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Chiemela Enyinnaya Chinma
Federal University of Technology Minna

Babatunde Sunday Ogunsina
Obafemi Awolowo University

Olawunmi Oloyede
University College Cork

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EFFECT OF ADDITION OF GERMINATED *MORINGA* SEED FLOUR ON THE QUALITY ATTRIBUTES OF WHEAT-BASED CAKE

C.E. CHINMA[1,3], K.B. GBADAMOSI[1], B.S. OGUNSINA[2], O.O. OLOYEDE[1] and S.O. SALAMI[1]

[1]Department of Food Science and Nutrition, Federal University of Technology Minna, P.M.B. 65, Minna, Niger State, Nigeria
[2]Department of Agricultural and Environmental Engineering, Obafemi Awolowo University, Ile Ife, Osun State, Nigeria

[3]Corresponding author.
TEL: +2348063661494;
FAX: +23466221101;
EMAIL: chinmachiemela@yahoo.com

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ABSTRACT

The effects of substituting germinated *Moringa* seed flour for wheat flour on the rheological properties of flour blends and cake quality were investigated. Wheat and germinated *Moringa* seed flour were blended at different proportions. Pasting properties of wheat flour were influenced by germinated *Moringa* seed flour substitution. Substitution of the germinated *Moringa* flours for wheat flour increased protein, crude fiber, iron, calcium and zinc contents of cakes from 13.14 to 23.10%, 0.71 to 2.52%, 2.95 to 7.88 mg/100 g, 48.29 to 54.56 mg/100 g and 0.86 to 1.44 mg/100 g, respectively, while carbohydrate content decreased from 65.40 to 51.08%. Physical properties of cakes were influenced by substitution of germinated *Moringa* seed flour for wheat. There was no significant ($P \geq 0.05$) difference in crust and crumb color, aroma and texture between 100% wheat cake and composite cakes. The taste and overall acceptability of composite cakes up to 30% germinated *Moringa* seed flour substitution were not significantly ($P \geq 0.05$) different from the whole wheat flour cake.

PRACTICAL APPLICATIONS

This study provided some basic information required for production of wheat-germinated *Moringa* seed-based cake. Considering the high protein and mineral contents of *Moringa* seeds and its lower carbohydrate content compared with wheat, this food product will be beneficial to the nutrition of vulnerable groups.

INTRODUCTION

Moringa oleifera is an important traditional vegetable tree that grows in the tropics (Ogunsina *et al.* 2010). In Nigeria, *Moringa* is largely grown in the northern part of the country. *Moringa* seed is rich in protein (36.18%) with good balance of essential amino acids, vitamins (such as provitamin A, B and C) and minerals (particularly iron calcium, potassium, manganese, zinc and copper; Foidl *et al.* 2001; Gopalan *et al.* 2007; Ogunsina *et al.* 2010). *Moringa* flour has high antioxidant (99.74%), phenolic (145.16 mg/100 g) (Compaoré *et al.* 2011) and flavonoid (144.07 mg/100 g) contents. Phenolics act as antioxidant, anti-cancer and anti-diabetic agents (Sroka and Cisowski 2003; Fiuza *et al.* 2004; Kanadaswami *et al.* 2005). Flavonoids are also known to exhibit health beneficial properties on various chronic diseases (Kanadaswami *et al.* 2005).

Due to the high demand for functional foods, *Moringa* seed has gained wide recognition due to its health benefits. This partly stimulated our previous research (Chinma *et al.* 2013) to improve the functionality of *Moringa* flour through germination process in order to increase its potential as a functional material in food systems. The results indicated that germinated *Moringa* flour has improved chemical, functional and pasting properties with reduced bitter taste and astringency, and could find useful applications in soft textured-baked products. This forms the main thrust of this research on the effect of germinated *Moringa* flour on wheat-based cake.

Several flour samples, such as African yam bean, banana, chickpea, tigernut and lentil, have been incorporated into wheat flour (WF) for cake preparation, with the purpose of improving the amino acid balance, combating the world protein calorie malnutrition problem and micronutrient deficiency, sensory property and reducing total dependence on imported WF (Gómez *et al.* 2008; Alozie *et al.* 2009; Eke *et al.* 2009; Chinma *et al.* 2010; Dela Hera *et al.* 2012). To the best of our knowledge, there is virtually no research documentation on the effect of germinated *Moringa* seed flour addition on wheat-based cakes. This study could be an avenue for delivery of functional ingredients present in germinated *Moringa* flour while complementing the essential nutrients in wheat cake with reduction in total dependence on imported WF. The objective of the study was to investigate the effect of substitution of germinated *Moringa* seed flour on the quality attributes of wheat-based cakes.

MATERIALS AND METHODS

Source of Raw Materials

Moringa seeds, WF (Golden Penny, Flour Mills of Nigeria Plc) and cake ingredients (granulated sugar, margarine, egg and baking powder) were purchased from Minna, Central market, Minna, Nigeria.

Preparation of *Moringa* Seed

The method of Chinma *et al.* (2009) was adopted for the germination of *Moringa* seed. *Moringa* seeds was separately sorted, cleaned and washed with cold tap water. The seeds were soaked in cold tap water for 12 h (water used for soaking the seeds were changed every 2 h to prevent fermentation) at room temperature (32 ± 2C). After soaking, the seeds were drained and spread on a clean jute bag and also covered with a damp cotton cloth and left for 72 h to germinate. The germination period was chosen based on the results of earlier studies (Chinma *et al.* 2013). Water was sprinkled at 12-h interval to facilitate the germination process. At the end of germination, root hairs were manually removed from the germinated seeds. Germinated *Moringa* seeds were dried at 60C in an air-dry oven (Gallenkamp 300 plus series, Widnes, Cheshire, U.K.) followed by grinding using a disc attrition mill (Globe P44, Diamond Tools Co. Ltd., Henan, China) that passed through a 0.45-mm mesh size sieve. The germinated *Moring*a seed flour (GMSF) were packed in a vacuum bag and stored in a plastic container with lid and then stored in a refrigerator from where samples were taken for analysis.

Formulation of Blends

WF and GMSF were blended at ratios of 100:0%, 90:10%, 80:20%, 70:30% and 60:40%, respectively, with 100% WF as the standard. A Kenwood mixer was used for mixing samples at speed 6 for 5 min to achieve uniform blending.

Proportion of Ingredients

The proportion of ingredients used consists of flour (100 g), sugar (62.5 g), margarine (62.5 g), (47.9 g), baking powder (5.7 g) and vanilla essence (three drops), as described by Akubor (2004).

Preparation of Cake

The method of Akubor (2004) was adopted for the preparation of cakes. The margarine and sugar were creamed manually for 5 min in a bowl until soft and fluffy. The egg was beaten for 3 min, added to the mixture and mixed manually for 5 min. Flour samples from various composite blends were separately sieved, and baking powder was then added and mixed lightly by hand until soft dough was formed. The dough was transferred to a greased baking pan and baked in a preheated oven at 200C for 30 min.

Chemical Analysis

The moisture, protein, crude fiber, fat, ash, carbohydrate, energy and mineral (such as iron, calcium and zinc) contents of flour samples and cake were determined as described by AOAC (2000).

Determination of Pasting Properties

Pasting parameters were determined using rapid visco analyzer (RVA; Newport Scientific Pty Ltd., Warrie-wood NSW, Australia). Two and a half grams of flour samples were weighed into a dried empty canister and then 25 mL of distilled water was dispensed into the canister containing the sample. The suspension was thoroughly mixed and the canister was fitted into the rapid visco analyzer. Each suspension was kept at 50C for 1 min and then heated up to 95C at 12.2C/min and held for 2.5 min at 95C. It was then cooled to 50C at 11.8C/min and kept for 2 min at 50C.

Determination of Physical Properties of Cake

Batter density was determined with a measuring cylinder and expressed as the relation between the weight of batter and the same volume of distilled water. Volume of cake was determined by seed displacement method, as described by AACC (2000). Volume index of cake samples was measured according to AACC (2000). In this method, cake is cut vertically through the center and the heights of the cake sample were measured at three different points (*B*, *C* and *D*) along the cross-sectioned cakes using the template. According to this method, volume index was determined by the following formula:

Volume index = $B + C + D$, where C is the height of the cake at the center point, while B and D are the heights of the cake at the points 2.5 cm away from the center toward the left and right sides of the cake, respectively. Weight of cake was determined using the electronic digital balance.

Determination of Sensory Properties

A semi-trained 20-membered panel consisting of students and members of Food Science Option, Department of Animal Production Federal University of Technology, Minna, Nigeria, was selected for sensory evaluation. Cake samples prepared from each flour blend were presented in coded form in white plastic plates. The order of presentation of samples to the panel was randomized. Tap water was provided to rinse the mouth between evaluations. The panelists were instructed to evaluate the coded samples for appearance, crust color, crumb grain, texture, aroma and overall acceptability. Each sensory attribute was rated on a 9-point hedonic scale (1 = disliked extremely, while 9 = liked extremely).

Statistical Analysis

Data were analyzed by analysis of variance (Steel and Torrie 1980). The difference between mean values was determined by least significant difference test. Significance was accepted at 5% probability level.

RESULTS AND DISCUSSION

Chemical Composition of Wheat and Germinated *Moringa* Flour

The chemical composition of wheat and germinated *Moringa* flour is shown in Table 1. Germinated *Moringa* flour had higher moisture, protein, fat, ash, crude fiber, iron, calcium and zinc contents than WF, while WF had higher carbohydrate content. The high protein, fat, ash, crude fiber, iron, calcium and zinc contents of germinated *Moringa* flour than WF could be attributed to higher amount of these chemical components in legumes than cereals. This implies that substitution of germinated *Moringa* flour for WF will enhance the nutritional qualities of their blends.

TABLE 1. CHEMICAL COMPOSITION OF WHEAT AND GERMINATED *MORINGA* FLOUR

Composition	Wheat	Germinated *Moringa*
Moisture (%)	9.41 ± 0.39	10.03 ± 0.05
Ash (%)	0.54 ± 0.06	4.11 ± 0.17
Protein (%)	10.68 ± 0.25	38.29 ± 0.81
Fat (%)	1.13 ± 0.07	6.87 ± 0.42
Crude fiber (%)	0.69 ± 0.04	3.16 ± 0.15
Carbohydrate (%)	77.55 ± 0.81	37.54 ± 0.36
Iron (mg/100 g)	1.95 ± 0.03	3.02 ± 0.11
Calcium (mg/100 g)	38.29 ± 0.51	175.45 ± 0.63
Zinc (mg/100 g)	0.17 ± 0.02	1.78 ± 0.05

Mean value and standard deviation of two determinations.

Pasting Properties of Flour Blends

The pasting properties of wheat and germinated *Moringa* flour blends are presented in Table 2.

Substitution of germinated *Moringa* flour to WF decreased the peak viscosity, trough, breakdown, and final and setback viscosity of WF. The decrease in these RVA parameters could be ascribed to amylase activity in germinated *Moringa* flour. The α-amylase is an endo-acting enzyme that can break the interior of starch molecule, and a small amount of this enzyme can cause drastic reduction in the viscosity of the flour (Mares and Mrva 2008). Hallen *et al.* (2004) reported higher α-amylase activity in WF partially substituted with germinated cowpea flour (5–20%) than WF. Also, the decrease in the pasting parameters could

TABLE 2. PASTING PROPERTIES OF WHEAT AND GERMINATED *MORINGA* FLOUR BLENDS

Parameters	100WF	100GM	90WF : 10GM	80WF : 20GM	70WF : 30GM	60WF : 40GM
Peak viscosity (RVU)	132.74 ± 0.59[a]	81.36 ± 0.21[f]	125.67 ± 0.88[b]	120.92 ± 0.16[c]	117.42 ± 0.77[d]	112.87 ± 0.32[e]
Trough (RVU)	80.14 ± 0.66[a]	54.29 ± 0.35[f]	80.48 ± 0.56[b]	76.59 ± 0.93[c]	75.56 ± 0.19[d]	73.16 ± 0.51[e]
Breakdown (RVU)	52.60 ± 0.17[a]	27.07 ± 0.29[d]	45.19 ± 0.70[a]	44.33 ± 0.21[d]	41.86 ± 0.92[c]	39.71 ± 0.30[a]
Final viscosity (RVU)	157.92 ± 0.81[a]	95.14 ± 0.73[f]	151.54 ± 0.28[b]	145.99 ± 0.46[c]	139.52 ± 0.19[d]	135.04 ± 0.23[e]
Setback (RVU)	77.78 ± 0.15[a]	40.85 ± 0.13[f]	71.06 ± 0.64[b]	69.40 ± 0.68[c]	63.95 ± 0.26[d]	61.88 ± 0.45[e]
Peak time (min)	5.01 ± 0.01[a]	5.07 ± 0.05[a]	5.10 ± 0.03[a]	5.14 ± 0.11[a]	5.22 ± 0.03[a]	5.27 ± 0.19[a]
Pasting temperature (C)	67.82 ± 0.43[f]	66.95 ± 0.68[e]	73.23 ± 0.34[d]	75.49 ± 0.20[c]	75.81 ± 0.44[b]	77.15 ± 0.42[a]

Values in the same row followed by different superscripts are significantly ($P \leq 0.05$) different from each other.
100WF = 100% wheat flour; 90WF : 10GM = 90% wheat flour : 10% germinated *Moringa* flour; 80WF : 20GM = 80% wheat flour : 20% germinated *Moringa* flour; 70WF : 30GM = 70% wheat flour : 30% germinated *Moringa* flour; 60WF : 40GM = 60% wheat flour : 40% germinated *Moringa* flour.
RVU, rapid visco unit.

TABLE 3. CHEMICAL COMPOSITION OF CAKES PREPARED FROM WHEAT AND GERMINATED *MORINGA* FLOUR BLENDS

Parameter	100WF	90WF : 10GM	80WF : 20GM	70WF : 30GM	60WF : 40GM
Moisture (%)	13.09 ± 0.51^{b}	13.47 ± 0.46^{b}	13.84 ± 0.23^{ab}	14.16 ± 0.33^{a}	14.52 ± 0.61^{a}
Protein (%)	13.14 ± 0.23^{e}	15.75 ± 0.17^{d}	18.42 ± 0.11^{c}	20.89 ± 0.46^{b}	23.10 ± 0.48^{a}
Fat (%)	5.06 ± 0.05^{d}	6.20 ± 0.08^{c}	6.61 ± 0.19^{b}	7.04 ± 0.66^{b}	7.96 ± 0.13^{a}
Crude fiber (%)	0.71 ± 0.14^{c}	$1.25 + 0.01^{bc}$	1.83 ± 0.05^{ab}	2.06 ± 0.14^{a}	2.52 ± 0.39^{a}
Ash (%)	1.60 ± 0.01^{c}	1.93 ± 0.01^{bc}	2.19 ± 0.10^{b}	2.42 ± 0.05^{a}	2.98 ± 0.04^{a}
Carbohydrate (%)	65.40 ± 0.97^{a}	61.40 ± 0.03^{b}	57.11 ± 0.84^{c}	53.43 ± 0.27^{d}	51.08 ± 0.86^{e}
Iron (mg/100 g)	2.95 ± 0.04^{e}	3.61 ± 0.19^{d}	4.79 ± 0.66^{c}	6.03 ± 0.11^{b}	7.88 ± 0.20^{a}
Calcium (mg/100 g)	48.29 ± 0.13^{e}	50.20 ± 0.43^{d}	51.06 ± 0.59^{c}	53.18 ± 0.83^{b}	54.06 ± 0.97^{a}
Zinc (mg/100 g)	0.86 ± 0.09^{b}	$0.94 + 0.17^{b}$	1.15 ± 0.03^{ab}	1.29 ± 0.51^{a}	1.44 ± 0.28^{a}

Values in the same row followed by different superscripts are significantly ($P \leq 0.05$) different from each other.
100WF = 100% wheat flour; 90WF : 10GM = 90% wheat flour : 10% germinated *Moringa* flour; 80WF : 20GM = 80% wheat flour : 20% germinated *Moringa* flour; 70WF : 30GM = 70% wheat flour : 30% germinated *Moringa* flour; 60WF : 40GM = 60% wheat flour : 40% germinated *Moringa* flour.

be due to the decrease in the available starch for gelatinization. According to Gómez *et al.* (2008), substitution of chickpea flour in wheat decreased the peak viscosity, break down and setback due to its decreased carbohydrate content and different protein contents affecting the viscosity parameters.

The high pasting temperatures of composite blends than WF could be attributed to high water absorption capacity caused by the addition of germinated *Moringa* flour. Pasting temperature has been reported to be related to water-binding capacity (Adebowale *et al.* 2005). The pasting results obtained in this study is not in agreement with those of Chinma *et al.* (2013) and Charoenthaikij *et al.* (2010) for germinated *Moringa* flour and wheat-germinated brown rice flour, respectively.

Chemical Composition of Cakes

The chemical composition of cakes prepared from wheat and germinated *Moringa* flour blends are presented in Table 3. The addition of germinated *Moringa* flours to wheat increased the moisture, protein, fat, crude fiber, ash, iron, calcium and zinc contents from 13.09 to 14.52%, 13.14 to 23.10%, 5.06 to 7.96%, 0.71 to 2.52%, 1.60 to 2.98%, 2.95 to 7.88 mg/100 g, 48.29 to 54.56 mg/100 g and 0.86 to 1.44 mg/100 g, respectively, while carbohydrate content decreased from 65.40 to 51.08%. The increased protein, fat, crude fiber, ash, iron, calcium and zinc contents in composite cakes than 100% wheat cake could be attributed to the substitution effect caused by germinated *Moringa* flour. The high chemical composition of the composite cakes could be an indication that the prepared composite cakes are more nutritious than the 100% wheat cake. However, moisture, ash and protein contents of cake samples obtained in this study were comparable to the values of 14.40–15.60% (moisture) and 1.79–2.50% (ash) reported by Alozie *et al.* (2009) as well as 19.00–30.50% (protein) by Akubor (2004).

Physical Properties of Cakes

The physical properties of cake prepared from wheat and germinated *Moringa* flour blends are presented in Table 4. Batter density, cake weight, cake volume and volume index of cakes decreased from 0.79 to 0.67, 35.81 to 33.10 g, 244.85 to 241.76 cm^3 due to the addition of germinated *Moringa* flour to wheat. Although batter density, cake weight and volume decreased with an increase in germinated *Moringa* level in the blends, such decrease was not significant ($P \geq 0.05$) up to 20% level of germinated *Moringa* substitution in the blends. The decrease in batter density

TABLE 4. PHYSICAL PROPERTIES OF CAKE PREPARE FROM WHEAT AND GERMINATED *MORINGA* FLOUR BLENDS

Parameters	100WF	90WF : 10GM	80WF : 20GM	70WF : 30GM	60WF : 40GM
Batter density	0.79 ± 0.01^{a}	0.75 ± 0.03^{a}	0.73 ± 0.01^{a}	0.70 ± 0.01^{a}	0.67 ± 0.01^{a}
Cake weight (g)	35.81 ± 0.07^{a}	35.54 ± 0.10^{a}	34.90 ± 0.13^{ab}	33.77 ± 0.25^{b}	33.10 ± 0.06^{c}
Volume (cm^3)	244.85 ± 1.27^{a}	244.70 ± 0.91^{a}	244.05 ± 0.87^{a}	243.24 ± 1.14^{b}	241.76 ± 0.17^{c}
Volume index	101.43 ± 0.14^{a}	99.72 ± 0.14^{b}	94.11 ± 0.14^{c}	90.86 ± 0.51^{d}	86.50 ± 0.05^{e}

Values in the same row followed by different superscripts are significantly ($P \leq 0.05$) different from each other.
100WF = 100% wheat flour; 90WF : 10GM = 90% wheat flour : 10% germinated *Moringa* flour; 80WF : 20GM = 80% wheat flour : 20% germinated *Moringa* flour; 70WF : 30GM = 70% wheat flour : 30% germinated *Moringa* flour; 60WF : 40GM = 60% wheat flour : 40% germinated *Moringa* flour.

TABLE 5. SENSORY PROPERTIES OF CAKE PREPARED FROM WHEAT AND GERMINATED *MORINGA* FLOUR BLENDS

Flour blends (wheat : *Moringa*)	100WF	90WF : 10GM	80WF : 20GM	70WF : 30GM	60WF : 40GF
Crust color	7.1[a]	7.1[a]	7.0[a]	6.9[a]	6.8[a]
Crumb color	7.6[a]	7.6[a]	7.5[a]	7.5[a]	7.0[a]
Crumb grain	7.0[a]	6.8[a]	6.9[a]	6.8[a]	6.5[a]
Texture	7.0[a]	7.1[a]	7.2[a]	7.2[a]	7.1[a]
Taste	8.1[a]	7.7[a]	7.7[a]	7.5[a]	6.4[b]
Aroma	8.1[a]	8.1[a]	8.0[a]	8.0[a]	7.7[a]
Overall acceptability	8.5[a]	8.2[a]	8.0[a]	7.9[a]	7.0[b]

Values in the same row followed by different superscripts are significantly ($P \leq 0.05$) different from each other.

100WF = 100% wheat flour; 90WF : 10GM = 90% wheat flour : 10% germinated *Moringa* flour; 80WF : 20GM = 80% wheat flour : 20% germinated *Moringa* flour; 70WF : 30GM = 70% wheat flour : 30% germinated *Moringa* flour; 60WF : 40GM = 60% wheat flour : 40% germinated *Moringa* flour.

could be ascribed to the increase in the level of *Moringa oleifera* flour, which decreased air incorporation in batter due to reduced gluten content in wheat. Also, the decrease in batter density could be attributed to reduced starch content. This is in line with the reports of Gómez *et al.* (2008) and De La Hera *et al.* (2012) for wheat-chickpea cake and wheat-lentil cake, respectively.

The decrease in batter density due to substitution of germinated *Moringa* flour could be responsible for the reduction in cake volume. Reduced volume and volume index of wheat-germinated *Moringa* cakes than 100% wheat cake could be attributed to reduced peak viscosity of the flour blends. High peak viscosity in composite blends could be responsible for high gas retention and high expansion of the product, resulting to an increase in cake volume (Chinma *et al.* 2010). However, there are other factors that influence final volume, such as gas loss during processing, starch gelatinization and possible collapse of the structure after baking (De La Hera *et al.* 2012).

The decrease in weight of cakes with increasing the level of germinated *Moringa* flour in WF could be attributed to the reduction in bulk density. The increase in weight of wheat-tigernut cakes has been attributed to low batter density or increased bulk density of flour blends because of the high bulk density of tigernut flour in wheat-based cake (Chinma *et al.* 2010). However, the result of the physical properties of cakes obtained in this study is in close agreement with the results of Chinma *et al.* (2010) for wheat-tigernut cake.

Sensory Properties of Cakes

There was no significant ($P \geq 0.05$) difference in crust and crumb colors between composite cakes and 100% wheat cake (Table 5). Also, there were no significant ($P \geq 0.05$) differences in taste and overall acceptability between 100% wheat cake and composite cakes up to 30% germinated *Moringa* flour addition.

The slight reduction in crumb grain scores as a result of the addition of germinated *Moringa* flour in wheat cake could be attributed to variations in particle size.

The texture of composite cakes was softer than 100% wheat cake and could be attributed to reduced viscosity/amylose content. According to De La Guerivier (1976), amylose provides surface and textural regularity, elasticity and sticky characteristics to starch-based products.

Aroma of food products is associated with the interaction of flavor compounds present when foods are subjected to high temperature. The decrease in aroma of composite cakes with increasing level of germinated *Moringa* flour could be attributed to high bioactive compounds in *Moringa* than wheat. This trend of result also reflected in the taste attribute of composite cakes.

Taste of wheat cakes decreased slightly with a increase in the addition of germinated *Moringa* flour in the blends. However, the bitter and astringent taste became pronounced at 40% substitution level. This was evident by the reduction in taste score at 40% substitution level. Overall acceptability of cake samples was judged by panelist based on other evaluated sensory parameters. However, up to 30% germinated *Moringa* substitution level compared favorably with 100% wheat cake.

CONCLUSIONS

Substitution of germinated *Moringa* flour in WF improved the desirable pasting properties required in cake preparation and the chemical composition of wheat-based cakes. The physical properties of wheat-based cakes, such as batter density, weight, volume and volume index, decreased with an increase in germinated *Moringa* flour level. Wheat-germinated *Moringa* cake was acceptable up to 30%

germinated *Moringa* flour substitution. This study provided basic information required for the production of wheat-germinated *Moringa* cake. Future studies should consider the glycemic index of the prepared cakes as a functional food.

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