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# Effects of Fermented Maize Residue on the Physicochemical and Nutritional Properties of Cookies

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author OF designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors KKDB and AM managed the analyses of the study. Author AM managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

Fermented maize residue, a by-product of the production of fermented starch, a local weaning food and breakfast cereal for adults in Nigeria and West Africa was dried, milled into flour and utilized as a fibre source in cookies production at 0 – 30% levels of substitution. The effects of the addition of the fermented maize residue on the physical, sensory and nutritional properties on the cookie sample were investigated. Results showed spread ratio values decreased with residue flour addition, ash content and protein content and carbohydrate also showed a decrease. The crude fibre content increased with levels of replacement. The result of sensory evaluation showed equal preference among the samples. Invitro-protein digestibility showed a decrease with fermented maize residue addition. Addition of fermented maize residue to cookie production can be a viable way of utilizing the fibre rich fermented maize residue

*Keywords: Fermented maize residue; digestibility.*

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## 1. INTRODUCTION

Cookies also referred to as biscuits in some countries are convenient food items, baked flour confectionery dried down to low moisture content. Cookies contain the same ingredients as cakes except that the amount of liquid is low with a higher amount of sugar and fat to flour [1]. Calories in cookies come from basic ingredient such as refined flour, sugar and butter or oil [2]. Cookies can be prepared in a Myriad of shapes, flavours and textures [1]. A variety of fibres from plant sources have been used in cookies to improve the texture, colour and aroma with a reduced energy of the final product. These fibre sources which include lemon and apple fibre are reported to have high water holding capacity and their use in cakes, breads and other cereal products had improved the softness and product yield with a reduced energy value of the product [3].

Fermented maize residue is a by-product of the production of fermented starch. It is the residue generated after the starch is recovered through a sieving process. It is the pomace (residue) retained on the sieve which is most often air dried as an animal feed stuff ingredient or discarded into the environment with its attendant waste disposal consequence.

Large number of food processing by-products such Hulls, Husks and Brans possess a large potential for use as a source of insoluble Dietary fibre [4]. Chickpea husk containing 32.20 – 46.60% crude fibre has been used to enrich cracker biscuit [5]. Brans have also been used to replace flour in preparation of cookies [6].

A large number of studies have been reported on the physiological actions of fibre addition in foods such as maintenance of gastrointestinal health, reduction of intestine transit time, protection against colon cancer lowering of total and low density lipo-protin cholesterol, reduction of post-prandial blood glucose levels, increase of calcium bioavailability and reinforcement of the immune system [7].

There is presently a preference for food products which contain bioactive compounds that provides additional benefits beyond basic nutrition. Different plant products traditionally from cereals such as wheat, corn and oats have been added to various baked food products to increase their fibre content [8]. Fermented maize residue which is a cheap source of fibre is predominantly consigned to the refuse dump, could find useful application in the baked food product industry because of its fibre content and also been a by-product of a fermentation process can find utilization in cookie production. And as a result, its effects on the physico-chemical sensory and nutritional properties of cookies needs to be scientifically investigated.

## 2. MATERIALS AND METHODS

### 2.1 Production of Fermented Maize Residue

The procedure for fermented starch (Ogi) production was employed. One kg of maize was cleaned to remove dirts and soaked in 4000ml of water for 2 days. The soaked seeds were milled using a grinding mill, sieved and the filtrate allowed to stand for 2 hours. The top water was decanted and the sediment (slurry) bagged to allow more water to drain out. The resultant wet cake was fermented starch.

The residue after sieving were dried at 500C for 12hour, milled using the dry mill component of a blender and packed in container until ready for use.

### 2.2 Preparation of Composite Blends

The wheat flour and fermented residue flour were weighed in portions and mixed together using a milling machine (Cylotec 1093, UK) as shown in Table 1.

### 2.3 Cookie Formulation and Preparation

Flour blends and wheat flour as control was prepared by gradual mixing using milling machine (Cylotec 1093, UK). A modified sugar cookie recipe and procedure described by Mc – waters et al. (2003) as reported by Giami et al. [9] was used for cookies preparation as shown in Table 2.

The dry ingredients (flour, sugar, salt and baking powder) were thoroughly mixed in a bowl by hand for 3 – 5 minutes. Vegetable shortening was added and was further mixed to ensure uniformity with a resultant slightly firm dough. The dough was manually rolled on a pastry board into sheets of uniform thickness (0.4cm), cut into circular shapes of 5.8cm diameter using a cookie cutter. The cut dough pieces were transferred into oil-greased pans and baked at 1800C for 10 minutes. They were brought out from the oven, allowed to cool and packed for analyses.

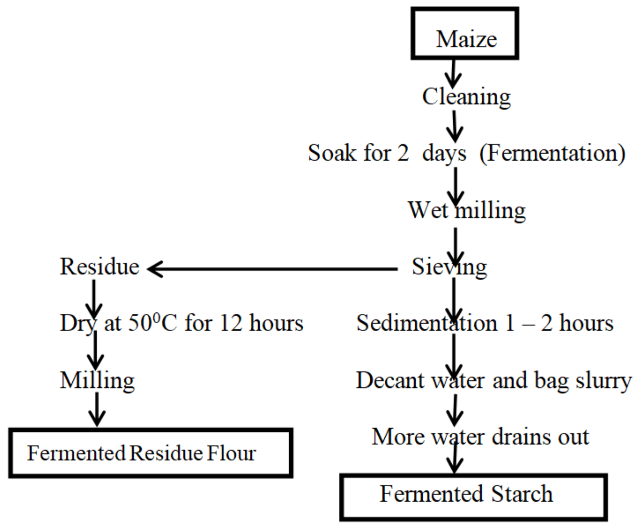


**Fig. 1. Flow diagram for fermented maize residue**

**Table 1. Flour Composition Blend for Cookie**

| Sample | Component A (Wheat Flour) | Component B (Residue Flour) |
|---|---|---|
| WF | 100 | - |
| WFRA | 95 | 5 |
| WFRB | 90 | 10 |
| WFRC | 85 | 15 |
| WFRD | 80 | 20 |
| WFRE | 75 | 25 |
| WFRF | 70 | 30 |

*Key: WF =Wheat flour 100%; WFRA=Wheat flour + Residue at 5% substitution; WFRB=Wheat flour + Residue at 10% substitution; WFRC=Wheat flour + Residue at 15% substitution; WFRD=Wheat flour + Residue at 20% substitution; WFRE=Wheat flour + Residue at 25% substitution; WFRF= Wheat flour + Residue at 30% substitution*

**Table 2. Recipe for Cookies Production**

| | Flour Proportion | | | | | | |
|---|---|---|---|---|---|---|---|
| **Ingredients** | **WF** | **WFRA** | **WFRB** | **WFRC** | **WFRD** | **WFRE** | **WFRF** |
| Wheat flour (%) | 100 | 95 | 90 | 85 | 80 | 75 | 70 |
| Fermented Residue (%) | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| Sugar (g) | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 |
| Shortening (g) | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| Egg (g) | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| Baking powder (g) | 3.75 | 3.75 | 3.75 | 3.75 | 3.75 | 3.75 | 3.75 |
| Milk (g) | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |

*Source: Giami et al. [9]*
*WF: Wheat flour; WFR: Wheat flour + Residue (A, B, C, D, E, F)*

## 2.4 Determination of Physical Properties

The weight (g), height (cm) diameter (cm) of the cookies were taken. The spread ratio was calculated using the formula below:

Spread ratio = (Diameter (cm))/(Height (cm))

## 2.5 Sensory Evaluation

The cookies were evaluated for the attributes of texture, colour, aroma and taste using a five-point hedonic scale where I was designated very poor, 2 was fair, 3 was good, 4 very good and 5 designated excellent.

## 2.6 Proximate Composition

Proximate compositions were determined according to the methods of the Association of Official Analytical Chemist [10].

## 2.7 Invitro-Protein Digestibility (IVPD)

IVPD was carried out according to the method described by Manjula and John [11] with a minor modification. A known weight of the sample containing 16mg nitrogen was taken in triplicate and digested with 1mg pepsin (Cat no P6887, sigma chemicals Ltd USA) in 15ml of 0.1N HCl at 370C for 2 hrs in an incubator (DHP – 9053A), Haris England). The reaction was stopped by the addition of 15ml 10% trichloroacetic acid (TCA). The mixture was then filtered quantitatively, through Whatman No. 1 filter paper. The TCA soluble fraction was assayed for nitrogen using the micro-kjeldahl method (AOAC, 2000). Digestibility was estimated by using the following equation:

IVPD(%)=(N in Supernatant-Enzyme N)/(N in sample)x100

## 2.8 Statistical Analysis

The experimental design was Complete Randomized Design (CRD). The statistical analysis was carried out using SPSS version 14 and the mean values and standard deviation of the replicate were calculated. Data obtained were analyzed using analysis of variance (ANOVA) to separate means.

# 3. RESULT

## 3.1 Physical Properties

Table 3 showed result of physical properties of cookies from wheat-fermented white maize residue composite flour. The weight (g) ranged from 10.05 in A1 FWR to 10.93 in A2 FWR, Height (cm) ranged from 0.68 in A5 FWR to 0.73 in A6 FWR, Diameter (cm) ranged from 4.60 in A4 FWR to 4.83 in AAA, while spread ratio ranged from 6.36 in A4 FWR to 6.90 in AAA.

## 3.2 Sensory Evaluation

Table 4 showed mean sensory scores of cookies produced from wheat fermented white maize residue composite flour, score for colour ranged from 3.09 in A5 FWR to 3.78 in A3 FWR, Texture ranged from 3.04 in sample A1 FWR and A5 to 3.65 in AAA and A3 FWR, Aroma ranged from 3.17 in A5 FWR to 3.48 in AAA, Taste ranged from 3.26 in A6 FWR to 3.65 in A1 FWR while overall acceptability ranged from 3.18 in A5 FWR to 3.59 in A3 FWR.

Table 5 showed proximate composition results of cookies. The moisture content (%) ranged from 6.03 in AAA to 8.35 in A4 FWR, Ash (%) ranged from 1.54 in A2 FWR to 2.11 in AAA, Fat (%) ranged from 18.44 in A4 FWR to 22.02 in A6 FWR, Crude protein ranged from 8.14 in A5 FWR to 9.21 in AAA, Crude fibre (%) ranged from 2.11 in AAA to 5.27 in A6 FWR, while carbohydrate (%) ranged from 55.02 in A6 FWR to 60.84 in AAA.

## 3.4 Invitro-Protein Digestibility

Table 6 showed result of invitro protein digestibility of cookies The IVPD ranged from 39.38 in A6FWR to 61.27% in control sample (AAA).

**Table 3. Physical Properties of Cookies from Wheat and Fermented White Maize Residue Flour**

| Sample** | Weight (g) | Height (cm) | Diameter (cm) | Spread Ratio |
|---|---|---|---|---|
| AAA | $10.17^{ab}\pm0.82$ | $0.70^{a}\pm0.28$ | $4.83^{a}\pm0.02$ | $6.90^{a}\pm0.07$ |
| $A_1$FWR | $10.05^{ab}\pm0.84$ | $0.70^{a}\pm0.00$ | $4.77^{ab}\pm0.00$ | $6.82^{a}\pm0.07$ |
| $A_2$FWR | $10.29^{a}\pm0.19$ | $0.70\pm0.02$ | $4.80^{a}\pm0.09$ | $6.85^{a}\pm0.00$ |
| $A_3$FWR | $10.37^{bc}\pm1.37$ | $0.70^{a}\pm0.00$ | $4.67^{abc}\pm0.00$ | $6.67^{b}\pm0.07$ |
| $A_4$FWR | $10.09^{ab}\pm1.70$ | $0.73^{a}\pm0.01$ | $4.60^{bc}\pm0.00$ | $6.36^{a}\pm0.41$ |
| $A_5$FWR | $10.93^{b}\pm0.66$ | $0.68^{a}\pm0.00$ | $4.63^{bc}\pm0.15$ | $6.89^{a}\pm0.50$ |
| $A_6$FWR | $10.49^{ab}\pm0.76$ | $0.73^{a}\pm0.04$ | $4.70^{abc}\pm0.08$ | $6.43^{a}\pm0.37$ |

** Values are Means of Duplicate Determinations ± Standard Deviation*

*Means with different superscript within a column are significantly different (P>0.05)*

*** Sample; AAA = 100% Wheat Flour; $A_1$FWR = 95% Wheat: 5% Residue Flour; $A_2$FWR = 90% Wheat: 10% Residue Flour; $A_3$FWR = 85% Wheat: 15% Residue Flour; $A_4$FWR = 80% Wheat: 20% Residue Flour; $A_5$FWR = 75% Wheat: 25% Residue Flour; $A_6$FWR = 70% Wheat: 30% Residue Flour*

**Table 4. Mean Sensory Scores of Cookies from Wheat and Fermented White Maize Residue Composite Flour**

| Sample | Colour | Texture | Aroma | Taste | Overall Acceptability |
|---|---|---|---|---|---|
| AAA | $3.52^a \pm 0.846$ | $3.65^a \pm 0.885$ | $3.48^a \pm 0.665$ | $3.52^a \pm 0.898$ | $3.54^a \pm 1.123$ |
| $A_1$FWR | $3.48^a \pm 1.039$ | $3.04^a \pm 1.147$ | $3.35^a \pm 0.935$ | $3.65^a \pm 0.885$ | $3.38^a \pm 0.896$ |
| $A_2$FWR | $3.35^a \pm 0.832$ | $3.13^a \pm 1.014$ | $3.22^a \pm 0.851$ | $3.52^a \pm 1.039$ | $3.31^a \pm 0.992$ |
| $A_3$FWR | $3.78^a \pm 0.951$ | $3.65^a \pm 0.982$ | $3.44^a \pm 0.728$ | $3.52^a \pm 0.847$ | $3.59^a \pm 0.945$ |
| $A_4$FWR | $3.13^a \pm 0.869$ | $3.44^a \pm 1.037$ | $3.35^a \pm 1.027$ | $3.52^a \pm 1.082$ | $3.36^a \pm 1.037$ |
| $A_5$FWR | $3.09^a \pm 1.164$ | $3.04^a \pm 0.878$ | $3.17^a \pm 0.887$ | $3.43^a \pm 0.945$ | $3.18^a \pm 1.096$ |
| $A_6$FWR | $3.52^a \pm 0.846$ | $3.09^a \pm 0.996$ | $3.26^a \pm 0.665$ | $3.26^a \pm 1.096$ | $3.28^a \pm 1.027$ |

** Values are Means of Duplicate Determinations ± Standard Deviation*
*Means with different superscript within a column are significantly different (P>0.05)*
***Sample; AAA = 100% Wheat Flour; $A_1$FWR = 95% Wheat: 5% Residue Flour; $A_2$FWR = 90% Wheat: 10% Residue Flour; $A_3$FWR = 85% Wheat: 15% Residue Flour; $A_4$FWR = 80% Wheat: 20% Residue Flour; $A_5$FWR = 75% Wheat: 25% Residue Flour; $A_6$FWR = 70% Wheat: 30% Residue Flour*

**Table 5. *Proximate Composition of Cookies from Wheat and Fermented White Maize Residue Flour**

| Sample** | Moisture Content(%) | Ash (%) | Fat (%) | Crude Protein (%) | Crude Fibre (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|
| AAA | $6.03^b \pm 0.28$ | $2.11^a \pm 0.09$ | $19.65^{bc} \pm 0.06$ | $9.21^a \pm 0.00$ | $2.11^a \pm 0.62$ | $60.84^a \pm 1.18$ |
| $A_1$FWR | $9.29^a \pm 1.09$ | $2.05^{ab} \pm 0.06$ | $20.15^b \pm 0.36$ | $9.12^{ab} \pm 0.00$ | $2.87^a \pm 0.15$ | $56.26^{ab} \pm 1.74$ |
| $A_2$FWR | $7.50^{ab} \pm 0.68$ | $1.54^c \pm 0.19$ | $20.48^{ab} \pm 0.34$ | $9.16^{ab} \pm 0.00$ | $2.94^a \pm 0.93$ | $58.38^{ab} \pm 1.74$ |
| $A_3$FWR | $6.99^{ab} \pm 0.89$ | $1.86^{abc} \pm 0.13$ | $20.72^{ab} \pm 0.58$ | $8.82^a \pm 0.21$ | $2.95^a \pm 0.21$ | $58.66^{ab} \pm 1.56$ |
| $A_4$FWR | $8.35^{ab} \pm 0.19$ | $1.68^{bc} \pm 0.36$ | $18.44^c \pm 0.36$ | $8.68^{abc} \pm 0.61$ | $3.01^a \pm 0.63$ | $59.84^{ab} \pm 0.53$ |
| $A_5$FWR | $7.39^{ab} \pm 0.75$ | $1.86^{abc} \pm 0.03$ | $21.82^a \pm 0.38$ | $8.14^{bc} \pm 0.31$ | $3.63^a \pm 0.49$ | $57.16^{ab} \pm 0.08$ |
| $A_6$FWR | $7.47^{ab} \pm 0.14$ | $1.88^{abc} \pm 0.01$ | $22.02^a \pm 0.42$ | $8.34^{abc} \pm 0.00$ | $5.27^a \pm 2.32$ | $55.02^b \pm 2.04$ |

**Values are Means of Duplicate Determinations ± Standard Deviation*
*Means with different superscript within a column are significantly different (P>0.05)*
***Sample; AAA = 100% Wheat Flour; $A_1$FWR = 95% Wheat: 5% Residue Flour; $A_2$FWR = 90% Wheat: 10% Residue Flour; $A_3$FWR = 85% Wheat: 15% Residue Flour; $A_4$FWR = 80% Wheat: 20% Residue Flour; $A_5$FWR = 75% Wheat: 25% Residue Flour; $A_6$FWR = 70% Wheat: 30% Residue Flour*

**Table 6. Invitro-Protein Digestibility of Wheat-Fermented White Residue Cookies and Chin-chin (%)**

| **Sample | Cookies |
|---|---|
| AAA | $61.27^a \pm 0.028$ |
| $A_1$FWR | $48.15^b \pm 0.071$ |
| $A_2$FWR | $48.95^b \pm 3.09$ |
| $A_3$FWR | $48.16^b \pm 1.41$ |
| $A_4$FWR | $45.54^b \pm 0.05$ |
| $A_5$FWR | $43.99^{bc} \pm 0.02$ |
| $A_6$FWR | $39.38^c \pm 0.03$ |

**Values are Means of Duplicate Determinations ± Standard Deviation*
*Means with different superscript within a column are significantly different (P>0.05)*
***Sample; AAA = 100% Wheat Flour; $A_1$FWR = 95% Wheat: 5% Residue Flour; $A_2$FWR = 90% Wheat: 10% Residue Flour; $A_3$FWR = 85% Wheat: 15% Residue Flour; $A_4$FWR = 80% Wheat: 20% Residue Flour; $A_5$FWR = 75% Wheat: 25% Residue Flour; $A_6$FWR= 70% Wheat: 30% Residue Flour*

## 4. DISCUSSIONS

Addition of the residue did not show a definite effect with respect to weight and height of the cookies, but the diameter does show a slight decrease, the effect of the residue on the cookies was more defined in the spread ratio as there was a decline in the value with substitution levels, though values were not significantly different between the control upto 25% level of substitution i.e. AAA – A5FWR.. Spread ratio and diameter of cookies have been used to determine the quality of flour for producing cookies. A decrease in the values of spread ratio in biscuits with increase in the levels of substitution of wheat with corn bran powder was also reported [12,13]. The higher the spread ratio of biscuit, the more desirable [14]. Spread ratio and diameter of biscuit are determinant factors for the quality of flour and the ability of the biscuit to rise [15]. A dilution of the gluten of wheat flour with the fibre residue is a factor responsible for this decrease in the spread ratio.

The attribute of colour as evaluated by the panelist indicated equal preference for all the samples. The colour score was highest in sample A3FWR with 15% addition of residue flour (3.78) and least in sample A5FWR (3.09) at 25% level of addition of residue flour, however there was no significant difference (P>0.05) among the means and this amount to equal preference for colour

For texture, the control sample (AAA) and A3FWR had the highest score of 3.65 respectively with samples A1FWR and A5FWR (5% and 25% residue inclusion) having the least score of 3.04. The result also indicate equal preference by the panelist as there was no significant difference among the means. For Aroma the control sample had the highest scores of 3.48 with sample A5FWR scoring the least (3.26), but all the samples still had equal preference as there was no significant difference among the means. Sample A1FWR had the highest score for taste with sample A6FWR scoring the least but none of the samples was most preferred for aroma. The result for overall acceptability also did not show any significant difference among the means, hence the samples all had equal preference. Previous studies on the addition of corn bran to wheat cookies showed corn bran addition at 20% level of substitution was more preferred than the control for overall acceptability [13].

The result for proximate composition of cookies, show moisture content appeared to show an increase with the addition of residue flour, this may probably be as a result of the ability of the fibre enrichment of the cookies. Increase in the water absorption capacity of wheat-citrus flour dough with increase in the amount of citrus fibres have been reported [7]. The moisture values of the cookies ranged from 6.03 in the control to 9.29% in A1FWR, though the effect is not graded downward, values were within limits by other workers, values of 2.42 – 3.52% for biscuits produced from wheat-corn bran composite flour [13]. And values of 5.45 – 6.10% for biscuits produced from wheat flour – maize bran composite flour [16]. Low residual moisture content in confectionaries has the advantage of reducing microbial activity [17]. A reduced moisture content will delay oxidative rancidity of fat and the activity of lipolytic enzymes all of which has a deleterious effect in high fat foods. The values for ash showed a decrease with addition of the fermented maize residue flour. This is not farfetched, the ash content is an indication of the total minerals, a withdrawal of wheat flour while replacing it with residue flour could not have increased the total mineral content. The addition of residue did not show a definite effect on the fat content. The protein content was higher in the control (9.21%) and showed a slight decrease downward with residue addition. This does not agree with the increase in the protein content in biscuits produced from blends of wheat and corn bran reported by [18]. The crude fibre content increased with residue flour addition. An increase in the crude fibre content in wheat-corn bran and wheat-wheat bran biscuits has also been reported [17,13]. Addition of residue flour led to a decline in the carbohydrate content, this decrease can be attributed to the removal of wheat flour and its replacement with fermented residue flour which can be attributed to dilution effect of wheat flour with the fermented residue flour can also be adduced. The result of invitro-protein digestibility (IVPD) decreased from the control from 61.2% in the control cookies to 39.38% in cookies at 30% level of substitution.

Invitro protein digestibility is a factor when assessing the nutritional status of a food. It is an index of protein quality. [3] also reported in decrease in IPVD of cookies substituted with wheat bran and other fibre sources and reported that the decrease could be possibly be as a result complex formation between the fibre components and the protein fraction of the samples. The decrease could also be as a result of the fact that the residue consisting largely of maize bran as its source of protein produce protein of low digestibility.

## 5. CONCLUSIONS

Incorporation of fermented maize residue produced cookies with acceptable sensory attributes that compared favourably with the control. The result also showed cookies with increased fibre content, a slight decrease in the protein content and a decrease in protein digestibility with a drop in the spread ratio. Though the spread ratio dropped the values were not significantly different from the control and the protein content upto 20% level of substitution.

This study has shown that the by-product of fermented starch can find application in cookie production as it brought about an increase in the crude fibre content with a decrease in the calories (carbohydrate content) with no adverse effect on the sensory attributes of the cookies.

## DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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