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Substitution of Kiwi Extract and Egg White Extract in a Special Formula for Severe Hypoalbuminemia in Type 2 Diabetes Mellitus and Hypertension Patients

Millennia Rillys Ramadhani*, Endang Sutjiati, and Rany Adelina

Dietitian Professional Education, Nutrition Department, Health Polytechnic, Ministry of Health, Malang

**Corresponding author*
Email: mrillysrm@gmail.com
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Abstract

Diabetes Mellitus (DM) and Hypertension are global health emergencies as declared by the World Health Organization. Hypoalbuminemia, often associated with severe illnesses, disrupts physiological processes and hinders recovery. This study developed and evaluated a modified enteral formula for diabetic patients with complications using local ingredients, specifically kiwifruit juice and egg white extract, known to reduce blood pressure and enhance albumin levels. The study employed a true-experimental design with a Completely Randomized Design (CRD). Three formulations were created by varying the proportions of diabetic milk, kiwifruit juice, and egg white extract: P1 (60:16:24), P2 (60:12:28), and P3 (60:8:32). The formulas underwent nutritional value analysis, viscosity testing, and organoleptic evaluations covering color, aroma, texture, and taste. Trained panelists assessed acceptability, and results were presented descriptively and in tabular form. Results showed that all formulas had similar energy content: P1 and P2 at 1.13 kcal/ml, and P3 at 1.12 kcal/ml. Viscosity tests confirmed P2 and P3 met optimal standards for enteral formulas. Organoleptic tests revealed P2 had the most preferred sensory attributes, including a fragrant aroma, smooth texture, and balanced taste. Acceptance tests also favored P2 for its superior sensory properties. In conclusion, P2 (60:12:28) was the most favorable formula, offering optimal nutritional value, viscosity, and sensory appeal. This formula demonstrates potential as a dietary intervention for diabetic patients with hypoalbuminemia, integrating local functional ingredients to support health and recovery.

1. INTRODUCTION

The World Health Organization (WHO) has declared Diabetes Mellitus (DM) and Hypertension as global health emergencies. According to the 2018 Riskesdas data, there was a 5% increase in the prevalence of these two diseases among the Indonesian population compared to the 2013 Riskesdas data. According to the International Diabetes Federation and the Global Status Report on Noncommunicable Diseases, one in every 16 people aged 20–79 years in Indonesia suffers from chronic diseases. This number is expected to increase by 31% over the next 15 years. This increase will become a burden on the country, negatively affecting the national economy (Wibowo, 2020). According to Dewi (2022), it has been found that the kiwi fruit (*Actinidia deliciosa*) contains compounds that can reduce hypertension. Kiwi contains 17 times more vitamin C than apples. Kiwi also contains vitamins E, B1, B2, B6, and vitamin A. The vitamin C and E content in kiwi act as antioxidants, which can prevent cancer and premature aging. The high vitamin C in kiwi is beneficial in lowering hypertension.

DM patients with gangrene often experience hypoalbuminemia due to antigen-antibody reactions that increase the permeability of the glomerular basement membrane, leading to leakage of proteins (albumin). This condition is a poor prognostic indicator, which results in a disruption of oncotic balance. A 50% decrease in albumin levels causes a 66% reduction in oncotic pressure. Treating patients with hypoalbuminemia requires expensive intravenous serum albumin injections. Albumin is the most abundant plasma protein, making up about 60%, and plays crucial roles in health, including the formation of new cells to repair damaged tissue and maintaining fluid balance between blood vessels and the interstitial spaces within normal limits. Normal albumin levels in the blood range from 3.5–5 g/dL (Sayuningsih et al., 2017).

Hypoalbuminemia is a condition where albumin levels in the blood fall below 3.5 g/dL. In hypoalbuminemia, physiological processes in the body are disrupted, especially in critically ill patients, hindering or delaying the healing and recovery process. Low albumin levels are associated with increased risk of infection complications, prolonged wound healing, extended hospital stays, and higher mortality rates in hospitalized patients, both those undergoing surgery and those who are not (Bonilla et al., 2014). Ovalbumin, the most abundant protein in egg whites, is a key source. Commercial egg whites contain 10.5 g of protein per 100 g, with 95% of it being albumin (9.83 g), while duck egg whites contain 11 g of protein (5.6 g) per 100 g (Indonesian Food Composition Table, 2009).

Enteral formulas refer to all liquid food administered through the digestive tract, either orally, through a nasogastric tube, or via a gastrostomy or jejunostomy tube (Escot-Stump, 2017). One enteral formula that can be provided for diabetes mellitus patients is Diabetasol milk. Diabetasol milk is a nutritional meal replacement designed for diabetes patients, providing a complete and balanced nutrient profile with a low glycemic index to help stabilize blood sugar levels. Its advantages include a complete and balanced nutritional profile, making it suitable as a meal replacement. It also contains Vitadigest, a combination of slow-releasing carbohydrates that prevent a drastic increase in blood sugar after meals, and a low glycemic index, allowing for slow absorption by the body. One modification of enteral formulas for diabetes patients with complications is to add local food ingredients.

The local food selected is one that has the potential to reduce blood pressure and increase albumin levels in the body, while also being affordable and easily accessible to the community. These local foods consist of ingredients that can lower high blood pressure, such as kiwi fruit, and foods intended to normalize albumin levels, such as egg

whites. The formulation of an enteral formula with kiwi extract and egg white extract in a special diabetes formula aims to examine the physical properties, test organoleptic characteristics and acceptance, and evaluate the chemical properties of the modified formula.

Although previous studies have examined the effects of kiwi fruit on hypertension (Dewi, 2022) and the protein content of egg whites on albumin levels (Sayuningsih et al., 2017), there is limited research on combining these ingredients into a single enteral formula for diabetic patients with hypoalbuminemia. Additionally, the physical, chemical, and organoleptic properties of such modified formulas remain underexplored. This study addresses these gaps by formulating and evaluating an enteral formula using kiwi extract and egg white extract in a specialized diabetes formula to assess its physical properties, organoleptic characteristics, and chemical properties..

2. MATERIALS AND METHODS

The research methodology used in this formula is a true experimental design with a Completely Randomized Design (CRD), employing 3 treatment levels. There is a repeated treatment approach in this research related to the different compositions of the modified enteral formula. The treatments involve three different formulations of the enteral formula, varying the proportions of Diabetasol milk, kiwi juice, and egg white extract. These are:

1. **P1**: 60% Diabetasol milk, 16% kiwi juice, and 24% egg white extract.
2. **P2**: 60% Diabetasol milk, 12% kiwi juice, and 28% egg white extract.
3. **P3**: 60% Diabetasol milk, 8% kiwi juice, and 32% egg white extract.

Each formulation is tested for its physical properties (viscosity), chemical properties (nutritional value), and organoleptic acceptability (color, aroma, texture, and taste). These repeated formulations allow for a comparative analysis to determine the best-performing combination.

The preparation of the enteral formula, viscosity test, organoleptic quality test, and acceptance test were conducted at the Food Science Laboratory (IBM) of Poltekkes Kemenkes Malang. The research was conducted from September to November 2022. Nutritional value calculations were performed using the empirical method with the assistance of the Nutrisurvey 2008 Software and Microsoft Excel 2010. The viscosity test was performed using the dynamic method with glassware, a dropper, and a stopwatch. The organoleptic quality and acceptance tests included 4 parameters: color, aroma, texture, and taste, which were conducted by 10 trained panelists, all female, aged 20 to 21 years, with prior experience as panelists. The data were presented descriptively and in tabular form. The independent variables were kiwi extract and egg white extract in a special diabetes formula, while the dependent variables were patients with severe hypoalbuminemia, type 2 diabetes mellitus, and hypertension.

The formulation was based on Diabetasol milk powder, which was then modified by adding kiwi fruit extract and egg white extract. For use as an enteral formula, the milk was prepared by adding 200 ml of warm water to 60 grams of powder. In the modified formula of Diabetasol milk with kiwi extract and egg white extract, three ratios were tested in the formulation design: Diabetasol milk : kiwi extract : egg white extract. These ratios were P1 (60 : 16 : 24), P2 (60 : 12 : 28), and P3 (60 : 8 : 32).

The procedure for making the modified formula begins with weighing the raw materials, including Diabetasol milk, boiled egg whites, and peeled kiwi fruit, according to the proportions specified. Diabetasol milk is then mixed with the pre-measured warm water. The boiled egg whites are chopped into smaller pieces. The chopped egg whites are blended with added water using a blender, and the

mixture is strained to obtain the egg white extract. The kiwi fruit is chopped into smaller pieces and blended to extract the kiwi juice. The kiwi juice is then strained. The Diabetasol milk, kiwi extract, and egg white extract are combined in a blender. Finally, the enteral formula is heated for 15 minutes and is ready to be served.

The statistical data analysis methods used in this study include:.

1. **Descriptive Analysis**
   Descriptive statistics were employed to summarize and present data on nutritional value, viscosity, organoleptic quality, and panelist acceptance.
2. **Completely Randomized Design (CRD)**
   The study used a true-experimental design with CRD, which allows for the comparison of three treatment levels (P1, P2, and P3) to analyze variations in the enteral formula compositions.
3. **Empirical Methods for Nutritional Calculations**
   Nutritional value was calculated using the Nutrisurvey 2008 software and Microsoft Excel, providing empirical estimates for key parameters like energy, protein, fat, and carbohydrate content.
4. **Panelist Evaluation**
   Organoleptic tests were conducted by trained panelists, assessing sensory attributes (color, aroma, texture, and taste) and acceptance. Data were presented descriptively in tabular form, which may involve ranking or scoring scales for interpretation

3. RESULTS and DISCUSSION

A. Nutritional Value Calculations

Absolutely right that visualizing data in the form of bar charts can make it easier for readers to interpret results. For this study, the following data could be effectively presented in bar chart form:.

1. **Nutritional Value of Modified Formulas**
   A bar chart comparing energy, protein, fat, and carbohydrate content for P1, P2, and P3 would clearly highlight their differences.
2. **Viscosity Test Results**
   A bar chart showing the viscosity values of the different formulas (P1, P2, P3) could emphasize which formulas meet the optimal viscosity standards.
3. **Organoleptic Test Results**
   Separate bar charts for each organoleptic parameter (color, aroma, texture, taste) could illustrate panelist scores for each formula, making comparisons straightforward.
4. **Acceptance Test Results**
   A bar chart summarizing the overall acceptance scores for P1, P2, and P3 would visually reinforce the conclusion that P2 is the most preferred formula

Based on the empirical nutritional value calculations, the following are the nutritional values of the modified formula:

Table 1: Nutritional Value of Diabetasol Milk (One Serving ≈ 200 ml)

Ingredient	Weight (g)	Energy (kcal)	Protein (g)	Fat (g)	Carbs (g)
Diabetasol Milk	60	260	10	7	39
Warm Water	200	-	-	-	-
Total	260	10	7	39	110

As shown in Table 1: Nutritional Value of Diabetasol Milk (One Serving ≈ 200 ml), Diabetasol milk provides a baseline for comparison. The modified formulas, detailed in Tables 2, 3, and 4, show variations in energy, protein, fat, and carbohydrate content across the three treatments (P1, P2, P3)

Table 2: Nutritional Value of Modified Formula (P1) (One Serving ≈ 250 ml)

Ingredient	Weight (g)	Energy (kcal)	Protein (g)	Fat (g)	Carbs (g)
Diabetasol Milk	60	260	10	7	39
Warm Water	200	-	-	-	-
Kiwi Extract	16	9.8	0.2	0.1	1.7
Egg White Extract	24	12	2.5	0	0.2
Total	281.8	12.7	7.1	40.9	150

As shown in Table 2: Nutritional Value of Modified Formula (P1) (One Serving ≈ 250 ml), the composition of the P1 formula highlights its balanced nutritional profile. Diabetasol milk contributes significantly, providing 260 kcal of energy, 10 g of protein, 7 g of fat, and 39 g of carbohydrates. The inclusion of 16 g of kiwi extract adds 9.8 kcal of energy and small amounts of protein (0.2 g) and carbohydrates (1.7 g), with minimal fat content (0.1 g). Additionally, 24 g of egg white extract enhances the formula with 12 kcal of energy and 2.5 g of protein. Combined, the modified formula totals 281.8 kcal of energy, 12.7 g of protein, 7.1 g of fat, and 40.9 g of carbohydrates per 250 ml serving, ensuring it meets the dietary needs of patients requiring enteral feeding.

Table 3: Nutritional Value of Modified Formula (P2) (One Serving ≈ 250 ml)

Ingredient	Weight (g)	Energy (kcal)	Protein (g)	Fat (g)	Carbs (g)
Diabetasol Milk	60	260	10	7	39
Warm Water	200	-	-	-	-
Kiwi Extract	12	7.3	0.1	0.1	1.3
Egg White Extract	28	14	2.9	0	0.3
Total	281.3	13	7.1	40.6	156.4

Table 3: Nutritional Value of Modified Formula (P2) (One Serving ≈ 250 ml) presents the nutritional composition of the P2 formula. Diabetasol milk remains the primary source of energy, contributing 260 kcal, along with 10 g of protein, 7 g of fat, and 39 g of carbohydrates. The addition of 12 g of kiwi extract provides 7.3 kcal, a minimal amount of protein (0.1 g), and 1.3 g of carbohydrates, with negligible fat content (0.1 g). Furthermore, 28 g of egg white extract enhances the formula, adding 14 kcal of energy and 2.9 g of protein. Collectively, the P2 formula totals 281.3 kcal of energy, 13 g of protein, 7.1 g of fat, and 40.6 g of carbohydrates per 250 ml serving, ensuring a balanced and nutrient-rich profile suitable for enteral feeding.

Table 4: Nutritional Value of Modified Formula (P3) (One Serving ≈ 250 ml)

Ingredient	Weight (g)	Energy (kcal)	Protein (g)	Fat (g)	Carbs (g)
Diabetasol Milk	60	260	10	7	39
Warm Water	200	-	-	-	-
Kiwi Extract	8	4.9	0.1	0.1	0.9
Egg White Extract	32	16	3.4	0	0.3
Total	280.9	13.5	7.1	40.2	162.8

As presented in *Table 4: Nutritional Value of Modified Formula (P3) (One Serving ≈ 250 ml)*, the P3 formula provides a balanced nutritional profile tailored for enteral feeding. Diabetasol milk contributes the largest portion of nutrients, delivering 260 kcal of energy, 10 g of protein, 7 g of fat, and 39 g of carbohydrates. The addition of 8 g of kiwi extract adds 4.9 kcal of energy, a negligible amount of protein (0.1 g), 0.1 g of fat, and 0.9 g of carbohydrates. Furthermore, the inclusion of 32 g of egg white extract enhances the protein content, contributing 16 kcal of energy and 3.4 g of protein. In total, the P3 formula offers 280.9 kcal of energy, 13.5 g of protein, 7.1 g of fat,

and 40.2 g of carbohydrates per serving, making it a nutrient-dense option designed to meet the dietary requirements of patients with specific health needs

Table 5: Nutritional Density of Modified Formula.

Formula	Energy (kcal)	Energy (kcal/ml)
P1	281.8	1.13
P2	281.3	1.13
P3	280.9	1.12

The highest nutritional value in the enteral blenderized formula is found in formula P1, as it has a higher kiwi content compared to the others. This formula also has appropriate sodium and potassium levels that align with normal daily nutrient needs.

B. Viscosity Test

Table 6: Viscosity Test Results of Enteral Blenderized Formula

Formula	Viscosity (cP)
P0	2.06
P1	2.74
P2	3.63
P3	7.45

The highest viscosity is observed in formula P3, followed by P2, while P0 and P1 have lower viscosities. According to a study, the optimal viscosity range for enteral formulas is between 3.5 – 10 cP, which is satisfied by P2 and P3. The viscosity is influenced by the higher egg white extract content, which increases viscosity, while the kiwi extract contributes to its fiber content.

C. Organoleptic Test

Table 7: Organoleptic Evaluation of Enteral Blenderized Formula by Trained Panelists

Formula	Color	Aroma	Texture	Taste
P0	Pale White	Slightly Aromatic	Runny	Very Sweet
P1	Brownish	Aromatic	Runny	Sweet
P2	Pale White	Aromatic	Slightly Thick	Slightly Sweet
P3	Pale White	Slightly Aromatic	Slightly Thick	Slightly Sweet

Evaluation Notes:

- **Color:** P0 had the palest color, as it only contained Diabetasol milk. Formulas P1, P2, and P3 showed a brownish-white or pale white color due to the addition of kiwi and egg white extract.
- **Aroma:** The aroma of Diabetasol milk dominated the formula, masking other aromas.
- **Texture:** Different textures were noted, with P1 and P2 being slightly thicker than the others.
- **Taste:** The formulas were sweet due to the Diabetasol milk, with kiwi's sourness being less pronounced.

D. Acceptance Test

Table 8: Acceptance of Enteral Blenderized Formula by Trained Panelists

Formula	Color	Aroma	Texture	Taste	Overall
P0	85%	85%	90%	90%	87.5%
P1	70%	77.5%	82.5%	45%	68.75%
P2	82.5%	80%	82.5%	50%	73.75%
P3	80%	75%	80%	45%	70%

Results: Formula P2 received the highest acceptance from the trained panelists with a score of 73.75%, categorized as "liked," though it was not extremely favored due to its taste

4. DISCUSSION

The selection of kiwi fruit in this case is aimed at lowering blood pressure, because kiwi contains arginine. Arginine is converted into nitric oxide by Nitric Oxide Synthase (NOS). Nitric oxide acts as a vasodilator, reducing total peripheral resistance, which in turn lowers blood pressure and blood glucose

levels in the body (Intan, 2013). Meanwhile, egg white is used to increase albumin levels in the body. Ovalbumin is most abundant in egg whites. Chicken egg whites contain 10.5g of protein per 100g, 95% of which is albumin (9.83g), while 100g of duck egg whites contains 11g of protein (5.6g). Egg whites are an easily accessible and inexpensive food source with the highest biological value compared to other foods, making them very effective in helping to increase albumin and hemoglobin levels in the blood (Indonesian Food Composition Table, 2009).

According to a study by Itoh et al. (2016), the optimal viscosity of enteral (blenderized) formula ranges from 3.5 to 10 cP. Viscosity in enteral formulas is very important because it affects the smoothness with which the formula enters the feeding tube, influences the method of feeding, and determines the size of the tube used. Based on the standard of optimal viscosity for enteral formulas, it is known that the modified formulas P2 and P3 meet the optimal viscosity standards. Formula P2 and P3 use a ratio of P2 (30:70) and P3 (20:80), and the viscosity of these formulas is influenced by the higher addition of egg white extract compared to kiwi juice, making these the most ideal compositions to be used in blenderized enteral formulas according to their viscosity. Egg whites have thickening properties, while kiwi fruit contains fiber that can thicken and affect the viscosity.

Based on their properties and functions, the total dietary fiber in fruit is divided into two main groups: soluble and insoluble fiber (in water). Cellulose and hemicellulose are insoluble fibers that are rigid and play a role in forming the structure of the fruit. Pectin, on the other hand, is water-soluble and determines the viscosity of dietary fiber (Guevarra, 2000). Meanwhile, egg whites have both thick and thin consistencies, with the thicker egg white containing ovomucin (Agustina et al., 2013). Ovomucin plays a role in forming and stabilizing foam and has high viscosity (thick). Ovomucin is a protein that is insoluble in water. Additionally, according to Welty et al. (2004), one factor that affects viscosity is temperature—if the temperature of a liquid is reduced, its viscosity will increase. This explains the viscosity of the blenderized formula.

In formula P0, there is no kiwi juice content, only milk, resulting in a clear white and pale white color. In formulas P1, P2, and P3, the colors are brownish white and some are pale white. This is because the product contains kiwi juice and egg white, which when combined, can affect the color to become brownish-green. However, when mixed with milk, the color slightly fades. Kiwi (Actinidia deliciosa) is a type of berry that can be eaten from a woody climbing plant and belongs to the Actnidiaceae family. In fact, the Actinidia genus consists of many species, with about 75 species reported. However, only two main species have been commercially developed: A. deliciosa (Green Kiwi) and A. chinensis (Golden Kiwi) (Burdon & Lallu, 2011; Hu, Zhao, Li, & Shen, 2018). The main difference is that A. deliciosa (Green Kiwi) has bright green flesh, which is due to the presence of chlorophyll that remains intact during fruit maturation and ripening. Meanwhile, A. chinensis has golden yellow flesh, which is due to the loss of some or all of the chlorophyll, making this variety known as the golden kiwi (Padmanabhan & Paliyath, 2016; Ward & Courtney, 2013). Furthermore, the white color of egg whites and powdered milk affects the product's color, so when combined, they result in a final brownish-green color in the formula.

In a food product, aroma is one of the important factors in determining consumer acceptance of a product. The deliciousness of a food item is often determined by its aroma; people can usually assess whether a food is tasty or not based on the aroma it produces. The pleasant aroma that is produced is the result of the mixture of Diabetasol milk, kiwi fruit, and egg white, but the most dominant aroma comes from the Diabetasol milk. According to Bastian et al. (2013), the savory aroma of milk dominates over the aroma of the other ingredients. All treatments have a

relatively similar aroma, with the third treatment being the most savory, characteristic of milk. This is because the proportion of skim milk powder is the highest, which covers the aroma of the other ingredients. In the study by Bastian et al. (2013), the aroma and taste of tempeh flour could be masked by using 2.25 g of cocoa powder (9% of 25 g of tempeh flour formula). This is also why the aroma of Diabetasol milk can mask the fishy aroma of the egg white, resulting in an aroma that tends to be sweet, specially designed for people with diabetes.

Texture is a characteristic of a substance resulting from the combination of several physical properties, including size, shape, quantity, and the elements that form the material, which can be perceived by the sense of touch and taste. Food products are not only made and processed to enhance their nutritional value but also to achieve functional characteristics that suit the organoleptic preferences of consumers. Based on the research conducted, texture was assessed after the ingredients were dissolved. The results showed that trained panelists evaluated the texture or thickness of each formula differently. The thin texture produced was influenced by the kiwi fruit juice and egg white extract being filtered twice, both before and after mixing, resulting in a thinner texture. Buckle et al. (1987) stated that coagulation is the most characteristic property of milk. Coagulation can be caused by enzymatic activity or the addition of acid. Proteolytic enzymes produced by bacteria can cause milk to coagulate. This enzymatic action usually occurs in three stages: absorption of the enzyme into the casein particles, followed by changes in the state of the casein particles as a result of the enzyme's activity, and finally, the precipitation of the altered casein as calcium salts or complex salts. Calcium ions in milk are required for the precipitation process. If deviations occur, the milk may become too liquid or even too thick, depending on the amount of water added.

Taste is the sensation formed from the combination of the ingredients and their composition in a food or beverage product, which is detected by the sense of taste. Taste is the most important factor in the final decision of whether a product is accepted or not. Even if the color, aroma, and texture are good, if the taste is unpleasant, consumers will reject the product. The taste produced in the formula of kiwi juice and egg white extract in Diabetasol milk, according to the panelists, tends to be sweet and very sweet. This is because the sweetness of the Diabetasol milk is more dominant than the sourness from the kiwi juice. The contents of fresh fruit are released into the liquid, giving a fruit taste and aroma sensation (Muzaifa et al., 2018). People prefer to consume green kiwi fruit, even though it has a slightly sour taste compared to yellow kiwi, because it is cheaper and more easily available (Mulyani, 2017). In the process of making egg white extract, egg coagulation during heating, foam formation ability, and emulsifying ability play a role. In addition, the ability of the egg to color and flavor food products is also important (Koswara, 2009).

5. CONCLUSION & SUGGESTIONS

Based on the results of the development of this formula, it can be concluded that in terms of nutrient density, it meets the requirements of an enteral formula. The viscosity test results show that the modified formula that fits the standard of the optimal viscosity for enteral formulas is formula P2 and P3. The organoleptic test results indicate that formulas P1, P2, and P3 have a brownish white color, with some appearing pale white. Formula P2 has a fragrant aroma, formula P3 has a slightly thick texture, and formulas P1 and P3 have a sweet and slightly sweet taste. The acceptance test results show that the overall average rating most favored was formula P2, so P2 was chosen as the best formula among the others.

From the research results conducted, in terms of color, aroma, texture, and taste, this modified enteral blenderized formula of Diabetasol milk with the addition of kiwi juice and egg white extract needs further development to achieve better results that are more easily accepted in terms of health. To achieve these results, one of the factors to consider is the addition of kiwi juice composition to reduce hypertension and egg white extract if the aim is to increase albumin levels in the body. Additionally, a processing technique such as drying can be applied to produce instant milk powder, which would make it easier for consumers to consume this enteral milk.

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