Acceptability and Sensory Properties of Specific Enteral Formula for Stroke-Diabetes Mellitus Patients

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Abstract. Stroke-Diabetes Mellitus (DM) patients are at risk of dysphagia which will reduce oral intake and increase the risk of malnutrition. Enteral formula is chosen as a nutritional therapy and must be specially formulated to manage hyperglycemia and meet dietary needs. This study aims to analyse the sensory evaluation of enteral formula specifically for Stroke-DM patients. This study used a completely randomized design with 3 treatments and 1 control. Hospital Formula (FRS-C) was used as the control group, Modified Formula without the addition of moringa or beetroot (FRS), with the addition of moringa (FRS-M), and beetroot (FRS-B). Sensory evaluation consisting of hedonic assessment tests and preference tests was conducted on 30 semi-trained panel. All data were analysed using one-way ANOVA followed by Tukey HSD at a 95% confidence level. The data showed that enteral formula with the addition of beetroot had good acceptability and could be further developed for enteral formula for diabetes-stroke patients.

Keywords: Beetroot, Diabetes Mellitus, Enteral Nutrition Formula, Moringa, Stroke

1 INTRODUCTION

Diabetes is a collection of metabolic disorders marked by high blood sugar levels due to problems with insulin production, insulin effectiveness, or a combination of both [1]. The Basic Health Research Report (RISKESDAS) of the Indonesian Ministry of Health in 2018 showed that the prevalence of diabetes mellitus (DM) based on a doctor's diagnosis in the population aged >15 years was 2% [2]. People with diabetes have twice the risk of experiencing a stroke, whether it is ischemic or haemorrhagic [3,4]. Individuals who have had a stroke are at a high risk of developing dysphagia, or difficulty swallowing, which often necessitates feeding through enteral formulas.

Enteral nutrition (EN) can aid in preventing malnutrition in these patients [5,6]. Stroke patients with diabetes require a specialized enteral nutrition formula that can help lower blood glucose levels, manage lipid profiles, and provide antioxidant benefits

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to reduce inflammation [7]. The limitation of enteral formulas in Indonesia is the lack of a specialized hospital formula (FRS) specifically for diabetic stroke patients. As a result, formulas are adjusted based on individual patient needs and the guidelines of certain hospitals. Diabetes-stroke specific formulas are needed to prevent hyperglycaemia related to enteral nutrition in diabetic patients that might worsen the associated adverse outcomes [8]. EN must meet the patient's macronutrient needs including carbohydrates, protein and fat according to recommendations and the patient's condition [9].

Patient acceptance of enteral formula depends on the patient's condition and level of preference when given orally. Measurement of the level of preference can be done by organoleptic testing including characteristics of taste, colour, aroma, and texture using a numerical score [10]. Therefore, in this study, a specific enteral formula was created which is a modification of FRS with a low glycaemic index and high antioxidants as an alternative to commercial formulas for diabetes mellitus patients with stroke that can meet macronutrient intake, as well as has good acceptability with a good level of preference so that it can be applied to overcome stroke-diabetes mellitus. This study aims to determine the level of preference for enteral formula specifically design for diabetes-stroke patients.

2 METHOD

2.1 Research Design

This experiment was conducted using completely randomized design to determine the effects of two difference addition of antioxidant rich food, moringa (FRS-M) and beetroot (FRS-B) powder, into the FRS. FRS-C served as the control group derived from the formula commonly used in hospital with no modifications from the standard recipe.

2.2 Enteral Formula Preparation

The formulation for all FRS were estimated using Nutrisurvey 2007 to meet the energy requirement of approximately 1800 calories. The composition for each formula is listed in Table 1.

2.3 FRS Formulation

First, oat milk was prepared using method described in Yu et al [11] with adjustments, by soaking the rolled oat in cold water (1 kg rolled oat in 4 litres of water) for 4-6 hours, then blend for 30 seconds. Next, strain the mixture with a fine mesh strainer covered with cheesecloth over a large bowl, pour and squeeze slowly to prevent the oat milk becomes slimy. Second, multigrain milk was prepared by soaking the nuts in plain water for 4-6 hours, then rinse until the water becomes clear. Steam the multigrain for 45 minutes over medium heat then blend for about 1-2 minutes with a ratio of multigrain and water of 1:10. The mixture was then strained using a clean cheese cloth and boiled over low heat for 30 minutes [12].

The next step was blending the date, steamed carrots, steamed egg whites, oranges, and water until smooth, followed by straining the mixture until only the pulp remains. The final step was dissolving the beetroot or moringa powder with 10 mL of water, mix all the ingredients, and add water until the volume reaches 2 L.

Table 1. The composition of each formula

Ingredients	Formula			
	FRS	**FRS-M**	**FRS-B**	**FRS-C**
Rolled oat	90 gram	90 gram	90 gram	-
Multigrain mix	100 gram	100 gram	100 gram	-
Date	30 gram	30 gram	30 gram	-
Skimmed milk	150 gram	150 gram	150 gram	80 gram
Full cream milk	-	-	-	120 gram
Whey powder milk	30 gram	30 gram	30 gram	-
Egg white	150 gram	150 gram	150 gram	150 gram
Orange	100 gram	100 gram	100 gram	100 gram
Corn starch	-	-	-	20 gram
Carrot	100 gram	100 gram	100 gram	-
MCT	15 mL	15 mL	15 mL	-
Inulin	10 gram	10 gram	10 gram	-
Sugar	5 gram	5 gram	5 gram	100 gram
Xanthan gum (0,05%)	0,4 gram	0,4 gram	0,4 gram	-
Vanilla powder	5 gram	5 gram	5 gram	-
Soy lecytin	1,95 gram	1,95 gram	1,95 gram	-
Margarine	-	-	-	20 gram
Beetroot powder (1%)	-	-	7,8 gram	-
Moringa powder (1%)	-	7,8 gram	-	-
Water	1800 mL	1800 mL	1800 mL	1800 mL

2.4 Sensory Evaluation

Sensory evaluation was done by conducting hedonic rating test to rate the four formula on a scale based on how much they like or dislike the sample. The 5-point hedonic scale used were (1): extremely dislike, (2): slightly dislike, (3): neither like nor dislike, (4): slightly like, and (5): extremely like. Meanwhile, acceptance test was utilized to evaluate detection, recognition, discrimination, scaling, and the ability of four key sensory attributes, including colour (very light, light, slightly light, dark, very dark), aroma (very not unpleasant, not unpleasant, slightly unpleasant, unpleasant, very unpleasant), texture (thin, slightly thick, mildly thick, moderately thick, extremely thick), and taste (very sweet, sweet, slightly sweet, bitter, very bitter) to express preferences of 31 semi-trained panellists aged 20-35 years old over three enteral formula developed. The test was conducted in a proper testing environment, appropriate serving size and temperature. All samples were coded using three-digit random numbers. The protocols for sensory evaluation was approved by the Ethics Committee of Faculty of Nursing and Health Science, University of Muhammadiyah Semarang with certificate number 202/KE/03/2024.

2.5 Data Analysis

Data from the sensory evaluation were analysed using the one-way ANOVA test and if applicable followed by Tukey's Honest Significant Difference (HSD) test at the 0.05 significance level on the GraphPad Prism 10.

3 RESULTS AND DISCUSSION

Sensory evaluation was done using hedonic rating with samples of each formula (FRS, FRS-M, FRS-B, and FRS-C) on the level of preference of the panel and followed by acceptance test for four sensory properties: color, aroma, texture, and flavor/taste.

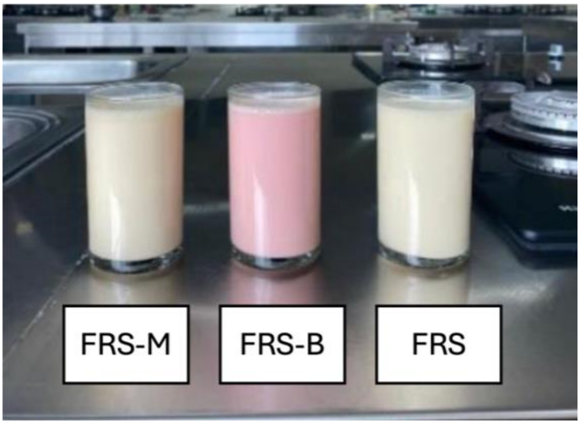


Fig. 1. The modified formulas made in the study

3.1 Preference

The results of the sensory evaluation test can be viewed in Figure 1. FRS-C scored the highest for aroma, texture, and flavour; while FRS-B showed the highest preference for colour. Likability of sensory properties is an important factor in the development of food products. This is particularly vital for patients at risk of malnutrition such as stroke-DM patients who experience dysphagia that leads to reduced overall intake [13]. The end goal of treatment is to restore oral eating thus the formula used should also be considered palatable for patients. Studies has shown that palatability, especially related to thickness and flavour, is essential to improve patients' adherence for nutrition support [14–16]. FRS-B was found to have the highest overall preference rating among the modified formulas for all sensory properties, thus proving its potential as an alternative enteral formula.

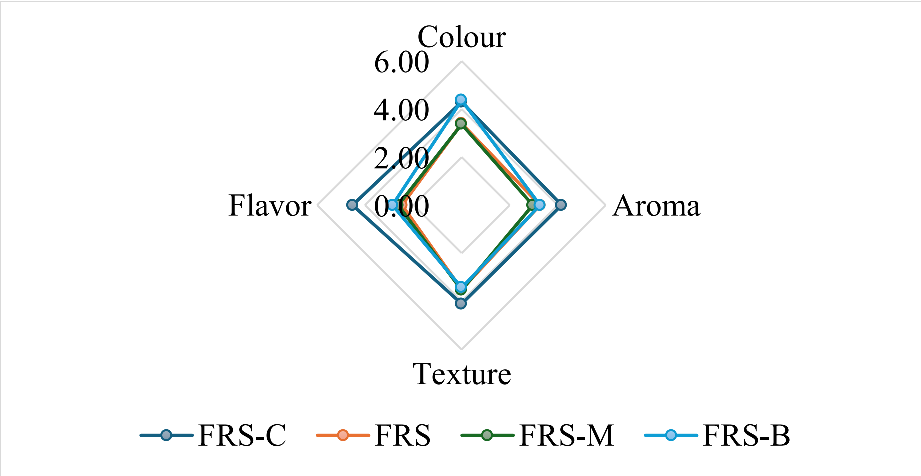
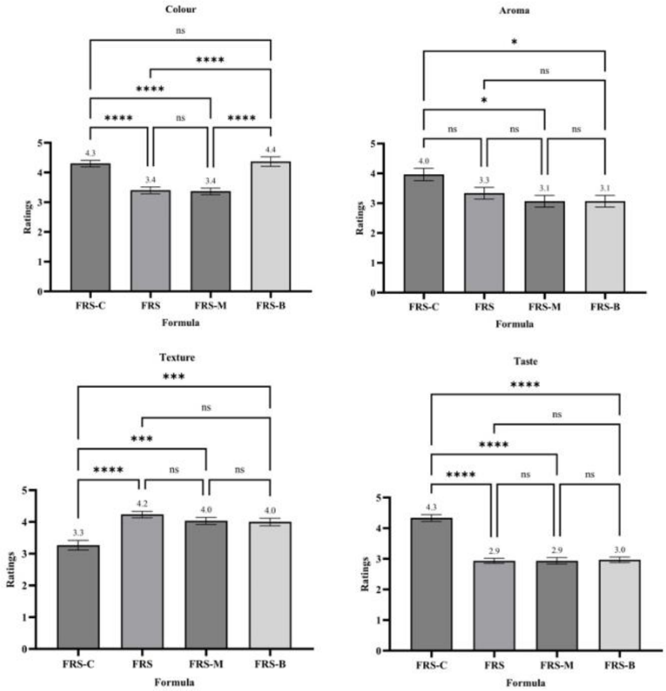


Fig. 2. Hedonic test spiderweb results

3.2 Acceptability

Colour. Preference testing on colour showed that FRS-C obtained the highest score (Figure 3) and described as "light" while other formulas were described as "slightly light". Friedman test revealed significant effect ($p<0.01$) of modification on the colour quality. Further statistical test also found significant difference ($p<0.01$) between FRS-C and the modified formulas. FRS-B was the most favoured among the modified formulas. None of the ingredients in FRS-C has a distinct colour, owing to milk and corn starch for the lightness in its appearance. Meanwhile, all modified formulas were made of several beans with predominantly mung bean that may have made it seem darker than the control. Heat during the formula processing may have also caused a variety of reactions that lead to colour changes, including degradation of volatile components and non-enzymatic browning [17,18]. Enzymatic browning also occur in processed mung beans, leading to lipid peroxidation and eventually degraded colour pigments such as karotenid and chlorophyll [18]. As a result, the formula seem slightly yellow-ish in comparison to control. FRS-B appeared pink-ish (Figure 2) due to color pigments of beetroot, particularly betanine that constitutes 70-95% of bioactive compounds in beetroot [19,20].

Aroma. Modified formulas were generally found to have less pleasant aroma than control ($p<0.05$), described as "slightly unpleasant" or "rather beany". Volatile compounds such as fatty acids, carbohydrates, and amino acids in beans contribute to the formation of beany aroma [21]. Essential fatty acids are hydrolysed by lipoxygenase into carbonyl, hydrocarbon, aldehyde, ketones, and other chemical compounds, resulting in a beany aroma [22]. Hexanal, cis-3-hexanal, and hexanol are commonly known lipid oxidation products in processed beans that generate its characteristic aroma [23]. Attempts were made to minimize the unpleasant aroma by steaming the bean ingredients for 45 minutes and boiling the juice, but the unique beany aroma still remained which made it less preferred (Figure 3). No difference was found between the acceptability of aroma among modified formulas (p>0.05), but FRS had the highest score.



ns = p>0.05; * = p≤0.05; ** = p≤0.01; *** = p≤0.001; **** = p≤0.001

Fig. 3. Acceptance test results

Texture. On the contrary to colour and aroma, FRS was rated the highest in texture, followed by FRS-M then FRS-B (Figure 3). The modified formulas were all described as "thin", while FRS-C was rated as "slightly thick". Statistical analysis also found significant difference between the formulas and control (p<0.01). FRS-C contained corn starch which consisted of amylose and amylopectin that gelatinized upon heat, resulting in its thick texture[24]. Meanwhile, the modified formulas used xanthan gum. Xanthan gum has been shown to be the superior option compared to starch for thickeners in enteral formula, producing formulas with finer stability, cohesion, and overall texture [25]. It also promotes safer swallowing with lower risks of aspiration and less pharyngeal residue [25]. FRS was the most acceptable in terms of texture among the modified formulas, although no significant difference was found among modified formulas (p>0.05).

Flavor/taste. The highest rating for flavor was found in FRS-C (Figure 3), with significant differences compared to the modified formulas (p<0.05). All formulas were described as "sweet", with FRS-C as the sweetest due to its high sugar content. The modified formulas used less sugar and replaced it with inulin that is 10% less sweeter than sugar [26]. FRS-B was the most approved among the modified formulas, although the scores were comparable with no significant difference (p>0.05).

4 CONCLUSION

An enteral formula supplemented with 1% beetroot has a colour, taste, aroma, and texture that are well-received by panel. However, further studies are necessary to assess the impact on postprandial blood sugar levels after consuming the formula, to ensure its safety for patients with diabetes-stroke.

Authors' Contributions. KN and ZML devised the project, proof outline, supervised the project, and wrote the manuscript. LA and AO carried out the experiments. All authors discussed the results and contributed to the final manuscript.

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