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Formulation and Physicochemical Characteristics and Acceptability of an Enteral Formula Based on Catfish, Soybean, and Purple Sweet Potato for Pregnant Women with Chronic Energy Deficiency (CED)

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Abstract
Introduction: *Chronic Energy Deficiency in pregnant women requires energy-dense nutritional interventions to support maternal and fetal health. One potential approach is the development of locally sourced enteral formulas with adequate nutritional and physicochemical properties.* ***Objective:*** *This study aimed to evaluate the physicochemical characteristics and sensory acceptability of a modified enteral formula based on catfish, soybeans, and purple sweet potatoes.* ***Method:*** *This experimental study compared two formulations, formulation A with soybean dominance and formulation B with catfish dominance, against a commercial control. The evaluation included measurements of energy density, viscosity, flow rate, acidity level, osmolarity, and sensory acceptability.* ***Result and Discussion:*** *The results showed that the modified formulas successfully achieved a high energy density of 1.2 kilocalories per milliliter. Both formulations showed ideal viscosity ranging from 31.45 to 36.39 centipoise, appropriate flow rate, and neutral acidity level suitable for nasogastric tube application, although both were categorized as hyperosmolar with values above 700 milliosmoles per liter. In the sensory evaluation, formulation A was significantly preferred over formulation B, particularly in texture and taste. The dominance of soybean protein in formulation A produced a smoother liquid consistency and effectively masked the fishy aftertaste found in formulation B.* ***Conclusions:*** *Formulation A is recommended as the most potential local food-based enteral formula prototype for pregnant women with chronic energy deficiency, although further optimization is needed to reduce its osmolarity level.*

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Introduction

Chronic Energy Deficiency (CED) is a long-term malnutrition condition caused by an imbalance in energy and protein intake that disrupts physiological body functions (Iskandar *et al*., 2022). During pregnancy, CED becomes an urgent public health issue because its prevalence in Indonesia remains at 16.9% (Rahayu & Purnomo, 2024). Early detection of this malnutrition risk generally relies on the measurement of Mid-Upper Arm Circumference, with a threshold indicator of less than 23.5 cm. The clinical impact of CED poses significant risks to maternal and fetal safety, including increased incidence of preterm birth, low birth weight, and neonatal mortality (Fauziah *et al*., 2025). Therefore, progressive nutritional interventions are crucial to minimize the risk of systemic complications such as anemia and preeclampsia in pregnant women (Alyssa Atikah Putri & Shella Salsabila, 2023). One nutritional strategy proven effective in critical conditions is enteral feeding, particularly when pregnant women experience failure of oral nutritional intake due to complications such as hyperemesis gravidarum or excessive nausea and vomiting (Nijsten *et al*., 2022). Liquid enteral formulas have significantly better tolerance and absorption by the gastric and intestinal mucosa compared to solid foods, enabling a faster correction of energy deficits (Oktavianti *et al*., 2021). In this study, the developed enteral formula is primarily intended as an oral nutritional supplement for pregnant women with Chronic Energy Deficiency. However, physicochemical evaluations related to viscosity, flow rate, and osmolarity were also conducted to assess the potential safety and compatibility of the formula for administration through a nasogastric tube (NGT) in pregnant women with severe feeding intolerance or hyperemesis gravidarum.

The development of enteral formulas using a combination of local food ingredients is a strategic approach to producing high-energy and high-protein products based on locally available and affordable resources (Isnaini *et al*., 2024a). Catfish (Clarias gariepinus) was selected as the primary protein source because it provides physiologically digestible protein and contains essential polyunsaturated fatty acids such as omega-3 and omega-6, which are crucial for supporting fetal neurogenesis and development (Maulu *et al*., 2021; Rachmat Scabra *et al*., 2022). Despite its high potential, the utilization of catfish in food product modification is limited by the dominance of its strong fishy aroma (Sundari *et al*., 2021). Various hedonic tests have demonstrated that the maximum acceptable proportion of catfish addition generally does not exceed 15% to 20% of the total formulation (Eka Pratama *et al*., 2019; Peninsula *et al*., 2024). To achieve the targeted nutritional density and complement the amino acid profile without reducing sensory acceptability, soybean was selected due to its plant-based protein content reaching approximately 35%, which is significantly higher and has a more complete amino acid composition compared to mung beans or other local cereals (Pramesti, 2024). In addition, soybean contributes essential iron at 6.9 mg per 100 g, making it a more effective micronutrient source for supporting anemia prevention in pregnant women compared to other plant-based ingredients (Hapsari *et al*., 2022; Isnaini *et al*., 2024b). Furthermore, purple sweet potato was incorporated as a source of complex carbohydrates superior to conventional tubers such as cassava or white sweet potato due to its high anthocyanin pigment concentration, ranging from 110 to 210 mg per 100 g (Rijal *et al*., 2019; Sumadewi *et al*., 2025). This pigment acts as a strong antioxidant agent capable of reducing oxidative stress caused by chronic malnutrition during pregnancy, providing additional functional value not found in common starch sources such as rice or wheat flour (Xue *et al*., 2024).

The modification of this enteral formula requires a series of physicochemical analyses to ensure physiological safety and clinical effectiveness. Osmolarity testing is a critical parameter to ensure that the product's osmotic pressure is tolerable for digestion, thereby preventing complications such as osmotic diarrhea (Eka Pratama *et al*., 2019; Selimoğlu *et al*., 2021). Evaluation of viscosity and flow rate is also essential to ensure that the liquid consistency remains within the optimal range (1-100 cP) and does not cause clogging when administered through a nasogastric tube (Rizqiyah & Sutjiati, 2023). In addition, testing of acidity level (pH) and moisture content serves as an indicator of formulation stability in inhibiting the growth of pathogenic microorganisms during storage (Zaki & Putri, 2021). Instrumental evaluation of color characteristics (L*, a*, b*) is also necessary to objectively measure the stability of anthocyanin pigment intensity in purple sweet potatoes, which directly correlates with visual appeal and consumption compliance of the target population (Xue *et al*., 2024).

This study focuses on the development of a high-energy and high-protein enteral formula based on local food ingredients, utilizing purple sweet potatoes, catfish, and soybeans. The selection of these ingredients is based on their nutritional density, accessibility, and economic value. The formula was specifically designed as an oral enteral nutritional supplement for pregnant women with Chronic Energy Deficiency, while maintaining physicochemical properties compatible with potential tube-feeding administration under clinical supervision. By emphasizing acceptability aspects, this product is projected to become a strategic nutritional intervention to address the prevalence of Chronic Energy Deficiency in pregnant women.

Method

Materials and Equipment

The materials used in the preparation of the enteral formulation included catfish obtained from fish farmers in Klaten, soybeans sourced from farmers in Boyolali, and purple sweet potato flour (Lingkar Organik brand) purchased from an e-commerce platform. Additional ingredients included skim milk powder, palm oil, granulated sugar, maltodextrin, vanilla essence, and water.

The equipment used for the preparation process included basins, measuring cups, pots, sieves, spatulas, food scales, spoons, and glasses. Instruments used for physicochemical analysis included an osmometer, viscometer, nasogastric tube (NGT) size 14, pH meter, and moisture analyzer.

Formulation Design

This study was an experimental study using a completely randomized design consisting of two treatments, namely formulation A and formulation B, and one control group (K) using a commercial high-energy, high-protein enteral formula. Each treatment was conducted in triplicate.

Two formulation variations were applied with different ratios of catfish and soybean. Formulation A had a higher proportion of soybean, while formulation B contained a higher proportion of catfish. This variation aimed to determine the effect of animal- and plant-based protein sources on the physical, chemical, and sensory characteristics of the formula. The detailed composition of each formulation is showed in Table 1.

Table 1
Formulation Design

Food Ingredients	Composition (grams) A	Composition (grams) B
Catfish	45	55
Purple Sweet Potato Flour	65	65
Soybeans	30	20
Skim Milk	110	110
Maltodextrin	30	30
Palm Oil	25	25
Granulated Sugar	35	35

Processing Method

The preparation procedure began with steaming the catfish for 15 minutes and soaking the soybeans for 8 hours. The catfish and soybeans were then blended, mixed with other dry ingredients, and heated at 80°C until homogeneous. All ingredients were subsequently added to 600 ml of hot water, stirred until evenly mixed, and filtered to obtain an enteral formula with a liquid consistency and smooth texture.

Testing and Data Analysis

Physicochemical testing of the enteral formula included viscosity measured using a Brookfield Ametek viscometer (Spindle 61, speed 60 RPM) at room temperature (Pratiwi *et al*., 2023), flow rate (ml/second) measured by observing the liquid flow through a nasogastric tube (NGT) size 14 (Argyadini & Rahmawaty, 2016), and osmolarity (mOsm/L) measured using an osmometer (Keohane *et al*., 1984; Jannah & Kristianto, 2025). pH measurement was conducted using a calibrated pH meter (Pratiwi *et al*., 2023), while moisture content was analyzed using the gravimetric method with a drying oven at 105°C until constant weight (Rodhiyah *et al*., 2024). Color profile was measured objectively using the CIE L*, a*, b* system with a colorimeter (Syasmar *et al*., 2024).

Organoleptic Test

The organoleptic test was conducted by 25 untrained panelists using a hedonic scale (Saputra *et al*., 2024). The evaluated parameters included preference levels for color, aroma, taste, texture, and overall acceptability.

Data Analysis

Data analysis was performed using statistical software with a significance level of $\alpha = 0.05$. The normality assumption was tested using the Shapiro-Wilk test ($n < 50$). Parameters with normal distribution (flow rate) were analyzed using One-Way ANOVA followed by the Least Significant Difference (LSD) post hoc test. Data that were not normally distributed (osmolarity, viscosity, and pH) were analyzed using the Kruskal-Wallis test followed by the Mann-Whitney test. Specifically, comparisons between two treatment groups (moisture content of formulation A and B) were analyzed using the Independent Sample T-Test (for normally distributed data) or the Mann-Whitney test (for non-normal data).

Result and Discussion

Nutritional Content

The nutrient composition of the enteral formulas and the commercial formula is presented in Table 2. Nutrient content was calculated using NutriSurvey 2007 software.

Table 2
Nutritional Composition of Commercial and Enteral Formulas

Formulation	Energy (kcal)	Protein (g)	Fat (g)	Carbohydrates (g)	Fiber (g)	Fe (mg)	Calcium (mg)	Energy Density (kcal/ml)
K	1000	56	12	172	-	5,3	660	1
A	1296,2	58,7	34,7	185,9	11,2	7,4	1568,3	1,2
B	1263,1	56,5	33	182,9	10,2	5,9	1541,4	1,2

Based on Table 2, the nutritional analysis indicates that enteral formulations A and B have higher nutritional values compared to the commercial formula (Formulation K) used as the control. Formulation A produced the highest total energy at 1296.2 kcal with a protein content of 58.7 g, followed by Formulation B with 1263.1 kcal and 56.5 g of protein. This significant increase in energy and protein is attributed to local food ingredients, namely catfish and soybeans, as sources of high biological value protein. This advantage is further reflected in the energy density of formulations A and B, which reached 1.2 kcal/ml, higher than the standard density of 1 kcal/ml in the control formula. According to the terminology of the European Society for Clinical Nutrition and Metabolism, a density of 1.2 kcal/ml places this enteral formula at the upper limit of clinical standards as an energy-dense formula, which is clinically essential for compensating calorie deficits (Lochs *et al*., 2006).

The superiority of these formulations is further supported by higher micronutrient and dietary fiber content compared to the commercial formula. The use of purple sweet potato in formulations A and B contributes not only carbohydrates but also dietary fiber, reaching 11.2 g in Formulation A and 10.2 g in Formulation B. Fiber stimulates intestinal motility and is highly effective in preventing functional constipation caused by smooth muscle relaxation induced by increased progesterone levels during pregnancy (Asih, 2022). Furthermore, calcium content in Formulation A (1568.3 mg) and B (1541.4 mg) is substantially higher than in Formulation K (660 mg). Calcium plays a crucial role in supporting fetal bone mineralization, preventing maternal bone demineralization, and reducing the incidence of preeclampsia (Meldawati, 2020). In addition, iron (Fe) content in Formulation A (7.4 mg) and B (5.9 mg) exceeds that of the control (5.3 mg). Iron supplementation is essential to respond to physiological hemodilution due to maternal plasma volume expansion during the second trimester and to minimize the risk of low birth weight associated with iron deficiency anemia (Laila *et al*., 2025).

The superior macro and micronutrient characteristics make formulations A and B highly relevant for dietary management in pregnant women with Chronic Energy Deficiency. Pregnant women with this condition, especially in the second trimester, experience increased maternal and fetal metabolic demands alongside limited energy reserves. To meet nutritional adequacy standards, the Supplementary Feeding Program guidelines from the Indonesian Ministry of Health recommend an additional intake of 500-600 kcal and 15-20 g of protein per day for pregnant women with Chronic Energy Deficiency (Kemenkes RI, 2021; PERMENKES, 2019). Based on portion calculations, if one recipe of Formulation A is divided into four servings, each serving provides

approximately 324 kcal and 14.6 g of protein. For optimal intervention effectiveness, this enteral formula is recommended to be administered twice daily as a supplementary meal, providing an additional 648 kcal and 29.2 g of protein per day. This amount is sufficient to compensate for nutritional deficits in second-trimester pregnant women with Chronic Energy Deficiency without causing gastric volume overload that may trigger nausea (Febriyani *et al*., 2026; Girsang *et al*., 2025).

Physicochemical Characteristics of Enteral Formulas

The results of osmolarity, viscosity, flow rate, and pH measurements are showed in Table 3.

Table 3
Physicochemical Characteristics of Enteral Formulations

Formulation	Osmolarity (Mean ± SD)	Viscosity (cP) (Mean ± SD)	Flow Rate (seconds) (Mean ± SD)	pH (Mean ± SD)
K	532 ± 1,15[a]	16,44 ± 0,20[a]	16,45 ± 1,07[a]	8,34 ± 0,07[b]
A	712,25 ± 46,18[b]	31,45 ± 8,98[b]	20,30 ± 0,36[b]	6,85 ± 0,00[a]
B	733 ± 48,13[b]	36,39 ± 6,22[b]	21,46 ± 0,46[b]	6,84 ± 0,03[a]

Osmolarity

Osmolarity is a measure of the osmotic concentration of solute particles in one liter of solution, expressed in mOsm/L (Ellis *et al*., 2019). Based on the Kruskal-Wallis test followed by the Mann-Whitney test, Formulations A (712.25 mOsm/L) and B (733.00 mOsm/L) were not significantly different from each other but showed a significant increase compared to the control (532.00 mOsm/L). Osmolarity testing aims to evaluate the suitability of the formula with recommended standards, typically ranging from 300-450 mOsm/kg (Hasanah Mardani *et al*., 2025). Referring to recommendations from the American Academy of Pediatrics and the study by Zadák & Kent-Smith (2009), the ideal osmolarity for enteral formulas in full-term infants is ≤450 mOsm/kg, while in adults and most populations, the physiological tolerance range is generally 270-700 mOsm/L, with values above this range classified as hyperosmolar. Based on these standards, formulations A and B are categorized as hyperosmolar. This high osmolarity is influenced by the composition of ingredients. The addition of catfish and soybeans contributes protein chains that are denatured or hydrolyzed into short peptides and free amino acids during heating. At the same time, sweet potato starch is broken down into simple sugars. The greater the breakdown of macromolecules into smaller molecules, the higher the osmotic pressure (Faidah *et al*., 2019). Clinically, the administration of hyperosmolar formulas requires caution, as high osmolarity may trigger gastrointestinal complications such as dumping syndrome and osmotic diarrhea (Puspitasari *et al*., 2025).

Viscosity

Based on the Kruskal-Wallis test followed by the Mann-Whitney test, Formulations A (31.45 cP) and B (36.39 cP) were not significantly different from each other but were significantly more viscous than the control formula (16.44 cP). According to Zaki *et al*. (2024), the preferred viscosity range is 1-50 cP, indicating that formulations A and B fall within the acceptable range. Formulation B exhibited the highest viscosity, followed by formulation A, while the control had the lowest viscosity. This increase in viscosity is influenced by the interaction of carbohydrates and water-binding proteins. Purple sweet

potato contains amylose and amylopectin that undergo gelatinization when reconstituted with warm or hot water, causing starch granules to absorb water, swell, and form a thick gel matrix (Herdiana *et al*., 2023). An increase in catfish flour proportion correlates positively with increased viscosity (Zaki *et al*., 2024). Additionally, soluble dietary fiber and protein from soybean flour have strong water-holding capacity, trapping free water into bound water and resulting in a thicker consistency (Cheng *et al*., 2025).

Enteral formulas with very low viscosity (<10 cP) are easy to administer but carry a high risk of gastroesophageal reflux and pulmonary aspiration in patients with dysphagia. Conversely, excessively high viscosity (>50 cP) may prevent adequate flow due to insufficient hydrostatic pressure, leading to occlusion in standard nasogastric tubes (8-12 Fr) (Wakita *et al*., 2012). Based on these criteria, formulations A and B fall within the ideal viscosity range (1-50 cP), showing that the formulas are technically compatible with enteral administration through an NGT in terms of liquid consistency and flow characteristics. However, this finding alone is insufficient to confirm over all clinical safety or tolerability because osmolarity values in both formulations exceeded the recommended physiological range. Therefore, despite their favorable viscosity and flow properties, the formulas should be administered cautiously and may require further osmolarity optimization before clinical application in tube feeding.

Flow Rate

Based on ANOVA followed by the Least Significant Difference test, the control formula (K) recorded the fastest flow time at 16.45 ± 1.07 seconds. In contrast, the modified local-based formulas showed longer flow durations, with 20.30 ± 0.36 seconds for Formulation A and 21.46 ± 0.46 seconds for Formulation B. Statistical analysis indicated a significant difference between the control and both modified formulations, while no significant difference was observed between Formulations A and B.

The flow rate results consistently demonstrate the physical principle that lower viscosity leads to faster flow. The control formula, with the lowest viscosity, showed the fastest flow, whereas formulations A and B required longer flow times due to their increased thickness (Zaki *et al*., 2024). The reduced flow rate is influenced by increased mechanical resistance (friction) between the liquid suspension particles and the inner surface of the nasogastric tube (Wakita *et al*., 2012). Nevertheless, an adequate flow rate does not necessarily indicate complete enteral safety. Clinical tolerability of enteral formulas is also strongly influenced by osmolarity, as hyperosmolar formulas may increase the risk of gastrointestinal intolerance, including osmotic diarrhea, abdominal discomfort, and dumping syndrome, particularly in vulnerable patients (Puspitasari *et al*., 2025).

pH

Formulations A (pH 6.85) and B (pH 6.84) were not significantly different from each other but were significantly more acidic compared to the control formula, which tended to be alkaline (pH 8.34). pH testing is an important parameter in evaluating product quality, as it affects stability, safety, and consumer acceptability. Appropriate pH values help maintain the physical and chemical properties of the product during storage, prevent degradation of active components, and minimize irritation or discomfort during use (Pratiwi *et al*., 2023).

The pH values of formulations A and B are considered ideal because they are close to the neutral pH of the human body. This condition is safe and helps prevent gastric irritation when the formula is administered enterally (Boullata *et al*., 2017). In enteral formula preparation, acidity must be carefully controlled. If the formula becomes too acidic (pH < 4.6), proteins from ingredients such as skim milk or soybeans may reach their isoelectric point (Damodaran *et al*., 2017). At this point, proteins coagulate, forming clumps that can clog the nasogastric tube and obstruct nutrient delivery (Bansal *et al*., 2021). However, pH suitability should not be interpreted as a standalone indicator of enteral safety. Although formulations A and B showed near-neutral pH values favorable for gastric tolerance, the elevated osmolarity observed in both formulations remains a major limitation that may affect gastrointestinal tolerance during enteral administration.

Moisture Content of Enteral Formulas

Table 4
Moisture Content of Enteral Formulas

Formula	Moisture Content (%) (Mean ± SD)
A	16.46 ± 1.07
B	20.30 ± 0.36

The results of moisture content analysis are showed in Table 3. Proximate analysis showed a significant difference ($p = 0.003$), where Formulation B had a substantially higher bound water content (20.30%) compared to Formulation A (16.46%). This difference is influenced by the composition of the ingredients. Purple sweet potato and soybean are rich in hemicellulose and pectin fibers that contain free hydroxyl groups. These groups form strong hydrogen bonds with surrounding water molecules. Formulation B likely contains a higher proportion of water-binding components, causing the drying process to be less effective in removing free water (Pramesti, 2024). These findings are consistent with previous studies indicating that catfish, soybean, and purple sweet potato contribute to total dissolved solids and water-binding capacity, while maltodextrin and skim milk contribute to solubility and stability of the formula (Hartati *et al*., 2023).

Moisture content in liquid enteral products plays an important role in determining consistency, energy density, and consumer acceptability (Pramesti, 2024; Zaki & Putri, 2021). Formulas with lower moisture content (Formulation A) tend to have a thicker consistency and higher nutrient concentration per volume. This is advantageous in improving the nutritional status of pregnant women with Chronic Energy Deficiency, as energy and protein requirements can be met without consuming excessive volume. Conversely, formulations with higher moisture content (Formulation B) produce a more diluted beverage that may be easier to accept sensorially but carries the risk of lower energy density.

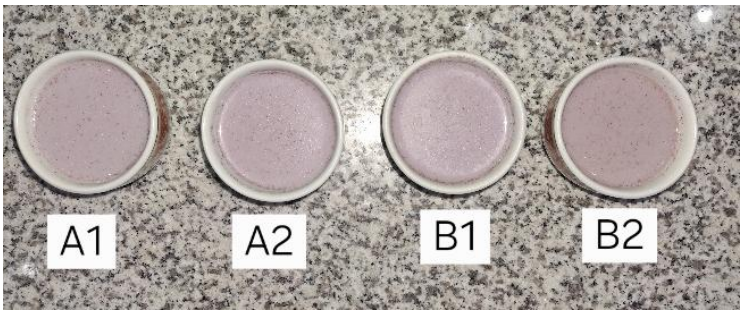

Figure 1. Enteral Formula

Color Evaluation

Table 5
Color Analysis of Enteral Formulas

Formula	Analysis Results (Mean ± Std Deviasi)		
	(L*)	(a*)	(b*)
K	63,28 ± 2,80^{c}	-9,20 ± 13,65^{a}	8,13 ± 4,00^{b}
A	40,70 ± 3,80^{a}	4,42 ± 1,14^{b}	-0,33 ± 2,34^{a}
B	46,75 ± 1,49^{b}	5,63 ± 0,60^{vb}	1,27 ± 1,25^{a}
p-value	<0,01	<0,0	<0,01

Color testing is an analytical method used to determine the visual characteristics of a product based on color parameters. Color often serves as an indicator of quality, freshness, ripeness, and chemical or physical changes during processing and storage. It is also the first organoleptic attribute assessed by consumers (Syasmar *et al*., 2024). This attribute strongly influences the acceptability and appetite of pregnant women with Chronic Energy Deficiency, who are prone to sensory perception changes.

Data in Table 4 show that Formulation A had a lightness (L*) value of 40.70 ± 3.80, Formulation B 46.75 ± 1.49, and the control 63.28 ± 2.80. ANOVA results indicated significant differences among treatments ($p < 0.05$). The control had the highest L* value, followed by Formulation B and Formulation A. The addition of purple sweet potato flour reduced brightness and increased the intensity of reddish-purple hues in modified products (Suarni *et al*., 2020). Furthermore, the brownish color characteristic is influenced by non-enzymatic browning (Maillard reaction) from catfish flour during drying (Zaki *et al*., 2024).

The redness parameter (a*) also showed significant differences based on the Kruskal-Wallis test ($p < 0.05$). Formulations A (4.42 ± 1.14) and B (5.63 ± 0.60) showed positive values indicating reddish-purple hues, while the control had a negative value (-9.20 ± 13.65). The Mann-Whitney test indicated no significant difference between Formulations A and B ($p = 0.092$), but both differed significantly from the control ($p = 0.004$). This confirms that purple sweet potato flour contributes significantly to the reddish-purple color. Anthocyanins are water-soluble flavonoid pigments stable at acidic to neutral pH but susceptible to degradation due to high temperature, oxidation, and prolonged storage (Khoo *et al*., 2017). Additionally, anthocyanins contribute antioxidant properties beneficial for the immune system (Zaki *et al*., 2024).

For the yellowness parameter (b*), Formulation A had a value of -0.33 ± 2.34, Formulation B 1.27 ± 1.25, and the control 8.13 ± 4.00. ANOVA results showed significant differences among treatments ($p < 0.05$). Based on the LSD test, there was no significant difference between Formulations A and B ($p = 0.498$), but both were significantly lower than the control ($p = 0.000$). The dominance of anthocyanin pigments from purple sweet potato likely masked the natural color pigments of other ingredients, reducing the b* value in modified formulas (Suarni *et al*., 2020). In contrast, the higher b* value in the control reflects the standardized yellowish-white appearance typical of commercial formulas.

Over all, the color characteristics demonstrate that local food-based formulations can produce visually appealing products competitive with commercial products. This aligns with previous research stating that local-based enteral formula development aims to create nutritionally rich products with acceptable physical properties (Hasanah *et al*., 2023). The natural reddish-purple hue from purple sweet potato enhances visual appeal and acceptability among pregnant women, potentially improving consumption compliance (Putri *et al*., 2022).

Organoleptic Test

Table 6
Organoleptic Test Results

	Analysis Results (Mean ± Std Deviasi)				
	Color	Aroma	Texture	Taste	Overall
K	6,00 ± 0,93	5,80 ± 1,32	5,87 ±1,06	5,47 ± 1,13	5,67 ± 0,98
A	5,67 ± 0,82	5,33 ± 0,98	4,87 ± 0,83	5,13 ± 1,06	5,13 ± 0,74
B	5,47 ± 0,83	5,33 ± 1,11	4,47 ±1,06	4,73 ± 1,03	4,67 ± 0,82
p-value	0,07	0,19	<0,00	0,14	<0,01

The organoleptic parameters evaluated included color, aroma, taste, texture, and overall acceptability using a 7-point hedonic scale ranging from 1 (strongly dislike) to 7 (strongly like). Statistical analysis using the Kruskal-Wallis test showed no significant differences across most parameters except texture and overall acceptance.

Color

The color parameter showed no statistically significant difference ($p = 0.07$). However, descriptively, the control formula had the highest score, followed by Formulation A and B. Panelists preferred the control due to its familiar white milk-like appearance. Among modified formulas, Formulation A was slightly preferred. The reduced preference for Formulation B may be influenced by higher catfish content, which dulls the purple hue (Khoo *et al*., 2017; Zaki *et al*., 2024).

Taste

No significant difference was observed in aroma ($p = 0.19$). Lower scores in modified formulas are attributed to soybean's beany flavor caused by lipoxygenase activity and catfish's fishy odor from trimethylamine compounds (Tao *et al*., 2022;

Sundari *et al*., 2021). The addition of vanilla flavoring helped mask these odors to a tolerable level.

Texture

Texture showed a highly significant difference ($p < 0.01$). The control formula was most preferred due to its homogeneity. Formulation A was preferred over B due to better solubility of plant protein, while animal protein in Formulation B contributed to sedimentation and a gritty mouthfeel (Hasanah Mardani *et al*., 2025).

Taste

Taste did not differ significantly ($p = 0.14$), but Formulation A was more preferred than B. The neutral taste of soybean blends better with sweet components, while fish-derived peptides in Formulation B create conflicting flavor profiles and fishy aftertaste (Zaki *et al*., 2024).

Over all Acceptability

Ove rall acceptability showed significant differences ($p < 0.01$). Formulation A was more preferred than B due to smoother texture, neutral taste, and better flavor synergy. Higher catfish proportion in Formulation B led to lower acceptability due to sedimentation and off-flavors (Hartati *et al*., 2023; Hasanah Mardani *et al*., 2025).

Sensory Implications for Pregnant Women with Chronic Energy Deficiency

This modified enteral formula is specifically developed as a nutritional intervention for pregnant women with Chronic Energy Deficiency. Organoleptic acceptability plays a crucial role in consumption compliance. Pregnant women, particularly in the first and second trimesters, experience heightened sensitivity to smell and taste, increasing the risk of nausea and vomiting (Oktavianti *et al*., 2021).

Although Formulation B offers advantages in animal protein composition, its sensory characteristics particularly fishy aroma and coarse texture may reduce acceptance and trigger nausea. In contrast, Formulation A, dominated by plant-based protein, demonstrated better acceptability in texture, taste, and aroma. This makes it the most feasible enteral formula for implementation in Supplementary Feeding Programs. High acceptability ensures consistent intake of energy-dense macronutrients, supporting improvements in Mid-Upper Arm Circumference and maternal weight gain during pregnancy (Peninsula *et al*., 2024).

Conclusion

The modified enteral formula based on catfish, soybean, and purple sweet potato flour has demonstrated advantages in energy density (1.2 kcal/ml) as well as essential macro and micronutrient profiles, making it a potential alternative nutritional intervention for pregnant women with Chronic Energy Deficiency (CED). Based on physicochemical evaluation, Formulations A and B exhibited ideal viscosity, flow rate, and neutral pH, indicating their safety for administration through a Nasogastric Tube (NGT). However, the hydrolyzed macronutrient composition resulted in both formulations being classified as hyperosmolar (>700 mOsm/L), thus requiring careful clinical administration to prevent the risk of osmotic diarrhea.

From the organoleptic evaluation, Formulation A, which contains a higher proportion of soybean, was significantly more preferred overall compared to Formulation B. The synergy between plant-based protein from soybean and carbohydrates from purple sweet potato in Formulation A produced a smoother liquid texture and a more harmonious flavor profile. In contrast, the higher proportion of catfish flour in Formulation B led to sedimentation and a fishy aftertaste, significantly reducing panelist acceptability. Therefore, Formulation A is recommended as the most promising prototype for further development of enteral nutrition products, with the note that formulation optimization is necessary to reduce osmolarity before clinical effectiveness testing in pregnant women.

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