.0 at a 95% confidence level ($\alpha = 0.05$) yielded a p-value of 0.781 ($p > 0.05$). This result indicates that there was no significant difference in aroma among the three formulated products, which may be attributed to the relatively similar composition of the ingredients used. Mung bean has a distinctive aroma, namely a slightly beany odor, because the lipoxygenase enzyme reacts with fat when the cell walls are disrupted (Ratnasari et al., 2021).

d) Texture

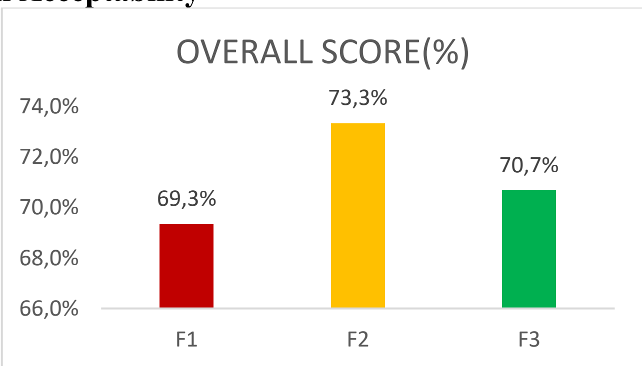


Description: 20–39% (Dislike); 40–59% (Less Like);
60–79% (Slightly Like); 80–99% (Like); 100% (Strongly Like)

Picture 4. Organoleptic Assessment of Texture

Based on the results of the organoleptic texture test conducted by 15 panelists, the average scores obtained were 73% for F1, 76% for F2, and 69% for F3, indicating that the formulas were slightly liked; however, the highest score was found in F2. The Kruskal–Wallis test performed using SPSS 25.0 at a 95% confidence level ($\alpha = 0.05$) yielded a p-value of 0.654 ($p > 0.05$). This result indicates that there was no significant difference in texture among the three formulated products, which may be attributed to the relatively similar composition of the ingredients used. The texture of an enteral formula can be determined by the composition of its ingredients and its density value. Based on the formulated product, Enkaje had a density value of 1, which was in accordance with the established standard; therefore, the resulting formula had an osmolality value within the standard range of 300–500 mOsm/kg (Nur'faizah, 2025).

e) Overall Acceptability



Description: 20–39% (Dislike); 40–59% (Less Like);
60–79% (Slightly Like); 80–99% (Like); 100% (Strongly Like)

Picture 5. Overall Organoleptic Assessment

Based on the results of the overall organoleptic test conducted by 15 panelists, the average scores obtained were 69.3% for F1, 73.3% for F2, and 70.7% for F3, indicating that the formulas were slightly liked; however, the highest score was found in F2. The Kruskal–Wallis test performed using SPSS 25.0 at a 95%

confidence level ($\alpha = 0.05$) yielded a p-value of 0.990 ($p > 0.05$). This result indicates that there was no significant overall difference among the three formulated products, which may be attributed to the relatively similar composition of the ingredients used.

Conclusion

The results of this study demonstrated that the enteral formula developed from mung bean flour and skim milk, supplemented with soy extract and ginger, contained higher levels of branched-chain amino acids (BCAAs) than the commercial enteral formula. Among the three formulations evaluated, Formula 2 (F2), consisting of an equal proportion of mung bean flour and skim milk (65%:65%), was identified as the optimal formulation. F2 exhibited an osmolality of 476.5 mOsm/L, which falls within the recommended standard for enteral nutrition. Per 100 g of product, F2 contained 1.98 g of isoleucine, 2.30 g of valine, and 3.68 g of leucine, all of which were higher than those found in the commercial formula. Sensory evaluation showed that F2 achieved the highest acceptability scores for taste, aroma, texture, and overall preference, with acceptance rates ranging from 60% to 79%, indicating that the product was moderately liked and generally acceptable to consumers. Furthermore, F2 was found to be more cost-effective than the commercial enteral formula while maintaining appropriate nutritional quality, suggesting its potential as an affordable locally sourced enteral nutrition option for cancer patients.

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