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Developing Enteral Feeding Formulas for Stroke Patients Using Lactose-Free Milk and Mung Bean as The Non-Dairy Protein Source

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ABSTRACT

This study aimed at developing two enteral feeding formulas; the milk-based Lactose-free Enteral Food (LEF) and a Mung Bean based Enteral Food (BEF) to replace the milk protein. This study used a complete randomized design. The factors that were tested were lactose-free-milk of 10, 14, and 18% (L1, L2, and L3 respectively); and the mung beans formulas of 7, 8, 9, and 10% (B0 or control, B1, B2, and B3 respectively). The parameters that were measured on the enteral feeding were osmolality value (osmometer), thickness, and nutritional content. The results showed that the osmolality value of the LEF was lower than the commercial product. Meanwhile, the osmolality value of the BEF was higher than control ($p<0.05$). Based on the estimated calorie density, the best formula of LEF was the L3. Whereas, the best formula of BEF was L1. We tested the qualitative thickness of the formula using gravity method, and all formulas were found to have good level of thickness due to the absence of obstruction while passing through the NGT (size of NGT=14 Fr). The nutritional content per serving size of 250 ml L3 formula was 6.3 g protein, 10.4 g fat, 35.5 g carbohydrates, 93.23 mg Na, and 189.55 mg K. The nutritional content per serving size of 200 ml B3 formula was 6.49 g protein, 2.67 g fat, 13.58 g carbohydrates, 73.15 mg Na, and 257.96 mg K. Therefore, L3 and B3 can be developed further as the alternative enteral food diet formulas for stroke patients

Keywords: enteral food, lactose-free, mung bean, osmolality, stroke

INTRODUCTION

Stroke is the second leading cause of death in the world after coronary heart disease in 2016, in which 44% or 17.9 million of the cases are caused by cardiovascular disease (WHO 2018). A total of 328.5 thousand Indonesians suffered deaths from stroke in 2012 (WHO 2012). According to the National Basic Health Research's (Riskesdas) 2018 data, the prevalence of stroke in Indonesia has been increasing every year from 7 per mile in 2013 to 10.9 per mile in 2018. The highest incidence rate is among the elderly aged 75 years and above. Thus, stroke is one of the major causes of disability in the elderly (MoH RI 2018).

Dysphagia or difficulty in swallowing food is a common complication in stroke. In addition to dysphagia, inadequate nutritional intake for a prolonged period of time in stroke patient is also caused by lowered level of consciousness, poor oral hygiene, depression, reduced mobility, and arm or facial muscle weakness. On the other hand, higher metabolic demands during recovery also increase the risk of malnutrition (Bouziana & Tziomalos 2011).

The prevalence of malnutrition in stroke patients ranges from 6.1% to 62% and is increasing in line with the length of stay at hospital and the decline in organ functions during rehabilitation. A study reported that 104 patients with acute stroke had a protein energy shortage of 16.3% and increased to 26.4% in the first week and then 35% in the second week at the hospital (Bouziana & Tziomalos 2011). Meanwhile, malnutrition before and after a stroke can lead to a prolonged hospitalization time, worse functional conditions, and increase in mortality in 3–6 months after the stroke (Sabbouh & Torbey 2017).

The provision of enteral feeding is one alternative to prevent malnutrition in stroke patients. Nutritional therapy with enteral food is a method of feeding using thick liquid directly

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into the stomach through a special tube. Enteral liquid food generally contains 80–85% of water with various formulas that is adapted to physical and metabolism conditions as well as the severity of the illness (Khan *et al.* 2015).

Enteral food can be purchased as ready-made or commercial enteral food. However, these commercial products are often not affordable. Thus, it is not accessible to stroke patients from lower socioeconomic backgrounds. This condition can affect the fulfillment of nutritional needs in these patients, especially during the recovery period after the hospitalization (Ariani *et al.* 2013; Walia *et al.* 2017).

One solution is to provide enteral food that is prepared by the nutrition centre at the hospital. This noncommercial enteral food can also be made at home using the hospital's formula. The home-made enteral food is very flexible and affordable. Materials which are used are varied, depending on the availability and accessibility of the ingredients. The processing involved simple steps such as mixing all the ingredients using a blender, adding water, boiling and then filtering (Walia *et al.* 2017). Enteral food for stroke patients can be a standard polymeric enteral food, containing macro nutrients (protein, carbohydrates, and fats) with a total energy of 1–2 kcal/ml (Ariani *et al.* 2013).

Based on its ingredients, enteral foods are divided into two groups namely dairy based and non-dairy based. Milk helps enteral foods reach their minimum energy content of 1kcal/ml, so dairy enteral food with milk usually has better energy compared to non-dairy enteral food. However, the main carbohydrate in milk is lactose. Stroke patients who experience lactose intolerance cannot digest lactose so that lactose remains in the intestine and increases the gastrointestinal osmotic burden which will further increase the intestinal water levels and cause diarrhea (Mill *et al.* 2018).

In addition, stroke patients sometimes suffer from intestinal motility disorders. Hosinian *et al.* (2016) stated that there was a decrease in Gamma-Aminobutyric Acid (GABA) in patients with acute ischemic stroke which was thought to be due to changes in GABA metabolism. GABA is a major neurotransmitter in the central nervous system. It regulates various processes in the body including intestinal motility. Aggarwal *et al.* (2018) stated that GABA can inhibit the release of intestinal inflammatory mediators in patients with irritable bowel syndrome with diarrhea (IBS-D). In these patients, lactose in enteral food will worsen the condition of their gastrointestinal disorders. It is proposed that stroke patients require low or lactose-free enteral food in their diets. Therefore, a lactose free formula should be offered to these patients.

Moreover, field experience showed that some patients dislike the taste of milk. Therefore, dairy-based lactose-free formula might not be appropriate. So, a non-dairy formula could be offered to these patients. Protein in enteral food that does not contain milk can be sourced from legumes, such as mung beans (*Vigna radiata*). Mung bean plants are originated from India and have been widely spread in Asia, including Indonesia. Mung bean is a legume crop that is easily obtained with a harvest period of 60–80 days. In addition, Mung bean contains isoflavones as antioxidants, vitexin and isovitexin, essential fatty acids and minerals such as potassium and sodium. The content of essential amino acids that is found in mung bean can meet the needs of complete essential amino acids (Hou *et al.* 2019).

In 2019, 51% of all stroke patients who were hospitalized at the National Brain Center Hospital (PON Hospital) received enteral food. The PON Hospital has formulated an enteral food that uses mung bean. However, the hospital has not yet had a standard recipe for a lactose-free enteral food. Hence, this study is aimed at developing two types of high-quality enteral food for stroke patients using lactose-free milk and mung bean as a non-dairy protein source.

METHODS

Design, location, and time

The research was conducted in October 2019–January 2020. The processing and proximate analysis of the product was carried out at the Food Experiment Laboratory and the Laboratory of Chemical and Food Analysis, Department of Community Nutrition, Faculty of Human Ecology, IPB University. The osmolality analysis was carried out at the Harapan Kita Heart Center Hospital, West Jakarta. Potassium and Sodium mineral analysis was carried out at PT. Saraswati Indo Genetech, West Bogor, Bogor City.

Materials and tools

The ingredients to make the lactose-free enteral food were chicken eggs, lactose-free milk, corn starch, coconut oil, granulated sugar, and water. Meanwhile, for the mung bean enteral food, the ingredients were mung beans, carrots, oranges, eggs, rice flour, coconut oil, maltodextrin, sugar and salt. All ingredients were bought at a food store in Bogor. Whereas, maltodextrin was ordered online from a trusted supplier. The Commercial enteral food that were used as the comparison of selected formulas are brands X and Y. The materials that were used for proximate analysis were boric acid, hydrochloric acid, sulfuric acid, hexane, sodium carbonate, selenium mix, aquadest, aluminum foil, filter paper, methyl indicator red, and methyl blue.

The tools that were used to make the enteral food included blenders, digital scales, filters, knives, bowls, pans, stirring spoons, measuring cups, gas stoves, and thermometers. The tools that were used for the analysis of physical properties were osmometer, Nasogastric Tube (NGT) size 14 French, and syringes. The tools that were used for the analysis of chemical properties were beakers, test tubes, fossil tubes, aluminum plates, proelient plates, Mohr pipettes, measuring flasks, measuring cups, burettes, fat flasks, Kjeltec, Soxhtec, Osmo 1 Single-Sample Micro-Osmometer, furnaces, ovens, hot plates, analytic desiccator, and analytic scale.

Procedures

The purpose of the initial experiment was to formulate the Lactose-free milk-based Enteral Food (LEF) and the Mung Bean Enteral Food (BEF) through trials and errors. This study compared between non-commercial products namely developed formulation (L1, L2, L3 and B1, B2, B3) and commercial or control products. For LEF, the manufacturing process was referring to the standard enteral food formula containing milk which was issued by the Indonesian Ministry of Health that is currently applied at PON Hospital. In the LEF, the use of full cream milk and skim milk in the standard formula was replaced with lactose-free milk. The composition of LEF and BEF is presented in Table 1 and 2.

The control or comparison formula for LEF was a commercial lactose-free enteral food. Meanwhile, the control formula for BEF was an enteral food that was made from mung bean that was based on the PON hospital standard recipe. On the other hand, for the cost estimation analysis, we used a commercial non-dairy plant-based enteral food as comparison for the BEF.

The LEF manufacturing process started with weighing all ingredients including chicken eggs, lactose-free milk, and corn starch. It then followed by dissolving them using boiled water and then blended using a blender. Boiling water was then added to the mix to reach a volume of 265 ml. Coconut oil and sugar were then added to the mixture and stirred evenly. After that, the mixture was cooked over a low heat for 3 minutes until it reached a temperature of 72ºC. After it set, the flame was turned off and the mixture was filtered.

The process of making BEF started with soaking the mung bean for 2 hours. then it was boiled at 100ºC for 20 minutes. Next, 10 g of carrots was added at minute 15. The boiled mung bean and carrots were mixed using a blender. Then, it was mixed with maltodextrin, sugar, salt, and coconut oil. The mixture then was cooked on a low heat for 3–5 minutes until the temperature reached 70°C. The finished product was cooled down to reach a room temperature before 10g of orange juice was added.

After that, the experiment was conducted to determine the best amount of milk for the LEF formula and mung bean in the BEF formula based on the osmolality, qualitative thickness, and energy density estimation. The osmolality analysis used Osmo 1 Single-Sample Micro-Osmometer and the enteral food must also be able to flow smoothly and must not clogging the French Nasogastric Tube (NGT) 14. The calorie density was obtained from the calculations of the total energy content based on the reference of the 2017 Indonesian Food Composition Table that is divided by volume per serving size.

The selected LEF and BEF enteral food formulas were then subjected to a chemical analysis (AOAC 2012). The proximate analysis included water content (AOAC 990.20), ash content (AOAC 900.02), total protein content (AOAC 991.20), total fat content (AOAC 905.02), and total carbohydrate content by difference. Potassium and enteral food sodium levels were analyzed using ICP-OES (AOAC official method 2011.14). The results of proximate analysis were compared with control formula, i.e. product X for LEF and BEF 7% for BEF. LEF and BEF energy and nutritional content in one serving were also compared with commercial products, i.e. product X for LEF and product Y for BEF. The information of nutritional content of product Y was obtained from the nutritional value information label on the package. Then, the estimated cost that is needed to produce one serving of the selected formulas (LEF and BEF) and the commercial products (X and Y) were calculated for the cost comparison.

Experimental design

This research used a Complete Random Design with the treatment on the LEF arm where the percentages of lactose-free milk were 10, 14 and 18%. Meanwhile, on the BEF arm, the percentages of mung bean were four levels of 7% as control and 8, 9, and 10 % as the treatment groups. Each sample of LEF and BEF were tested twice for all parameters namely osmolality, thickness, and nutritional content.

Data analysis

The data were processed using the Microsoft Excel 2013 program. Independent sample t-test was used to determine the differences between the selected products and commercial or control products. The treatment effect was analyzed using One-way ANOVA. If the treatment showed a significant effect at 95% ($p<0.05$), then the Duncan's Multiple Range test was conducted as the post hoc test.

RESULTS AND DISCUSSION

The processing of enteral food

The Lactose-free Enteral Food (LEF) was cooked in a low heat for 3 minutes to reach a temperature of 72ºC for 15 seconds. It is the temperature for the pasteurization of milk that kills Salmonella pathogenic bacteria in eggs (Watt 2016). The maximum temperature for boiling enteral food must be lower than 76ºC. If the boiling temperature reaches more than 76ºC, the enteral food will begin to thicken. This thickening is caused by egg coagulation and gelatinization of the corn starch.

The BEF was cooked in a low heat for 3 minutes to reach a temperature of 70ºC. The BEF temperature that was used was lower than LEF because the BEF has higher carbohydrate content so that the viscosity increases faster during the cooking process.

Osmolality

The osmolality value of the enteral food is presented in Table 3. The osmolality value is considered as iso-osmolar if it is between 300–500 mOsm/kg (DAA 2018). L1 is an iso-osmolar solution because it has an osmolality below 400 mOsm/kg. The L2 and L3 and B0, B1, B2, and B3 have an osmolality between 400–550 mOsm/kg. So, these are close to hyperosmolar. The L1 osmolality is significantly lower than L2 and L3; whereas B0 and B1 osmolality are significantly lower than B3.

The higher the amount of the ingredients added, the higher the electrolyte content and energy density. Henriques *et al.* (2017) stated that the increase in enteral food osmolality is in line with the increase in the amount of sodium, potassium, and calories (Rambert 2014). Commercial products of brands X and Y have higher osmolality values compared to LEF and BEF. This might be caused by X and Y that have higher sodium and potassium contents compared to LEF and BEF. Although the osmolality of

Table 1. Composition of lactose-free milk enteral food (LEF) ingredients for 1 serving or 250 ml

Ingredients	Unit	Percentage of lactose-free milk		
		L1=10	L2=14	L3=18
Chicken eggs	g	25	25	25
Lactose-free milk	g	30	40	50
Corn starch	g	3	3	3
Coconut oil	g	2	2	2
Sugar	g	13	13	13
Drinking water (28–30ºC)	g	210	200	190

Table 2. Composition of mung bean enteral food (BEF) for one serving or 200 ml

Ingredients	% Mung beans*				
	Unit	B0=7 (Control)	B1=8	B2=9	B3=10
Rice flour	g	1	1	1	1
Maltodextrine	g	4	4	4	4
Chicken eggs	g	10	10	10	10
Mung bean	g	20	24	27	30
Sweet oranges	g	10	10	10	10
Carrots	g	10	10	10	10
Coconut oil	g	2	2	2	2
Sugar	g	20	20	20	20
Salt	g	0.2	0.2	0.2	0.2
Water	g	210	210	210	210

For the control was taken from the standard recipe of mung-bean-based enteral food from PON Hospital; Enteral food with the treatment of adding mung beans to the standard recipe

commercial products X and Y is classified as hyperosmolar because it has a value of more than 550 mOsm/kg, this product is still used for patients in hospitals. Yet, an enteral feeding with osmolality value of 500–600 mOsm/kg can increase the risk of gastrointestinal disorders.

The high osmolality of the enteral food is not the sole cause of Gastrointestinal (GI) disorders. Because, the human body has its own mechanism in regulating the GI osmotic. Additionally, the osmolality value that can be tolerated by the small intestine is around 600 mOsm/kg (Boullata *et al.* 2017). Thus, enteral food with high osmolality values can be given slowly to reduce the risk of GI disorders (Chang & Huang 2013). Research by Khan *et al.* (2015) found that 20 enteral homemade food have good viscosity or thickness without it causing obstruction in the NGT. So, this food can be administered for stroke patients with dysphagia.

Table 3. Effects of the percentage of material on enteral food osmolality

Treatment	Osmolality (mOsm/Kg)
A. Percentage of lactose-free milk	
L1 (10)	324.5±16.3[a]
L2 (14)	413.0±11.3[b]
L3 (18)	458.0±32.5[b]
Commercial product X	591.5±20.5
B. Percentage of mung bean	
B0 (7)	478±12.27[a]
B1 (8)	489±15.56[a,b]
B2 (9)	524± 6.36[b,c]
B3 (10)	545±16.26[c]
Commercial product Y	721.5±9.19

Numbers followed by letters on each different product indicate significantly different results ($p<0.05$)
Values are expressed as mean±SD (n=2)

Dysphagia in stroke patients is caused by the slow swallowing response, the impaired hyoid movement in which is resulting in oropharyngeal residue. It is a condition where food is left in the pharynx after ingestion and can cause aspiration (Gallegos *et al.* 2017). Hence, feeding too runny enteral food can increase the risk of aspiration. On the other hand, if it is too thick, it can cause blockages in the NGT. Enteral food is considered as too thick if it is unable to pass the NGT which is causing obstruction or blockage.

On the other hand, enteral food is considered as having a sufficient level of thickness if it could pass NGT (De Sousa *et al.* 2014). The rheology of liquid food is important in making enteral food because it can determine how easy or difficult the enteral food flows in an NGT. The test results showed that all samples can pass through the NGT and there was not any obstruction occurred.

The osmolality values of every sample met the recommended osmolality values. Additionally, the product flowed smoothly and did not clog the tubes. Furthermore, the determination of the chosen formula was based on its energy content. The target energy density was 1–1.5 kcal/ml for LEF and 1–1.2 kcal/ml for BEF (DAA 2018). The estimated energy density was 1.07, 1.27, and 1.47 kcal/ml (for L1, L2, and L3 respectively); and 1.11, 1.15, and 1.21 kcal/ml (for B1, B2, and B3 respectively). The highest estimated energy density were the LEF 18% (1.47 kcal/ml) and BEF 10% (1.21 kcal/ml). Thus, the chosen formula for the next stage of analysis were LEF 18% and BEF 10%.

Nutrient content comparison between selected enteral feeding and control

Proximate analysis comparison between the selected formula and the control products are presented in Table 4. The LEF was compared to commercial brand X and the 10 BEF was compared to the 7% BEF as control. For LEF, the content of protein, carbohydrate, ash, and potassium in the LEF 18% was significantly lower than the product X. On the contrary, the water and fat content were significantly higher, while the sodium content is the same.

For BEF, all nutrients in the 10% mung bean formula were not significantly different from the 7%, except for the potassium content. The potassium level in BEF 10% (128.98 mg/100g) was significantly higher than BEF 7% (104.62 mg/100g). According to Bento *et al.* (2017) the results of proximate analysis on blended enteral food is influenced by the number of ingredients that were used and also the type of ingredients used. Based on the Indonesian food composition table (TKPI 2017), the potassium content in mung bean is relatively high, which is 815.7mg per 100g (MoH RI 2018). Thus, the potassium content of BEF 10% is higher than BEF 7% due to the increased amount of mung bean that was used in the formula.

Enteral food formula should be about 70–80% water (DAA 2018). From our observation, the LEF 18% and the commercial product X water content was still in the range of 70–80%. Ash content reflects the total amount of minerals that is contained in a food or beverage product (Nielsen 2010). Thus, ash content was in line with sodium and potassium levels.

One of the considerations in choosing an enteral food formula for consumption is its protein content (Savino 2018). In this study, we found that the LEF 18% protein content was still far lower than the protein content of commercial product X. It was despite the fact that the protein source of LEF 18% came from casein of milk and eggs.

Fat is considered to have 2 main purposes, caloric provision and providing essential fatty acids (Savino 2018). The LEF 18% had almost eleven times higher fat than product X. It was because the fat source in LEF 18% were milk fat, eggs, and coconut oil.

Carbohydrates are important in food as a major source of energy, to impart crucial textural

Table 4. The comparison between selected enteral food and control on nutrient content per 100 g

Nutrient Content	Dairy Product		Non-dairy Product	
	LEF 18%	Control (X)	BEF 10%	Control (BEF 7%)
Water (%wb)	79.95±0.21[a]	76.35±0.08[b]	87.99±0.64[a]	88.52±0.00[a]
Ash (%db)	1.84±0.00[a]	3.37±0.16[b]	0.65±0.00[a]	0.51±1.27[a]
Protein (%db)	11.78±0.04[a]	22.08±0.45[b]	3.24±0.15[a]	2.89±0.11[a]
Fat (%db)	19.55±0.59[a]	1.79±0.38[b]	1.33±0.13a	1.44±0.23[a]
Carbohydrate (%db)	66.83±0.62[a]	72.76±0.22[b]	6.79±0.09[a]	6.98±0.21[a]
Potassium (mg)	358.94±41.24[a]	1386.50±20.63b	128.98±0.58b	104.62±0.18[a]
Sodium (mg)	176.50±20.23[a]	168.59±11.05[a]	36.58±1.42[a]	36.36±1.01[a]
Energy (kcal)	490.42±2.96a	395.44±2.55[b]	52.13±1.84[a]	52.44±5.66[a]

Different letters behind the numbers in the same line in each product show significant differences ($p<0.05$); Values are expressed in mean±SD (n=2); Control: PON Hospital enteral food standard recipe of BEF (7%); X is the comparative commercial product of LEF; LEF: Lactose-free enteral food; BEF: Mung bean enteral food properties, and act as a dietary fiber which influences the physiological processes (Nielsen 2010). However, the Atwater factor for protein and carbohydrates was 4 kcal/g. Meanwhile, the Atwater factor for fat was 9 kcal/g So, despite the lower carbohydrates content in the LEF 18%, its energy content was higher compared to product X due to the larger fat content.

Meta-analysis of nine cohort studies showed a protective effect from the risk of stroke due to higher potassium intake (Aburto *et al.* 2013). Increasing potassium intake from 90 to 120mmol/day can reduce the systolic blood pressure by 7.16 mmHg and diastolic pressure by 4.01 mmHg. A decrease in blood pressure to 130/80 mmHg will reduce the incident of recurrent stroke. In addition, low sodium intake is also one of the efforts that can be done in lowering the blood pressure (Hunt & Cappuccio 2014). Therefore, the analysis of sodium and potassium content in enteral food for stroke sufferers is important.

Nutritional content per serving of the enteral food formula

We analyzed the nutritional contents per serving of LEF 18% and BEF 10%, which were 250 ml and 200 ml respectively. The amount of enteral feeding a day is adjusted to the needs of the stroke patient. The nutritional content of selected enteral food and commercial product per serving size are presented in Table 5.

The protein content of product X was twice as high as LEF 18%. The protein content of product X contributed to 22.3% of total energy. Meanwhile, in LEF 18% it only contributed to 9.6% of total energy. As a reference, the protein content in standard enteral food formulas with the energy densities of 1–1.2 kcal/ml is 15–20% (DAA 2018). So, product X can be categorized as a high-protein enteral food formula because its protein content was higher than 20%. Also, low protein content in LEF 18% was more suitable for the elderly.

The LEF 18% protein content was more than 8% of the total calories. However, it has not been classified as a low-protein enteral food.

The decrease in kidney function in elderly are varied. For example, glomerular filtration rate decreases around 8–10 ml/minute or 1.73m^2 per decade after a person is 35 years old. As a consequence, decreased kidney function will affect the ability to filter and remove the remnants of protein and electrolyte metabolism among the elderly (PERSAGI/AsDI 2019).

The enteral food is required to have an energy density of at least 1 kcal/ml (PERSAGI/AsDI 2019). Two major contributors for energy density in enteral foods are fat and carbohydrates.

Table 5. Nutritional content of selected enteral foods and commercial product per serving size

Nutritional Content per Serving Size	Dairy Product (250 ml)		Non-dairy Product (200 ml)	
	LEF 18%	Brand X	BEF 10%	Brand Y*
Water	211.88±0.57[a]	196.6±0.19[b]	-	-
Ash	0.98±0.00[a]	2.05±0.11[b]	-	-
Protein (g)	6.26±0.08[a]	13.44±0.23[b]	6.49±0.29[b]	9.87±0.21[a]
Fat (g)	10.38±0.39[a]	1.09±0.23[b]	2.67±0.25[b]	5.19±0. 21[a]
Carbohydrate (g)	35.50±0.33[a]	44.30±0.28[b]	13.58±0.17[b]	35.28±0.08[a]
Sodium (mg)	93.23±10.92[a]	102.65±6.40[a]	73.15±2.84[b]	178.96±0.88[a]
Potassium (mg)	189.55±22.26[a]	833.25±9.83[b]	257.96±1.15[a]	602.84±2.94[a]
Energy (kcal)	260.57±3.98[a]	240.75±2.47[b]	104.00±1.86[b]	227.00±0.49[a]
Energy Density (kcal/ml)	1.04	0.96	0.52	1.14
Cost (IDR)	10,441	28,699	4,500	11,000

*Calculated based on nutrition facts in the packaging; The letters behind the numbers indicate significant differences ($p < 0.05$); Values are expressed as mean±SD (n=2); X and Y: commercial enteral food brands; IDR: Indonesian rupiah
LEF: Lactose-free enteral food; BEF: Mung bean enteral food

The LEF 18% had a higher energy density compared to product X. This was due to the higher fat content of LEF 18%. The LEF 18% fat content (35.9% of the total energy) was significantly higher compared to product X (4% of the total energy).

Dietitians Association of Australia - DAA (2018) states that the fat content in standard enteric polymeric food with the energy densities that is below 2kcal/ml is about 30–40% of the total energy. The LEF 18% contained 54.5% carbohydrate of the total energy. Meanwhile, product X contained 73.6% carbohydrates of the total energy. The percent of total energy that was provided by the carbohydrate in the enteral formulas with the energy density of 1–1.5 kcal/ml were 50% to 55% (DAA 2018). Meanwhile, Product X contained more than 60% carbohydrate from the total energy.

Potassium content per serving size of product X was higher than LEF 18%. Many researchers have investigated the protective effect of high potassium intake on the risk of stroke. It is believed that high potassium intake can reduce blood pressure and reduce the risk of recurrent strokes.

Based on Table 5, the nutritional content of product Y was significantly higher compared to BEF 10%. This was because BEF 10% used fresh ingredients that varied in nutritional contents and caloric densities. Thus, it was not in accordance with the recommended standard recipe, which is 1–1.2 kcal/ml. This was caused by the diversity of ingredients that were used to accommodate the availability of local food, season, processing methods, storage, and cooking methods.

The inadequate nutritional content of BEF 10% can affect the intake and impact the nutritional status of the patient. Especially, stroke patients with dysphagia complications can be generally classified as malnourished. This is caused by the unstable carbohydrate intake and lack of micronutrients that drive the patients to experience weight loss (Sabbouh & Torbey 2017). Therefore, the BEF 10% as a non-dairy or plant-based enteral food formula needs to be further developed to increase its energy density. It can be done by adding fat such as coconut oil.

According to Arsava *et al.* (2018), enteral dietary requirements for stroke patients are energy content that is obtained from 15–20% protein, 30–35% fat, 49–54% carbohydrate, and calorie density ≥1 kcal/ml. Additionally, sodium restriction <1500 mg/day can/should be implemented to prevent other complications and worsen the patient's condition (Turlova & Feng 2013). We calculated that the content of protein, fat, and carbohydrate in BEF 10% contributed to 24%, 23%, and 52% of the total energy respectively. The contribution of protein to energy exceeded that of the recommended value. Meanwhile, the contribution of fat fell below the recommended range according to dietary requirements. Although there were not any negative consequences for stroke patients, we could increase the total energy by increasing the fat content to balance the energy source.

Based on the estimated cost, the production of one serving of LEF 18% was IDR 10,441 and was lower than the product X IDR 28,699. The lower LEF 18% price can be one of the considerations in the selecting enteral food. Similiarly, the Y brand enteral food (IDR 11,000) is more than twice as expensive as BEF 10% (IDR 4,500). This is in line with the research of Khan *et al.* (2015) that discovered that 20 homemade enteral liquid food that were made using fresh ingredients were cheaper. Because, the ingredients that were used were not only adjusted to the illness, but also adjusted to the availability of the local food.

CONCLUSION

The research has developed two enteral feeding formulas for stroke patients with dysphagia to prevent malnutrition and minimize side effects. The two formulas were 18% of lactose-free milk formula and 10% mung bean for the non-dairy formula. Both selected formulas had the highest estimated energy density among other formulas and fulfilled the enteral feeding quality criteria based on osmolality and rheology indicators. Meanwhile, for the energy density, the lactose-free milk formula is comparable to the commercial brand. But, the 10% mung bean only contained half of the energy density of the commercial product. The estimated cost of making one serving size of 18% lactose-free milk enteral food and 10% mung bean enteral food is lower than the commercial products. Further research that is related to the modification of the formula to increase the energy and protein content needs to be done. In addition, despite its lower cost, homemade enteral nutrition process is more susceptible to microorganism contamination, so it is necessary to pay attention to aspects of sanitation and hygiene during the processing.

AUTHOR DISCLOSURES

The authors do not have any conflict of interest.

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