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Nutrition value and viscosity of polymeric enteral nutrition products based on purple sweet potato flour with variation of maltodextrin levels

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ABSTRACT

Background: *One obstacle in commercial enteral food formulation is the adjustment between nutritional value and rheological characteristics of the product.*
Objectives: *To evaluate the nutritional value and viscosity of polymeric enteral nutrition (PEN) products made from purple sweet potato flour with variations in the level of maltodextrin as a stabilizer.*
Methods: *The completely randomized design was used with four variations of maltodextrin, which was 2.5%, 5%, 7.5%, and 10%. The research was carried out by making purple sweet potato flour, then its proximate composition was measured as a basis for formulating a PEN product that was 200 kcal/200mL, with 60% carbohydrates (120 kcal / 200 mL), 15% protein (30 kcal), and 25% fat (50 kcal). The proximate composition and calorie value of the PEN products were tested. The PEN products were added hot water at a temperature of 90˚C; then, the viscosity was measured at room temperature. The viscosity of two types of commercial enteral nutrition products was measured as a reference.*
Results: *The results showed that there was an effect of maltodextrin level on moisture, fat, and protein contents of PEN products, but there was no effect on calorie values. The viscosity of the PEN products displayed that the higher the maltodextrin level, the higher the viscosity of the product. The viscosity of the PEN products in accordance with the commercial enteral products was the treatment of maltodextrin 5% and 7.5%.*
Conclusion: *There is an effect of maltodextrin as a stabilizer on the nutritional value and viscosity of PEN products based on purple sweet potato flour.*

Keywords: *enteral; nutrition value; purple sweet potato; viscosity*

INTRODUCTION

Everyone must meet the needs of nutrients for a healthy life obtained through food intake. However, in hospitals, there are often patients who have difficulties or are unable to meet their food intake needs orally so that malnutrition occurs.[1, 2] The patient causes this has a particular condition such as severe burns, post-surgery / surgery, stroke, kidney disease, cirrhosis of the liver, and other diseases. Besides, various reports show high cases of malnutrition for patients in hospitals, including 22% in South Korea, China, 72.8%, India 27.6%, Malaysia 21%, and Indonesia 34.8% to 37.1%.[3, 4]

Enteral nutrition is an attempt to overcome the problem. The enteral food is a liquid food and liquified flour, which is inserted through the tube into the gastrointestinal pathway, which is intended for patients who cannot consume food orally.[5] Enteral food can be given to individuals who have malnutrition problems and who want to maintain their nutritional status in good condition.[6]

Based on its availability, enteral food consists of two types, namely liquid or home-made and in the form of flour or commercial.[7] Liquid or blenderized enteral foods are made from ordinary foods that are blended and liquified.[6] Flour type enteral foods that are ready to be liquified are called commercial enteral foods, with varying nutritional values as needed, are practically prepared, and are not easily contaminated.[7]

Currently, various commercial enteral food products have been widely marketed, but commercial enteral food is only to meet the needs of nutrients. In general, the food produced should consider not only the adequacy of nutrients and physical standard[8, 9], but also the psychosocial factors associated with the use of local food, such as cassava, corn, nuts, fruits, and vegetables.[10] One of the local foodstuffs in Indonesia that has the potential to be developed as an enteral food raw material is the purple sweet potato.

Purple sweet potato has been widely known as a food that has many health benefits. The purple sweet potatoes indicated the anti-inflammatory and anti-cancer effects.[11] The inhibitory effect of colorectal cancer from purple sweet potato extract through apoptotic mechanisms.[12] Even reported that purple sweet potato extract has antioxidant activity and has a hypoglycemic effect.[13] The purple sweet potato extract could reduce blood glucose levels of rats given high glucose.[14] Purple sweet potato extract increased glycemic control in type 2 diabetes patients[15], and blood pressure in hypertensive elderly patients.[16]

The use of purple sweet potato flour as a raw material for enteral food products presents a particular obstacle to the product's rheological stability due to its

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high starch content. An attempt to overcome this problem is to add a stabilizer, such as maltodextrin. Maltodextrin is a modified product of starch which has a high solubility in cold water so that it is appropriate to be used as a stabilizer in enteral nutrition products. The use of these stabilizers can have an impact on the nutritional value and viscosity of enteral products. Preliminary research displayed that the use of maltodextrin in PEN products from PSP (purple sweet potato) flour following the viscosity of commercial PEN products, which was between 2.5% to 10%.

To the best of our knowledge, studies related to nutrition value and viscosity of polymeric enteral nutrition products based on purple sweet potato flour are still rare. Moreover, the research can be used as a reference in formulating enteral foods specifically for nutritionists. The purpose of this study was to evaluate the effect of maltodextrin on nutritional value and viscosity of PEN products based on purple sweet potato flour.

MATERIALS AND METHODS

Materials

The ingredients used in this study were PSP flour, maltodextrin, soy protein isolate, sugar, and vegetable oil. The PSP was obtained from a farmer in Ngawi Regency, Central Java Province, Indonesia. Maltodextrin, sugar, and vegetable oil were obtained from supermarkets in Surakarta. Isolated Soy Protein (ISP) was purchased from a chemical distribution company in Jakarta.

Purple Sweet Potato Flour Making

The manufacture of PSP flour was modified from the procedure of Rauf et al. (2018).[17] PSP is washed with running water then peeled. PSP thinly sliced with a thickness of ± 2 mm. PSP slices were then dried using sunlight for ± 24 hours, then milled and sieved using 80 mesh. The PSP flour was made in the Food Science Laboratory, Universitas Muhammadiyah Surakarta.

Formulation of Enteral Nutrition

The PSP flour and ISP were measured for moisture, ash, fat, and protein contents, as well as calorie values. The nutritional values and calories were used as a reference to calculate the needs of each ingredient with the calorie value of each nutrient specified, namely carbohydrates 60% (120 kcal.), protein 15% (30 kcal.) and fat 25% (50 kcal.) from total calorie (200 kcal.). The formula was based on the recommendation of ASPEN (American Society for Parenteral and Enteral Nutrition).[18]

The calorie values of carbohydrates, proteins, and fats from raw materials were calculated. Furthermore, the need for each ingredient was determined using the two until five variables Algebra equation, as follow:[19]

$$(AxWxCp)+(BxWxCp)=30\ kcal\ protein \quad \text{.............. Eq-1}$$

where:
A = PSP flour (%)
B = Isolated soy protein (%)
W = weight of enteral product
Cp = calorie of protein (kcal/g)

On the eq-1, total protein as much as 30 kcal was a constant. W was also a constant that must be estimated in advance how many grams of product for 200 kcal. In this study, it was estimated that 50g of the product. Only ingredients of A and B consist of the protein of five ingredients used so that in the eq-1, only two variables were included.

The variable A was also used as a constant by estimating the percentage of PSP flour needed from the total weight of the product. After the estimation value, it could be calculated how many grams of variable B (ISP needed with variable A to meet 30 kcal of protein from the product).

$$(AxWxCp)+(BxWxCp)+(DxWxCf)=50\ kcal\ fat \quad \text{......... Eq-2}$$

where:
A = PSP flour (%)
B = Isolated soy protein (%)
D = Vegetable oil (%)
W = weight of enteral product
Cf = calorie of fat (kcal/g)

On the eq-2, ingredients that consist of fat calories could be used as variables, including A, B, and D. The values of variables A and B were known from eq-1 so that the weight of the variable D from the vegetable oil could be determined.

$$(AxWxCp)+(BxWxCp)+(CxWxCf)+(DxWxCf)+ExWxCf=120\ kcal\ carbohydrate \quad \text{............ Eq-3}$$

Where:
A = PSP flour (%)
B = Isolated soy protein (%)
C = Maltodextrin (%)
D = Vegetable oil (%)
E = Sugar (%)
W = weight of enteral product
Cc = calorie of carbohydrate (kcal/g)
Cp = calorie of protein (kcal/g)
Cf = calorie of fat (kcal/g)

The values of variables A, B, and D have been determined from the Eq-1 and eq-2. The value of Variable C (maltodextrin) could also be determined, because it was a treatment in this study. The eq-3 was only applied to calculate the sugar requirement (Variable

E) to complete the total calorie value of carbohydrates, which was 120 kcal.

Table 1. Formula for the PEN Products

Ingredients	Maltodextrin			
	2.5%	5%	7.5%	10%
Maltodextrin (g)	1.25	2.50	3.75	5.00
PSP flour (g)	29.60	29.60	29.60	29.60
ISP (g)	8.90	8.90	8.90	8.90
Vegetable oil (g)	5.55	5.55	5.55	5.55
Sugar (g)	3.75	2.50	1.25	0
Calorie (kcal)	200	200	200	200
Netto (g)	49.05	49.05	49.05	49.05

All ingredients were weighed and then mixed. PEN products were packaged using aluminum foil and stored in the refrigerator at 4˚C until further analyzed.

Nutrition Value and Calorie Measurements

The nutrition value of enteral nutrition products evaluated was moisture, ash, fat, and protein contents. Moisture content was calculated using thermogravimetry, ash content using the dry method, fat using Soxhlet extraction, and protein using micro-Kjeldahl.[20] The nutrition value was conducted in the laboratory of food chemistry and biochemistry, Faculty of Agricultural Technology, Universitas Gadjah Mada.

The calorie value was tested in the Center for Food and Nutrition, Universitas Gadjah Mada, using a Bomb calorimeter. A 1 gram sample was put into the sample cup. The sample cup was placed in a Vessel Bomb calorimeter. A total of 1 mL of distilled water was included in the Calorimeter Bomb Vessel. Oxygen gas flows into the vessel as much as 30 atm; then, the vessel was put into the reactor. A bomb calorimeter was connected to an electric current to start the combustion process.

Viscosity Test

The viscosity measurement was conducted in the Food Science Laboratory, Universitas Muhammadiyah Surakarta, using a Brookfield DV-II + Pro viscometer with spindle no. 62, a rotation speed of 60 rpm following the procedures of Rauf and Sarbini (2012) and Stroud et al. (2003).[21, 22] The product was put into a glass, then brewed with hot water at a temperature of 90 ℃ to a volume of 200 mL, stirred for 20 seconds. The sample was cooled to 27 ℃. Viscosity data were taken every 10 seconds for 1 minute.

Data Analysis

This study used a completely randomized design with four variations of the concentration of maltodextrin, namely 2.5%, 5%, 7.5%, and 10% of total calorie. Each sample was analyzed three times for each quality indicator. The same treatment of samples was subsequently measured in triplicate. As a comparison of viscosity, two types of commercial enteral products were used. Data that not normally distributed were analyzed using Kruskal-Wallis, while those that normally distributed were analyzed using One Way Anova, followed by Duncan's at the 0.05 level.

RESULTS

Nutrition Value and Calorie

The results on nutrition values of PSP flour, especially for moisture, ash, fat, and carbohydrate levels, showed conformity with the standards proposed by Ambarsari (2009).[23] For ISP, the water content was following the provisions of codex general standard 175-1989, while the protein content did not meet the standard.[15] The nutrition value and calorie of PSP flour and ISP is displayed in Table 2.

Table 2. Nutrition Value and Calorie of PSP Flour and ISP

Nutrition	PSP Flour	ISP
Moisture (%)	7.12 ± 0.01	4.12 ± 0.02
Ash (%)	2.75 ± 0.03	1.03 ± 0.03
Protein (%)	1.7 ± 0.01	89.96 ± 0.12
Fat	0.03 ± 0.01	2.75 ± 0.07
Crude fiber (%)	1.18 ± 0.09	-
Carbohydrate (% by diff.)	89.86	2.17
Calorie (kcal.)	338.15 ± 0.35	338.02 ± 0.12

The nutrition value of PEN products, in general, was affected by the variation of maltodextrin levels. The more the maltodextrin level, the more the moisture, fat, and the calorie levels of PEN products. Although the nutritional value of PEN products was statistically significant, the difference in the nutritional value of each treatment was small. The treatment of 10% maltodextrin of PEN product indicated the highest moisture level, which was 7.19%. The highest fat level demonstrated by PEN product with the treatment of maltodextrin 10%, which was 11.66% of total calorie. The most significant calorie of PEN product was given by a 10% maltodextrin that was not significantly different from the 7.5% maltodextrin statistically. The nutrition value and calorie of PEN products are given in Table 3.

The PEN products for the treatments of 2.5%, 5%, and 7.5% maltodextrin revealed that there was no difference for the crude protein levels. The 10% of maltodextrin of PEN products indicated the highest crude protein. On the other side, the treatments of 2.5%, 5%, and 7.5% maltodextrin displayed no significant difference for protein level.

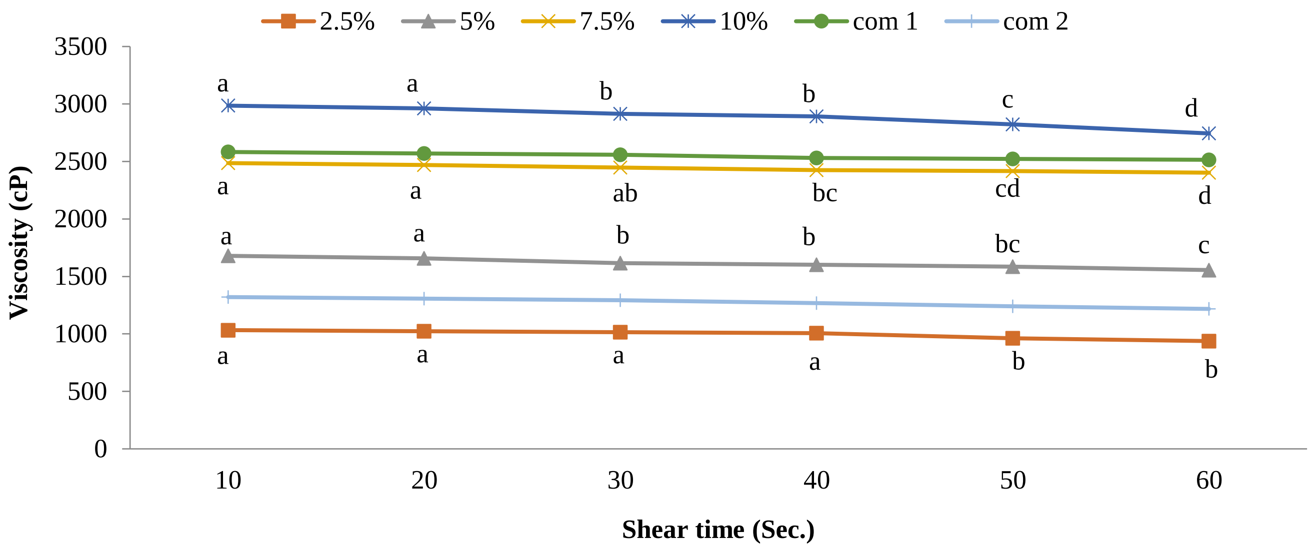
Table 3. Nutrition Value and Calorie of PEN Products

Ingredients	Maltodextrin			
	2.5%	5%	7.5%	10%
Moisture (%)	6.74 ± 0.11[a]	6.89 ± 0.44[ab]	7.03 ± 0.29[ab]	7.19 ± 0.35[b]
Ash (%)	2.37 ± 0.04 [b]	2.46 ± 0.15 [b]	2.26 ± 0.08 [a]	2.27 ± 0.07 [a]
Protein (%)	15.35 ± 0.14 [a]	15.38 ± 0.24 [a]	15.43 ± 0.19 [a]	15.74 ± 0.33 [b]
Fat (%)	11.27 ± 0.13 [a]	11.46 ± 0,26 [ab]	11.50 ± 0.34 [ab]	11.66 ± 0.33 [b]
Carbohyd. (by diff.)	64.10	63.79	63.73	63.24
Calorie (kcal)	198.4±0.5 [a]	198.43±1.1 [a]	199.27±0.7 [b]	199.33±0.7 [b]

Different letters represent significant differences (p ≤0.05).

Viscosity

The results demonstrated that there was an effect of maltodextrin levels on the viscosity of the PEN products. The more the maltodextrin level, the more the viscosity of the PEN products. The highest viscosity of the PEN product was shown by the treatment of 10% maltodextrin, whereas the treatment of 2.5% maltodextrin indicated the lower viscosity of the PEN product.



Different letters represent significant differences (p ≤0.05).

Figure 1. Viscosity of PEN Products with the Variation of Maltodextrin Levels.

The viscosity of PEN products during measurement every 10 seconds has decreased significantly. The higher the initial viscosity of a PEN product, the more significant the decrease in viscosity during shear-time. The most considerable decrease in viscosity occurred in PEN products with 10% maltodextrin treatment, whereas the lowest was 2.5% maltodextrin treatment.

DISCUSSION

The results of the nutritional value of PSP flour showed the suitability of the proximate composition with the recommendations for Indonesian National Standard, except for proteins with a minimum standard of 3%.[23] Although the protein from PSP flour used in this study was lower than the recommended standard. Low protein levels in PSP flour could be caused by planting location, temperature, and climate factors.[25, 26]

The primary indicator of ISP products is protein content. The ISP has a high protein content that is 85% to 96%, so it can be used to increase the nutritional value of food products.[27, 28] The protein content used in this study was 89.96%.

The nutrition value of PEN products that need to be modified is moisture content, which was 6.74% - 7.19%. There is no standard of moisture content for the commercial enteral formulas. These results meet the criteria if using a standard flour in general, which is less than 10%. However, the water content of PEN products still needs to be reduced if using the standard of formula milk, which is less than 5%, then. The moisture content of PEN products was mostly from PSP flour. The moisture content of PEN products can be reduced by lowering the moisture content of PSP flour.

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Table 4. The Nutrition Calorie of PEN Products

Ingredients	Predicted	Maltodextrin			
		2.5%	5%	7.5%	10%
Protein (kcal.)	30	30.12	30.18	30.27	30.88
Fat (kcal.)	50	49.75	50.59	50.77	51.47
Carbohyd. by diff. (kcal.)	120	118.53	117.66	118.23	116.98
Total calories (kcal.)	200	198.4	198.43	199.27	199.33

The nutrition value of PEN products in Table 3 can be converted into calorie value, which is given in Table 4. The calorie was in accordance with the results of the analysis of the PEN product nutrition value. The macronutrient calories of PEN products complied with the standards recommended by ASPEN as well as ESPEN (European Society for Parenteral and Enteral Nutrition), which are 15% to 25% protein or equivalent to 30 kilocalories to 50 kilocalories. Furthermore, for fat, which is 25% to 40% or equal to 50 kilocalories until 80 kilocalories. The maximum calorie for carbohydrates is 60% or the equivalent to 120 kilocalories.[18, 29] The nutritional calorie of the commercial PEN product indicated the protein, fat, and carbohydrate contents, which was 15%, 30%, and 55%, respectively or equivalent to 30 kilocalories, 60 kilocalories, and 110 kilocalories.[30] The fat content of the commercial PEN product was higher than the PEN product of this research, as well as ASPEN and ESPEN recommendations.

The results displayed that during the shear process through measurement, there was a significant decrease in viscosity for all PEN products. These PEN products provide a non-Newtonian type of viscosity. Non-Newtonian viscosity is the viscosity of a liquid that changes in friction between surfaces and the liquid wall.[31]

The viscosity of PEN products was not only affected by shear time but also the level of maltodextrin. The higher the level of maltodextrin used, the higher the viscosity. The lowest viscosity was shown by the treatment of maltodextrin 2.5% with initial viscosity of 1,032.9 cP and final viscosity of 937.6 cP. In contrast, the highest viscosity was given by maltodextrin 10% treatment with initial viscosity of 2,985.5 cP and final viscosity of 2,744 cP. Various commercial enteral formulas displayed a various range of viscosity such as 800 cP to13,000 cP, 900 cP to 12,000 cP, 1,000 cP to 10,000 cP, and 2,000 cP to 10,000 cP.[32] One of the factors that affect the viscosity of enteral nutrition products is thickener or stabilizer.[9] The more the level of thickener, the higher the viscosity of the PEN products. The higher the addition of maltodextrin concentrations, the higher the viscosity of pasta and gel of products.[33]

The viscosity of PEN products is still following the viscosity of commercial enteral formula products, both commercial products with low viscosity and high viscosity. There are two maltodextrin treatments whose viscosity is between the two commercial products, namely 5% and 7.5%. Viscosity is critical to consider in choosing a product because the viscosity can have a clinical impact on patients.[34]

CONCLUSION

Enteral food products derived from variations in raw materials can be designed for nutritional value and calorie by using the Algebra equation, including PSP flour. The use of maltodextrin can increase the viscosity of PEN products based on PSP products. PEN products provide a type of non-Newtonian viscosity with the characteristic of a decrease in viscosity during the shear process. Based on the nutrition and calorie values, as well as the viscosity, all formulas in the research meet the requirements compared to the ASPEN and ESPEN standards as well as commercial PEN products.

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