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PHYSICAL, CHEMICAL AND SENSORY CHARACTERISTICS OF COOKIES PRODUCED FROM FERMENTED SORGHUM FLOUR COMPOSITED WITH ROASTED PIGEON PEA FLOUR

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Abstract
This study assessed cookies from the blends of fermented sorghum and roasted pigeon pea flours at varying ratios of 100:0, 90:10, 80:20, 70:30 and 60:40, and 100% wheat flour served as control. The pigeon pea, sorghum, wheat flour and other ingredients were purchased from Bodija market, Oyo State Nigeria. The proximate composition of the flour blends and cookies and functional properties; and physical and sensory evaluation were determined. The proximate composition of flour blends showed that crude protein (8.65-18.94), crude fibre (1.48-2.60) and ash (2.23-3.53) % contents increased with increasing level of roasted pigeon pea flour. The water absorption capacity, bulk density and swelling capacity in the flour blends increased with increasing proportion of roasted pigeon pea flour. The cookies sample 60:40 had highest scores in moisture, protein, fat, ash and fibre, while, sample 100:0 scored lowest. The diameter in cookies sample 90:10 was highest with 81.33mm; thickness in sample 80:20 had highest value of 33.00mm and spread ratio in sample 90:10 had optimum score of 28.40; degree of lightness and yellowness had highest value in cookies sample 80:20, while, redness had highest value in sample 60:40. The overall acceptability of cookies was observed in 100% wheat flour cookies followed by sample 90:10.

Keywords: Sorghum, Pigeon pea, Composite flour, Cookies, Nutritional composition

The benefits of producing acceptable products from the combination of legumes and cereals are derived from the fact that West Africa has a large number of indigenous food crops peculiar to it. These have been largely ignored in agricultural development activities most probably because they have little or no economic value in the world market. The enrichment of cereal based foods with protein sources such as legumes have received considerable attention (Ayo *et al.,* 2010). This is because cereals are deficient in sulphur-containing amino acid such as lysine and tryptophan and generally low in protein, vitamin and mineral. Sorghum is a plant that is very economical to grow in dry areas with a high yield (Anglani, 1998). Though it contains adequate nutrients, fibre and anti-nutritional compounds such as tannin and phytic acid which affects human digestive system (Suarni, 2004; Elkhalifa *et al.,* 2004). Pigeon pea also known as *Cajanus cajan*, is a locally available, affordable and under-utilized grain legume of the tropics and subtropics. Pigeon pea varieties have protein content in the range of 23-26%, comparable to other legumes like cowpea and groundnut, which have been used in complementing maize (Peoples *et al.,* 1995). Pigeon pea grows well in Nigeria but hard-to-cook phenomenon and the presence of anti-nutrients have been limiting its utilization (Nene *et al*., 1990; El-TabeyShebata, 1992). The blend of pigeon pea and sorghum flours had found advantageous benefits in the production of breakfast cereal, *akara* and biscuit (Mbaeyi, 2005). Processing of underutilized cereal and legumes especially sorghum and pigeon pea into convenience foods will improve their acceptability by the urban population, and thus encourage the use of processed food based on local products, hence, replacing heavy importation. This study aims to determine the suitability of the blend flour of fermented sorghum and roasted pigeon pea for cookies production and evaluate the sensory properties and the nutritional contents of the cookies produced from the blend.

Materials and Methods

The pigeon pea, sorghum, wheat flour and other ingredients were purchased from Bodija market, Oyo Sate Nigeria. The pigeon pea and sorghum were sorted in order to remove extraneous materials and pests that can impair the quality of the final product, cleaned and dried.

Processing of Pigeon Pea Flour

Three hundred grams of pigeon pea seeds were moistened with 50mL of water and allowed to equilibrate for 15mins. The seeds were then roasted in an electric fryer for 10mins at 150°C with continuous stirring. The roasted seeds were dehullled using pestle and mortars, and then the seed coat was winnowed from the seeds. The roasted seeds were milled using hammer mill and the flour sieved using 1mm sieve size. The resultant flour was packed in ziplock bag for further analysis.

Processing of Sorghum Flour

Sorghum was fermented according to the method described by Hallén *et al.* (2004). Fermentation was carried out at 37°C for 24 hours. The samples were dried in a hot air oven at 60°C for 16 hours. Dried samples were ground via hammer mill to pass through 0.44mm mesh and stored in a ziplock bag till further use.

Formulation of Composite Flours

Flours of fermented sorghum and roasted pigeon pea were formulated at varying ratios 100:0, 90:10, 80:20, 70:30, 60:40 and labeled A, B, C, D and E respectively. The composite flours were thoroughly mixed to obtain homogenous blends. Wheat flour served as control and labeled X. Samples were stored in airtight containers and stored at room temperature until ready for use.

Preparation of Cookies from Fermented Sorghum and Roasted Pigeon Pea Flour Blends

Cookies were prepared using the modified recipes for digestive biscuit as described by Okaka and Isieh (1990). Fat and sugar were mixed using mixer until fluffy. Egg and milk were added while mixing for 40 mins. Baking powder (0.5g), composite flour, nutmeg, vanilla flavoring and salt were slowly introduced into the mixture. The dough was rolled, cut and baked at 160°C for 15 min. Cookies produced from 100% wheat flour served as control.

Chemical Analysis

Proximate composition of composite flours and cookies

Moisture, protein, crude fibre, fat and ash contents were determined according to the procedure described by AOAC (2010). Protein content was determined using Kjeldahl method and calculated by multiplying nitrogen percentage with a factor 6.25. Carbohydrate was determined by differences (%).

Functional Property of Composite Flours

The water absorption capacity (WAC) and oil absorption capacity (OAC) were determined using the procedure of Sathe and Salunkhe (1984) as modified by Adebowale *et al.* (2005), bulk density (BD) by method of Sathe *et al.* (1982), swelling capacity by the method described by Ukpabi and Ndimele (1990).

Physical Property of Cookies

The diameter of cookies was measured with a calibrated ruler as described by Ayo *et al.* (2010). The thickness of cookies was measured by placing six cookies on top of each other followed by a duplicate reading recorded by shuffling the cookies as described by AOAC, (2010). Spread ratio was further calculated as diameter/thickness (McWatters *et al.*, 2003).

Colour of flours and cookies

The colour of the flour samples and cookies was determined using a CL-200A Chroma-meter equipped with D65 illuminant on the basis of CIE L*, a* and b* system as described by Kaur and Singh (2005). L* represented lightness (with 0 = darkness/blackness to 100= perfect/brightness); a*corresponds to the extent of green colour (in the range from negative green to positive redness); b* represents blue in the range from negative blue to positive yellow. The colorimeter was calibrated against a standard white reference tile. The L*, a* and b* readings were obtained directly from the instrument and provided measures of lightness, redness and yellowness, respectively. All measurements were performed in triplicate and mean value recorded.

Sensory Evaluation

Sensory evaluation was carried out using 30 untrained panelists to assess the sensory attribute of enriched cookies. Selected panelists were students of the Department of Food Technology, University of Ibadan, Nigeria. They were provided with portable water and, instructed to rinse and swallow between samples. Prior to the sensory analysis, they were screened with respect to their interest and ability to differentiate food sensory properties. They were asked to evaluate the samples for taste, colour, flavour, crispiness, texture and overall acceptability based on a 9- point hedonic scale ranging from 9-liked extremely to 1-disliked extremely.

Statistical Analysis of Data

Experiments were replicated five times and the collected data subjected to analysis of variance using a completely randomized design. The difference between the means was separated using Duncan Multiple Range Test and significant difference was taken at 5% confidence limit.

Results and Discussion

Proximate composition of fermented sorghum and roasted pigeon pea flours

Table 1 shows the proximate composition of fermented sorghum-roasted pigeon pea composite flour. The moisture content of the composite flour are generally low (approximately 8%) and values less than 10% are unlikely to cause any adverse effect on the quality attributes of the flour (Okoli, 2011). There was a significant difference among the sample flours ($p<0.05$). Sanni *et al*. (2006) reported that the lower the moisture contents of a product, the better the shelf stability of such product. The protein contents increased with increasing substitution of roasted pigeon pea flour. It was observed that fermented sorghum flour (sample A) had lowest content. This is not surprising as cereal is low in protein hence, reason for the substitution of roasted pigeon pea flour to boost the nutritional composition of the composite flour. The statement concurred with the production of cookies from fermented pigeon pea, germinated sorghum and cocoyam flours (Okpala and Ekwe, 2013). There was a significant difference ($p<0.05$) among the samples with the exception in sample D (70:30) and E (60:40). The fat contents in the resulting flours decreased with increasing roasted pigeon pea with no noticeable ($p<0.05$) differences in sample D (70:30) and E (60:40). Fat plays a significant role in the shelf life of food products as it can promote rancidity in foods, leading to the development of unpleasant and odorous compounds (Awofadeju *et al.,* 2015). As such, relatively low fat content is desirable in baked food products. Fibre contents of the composite flour increased from 1.48 to 2.60 with lowest in sample A (100% fermented sorghum flour) and highest in sample E (60:40). Crude fibre and ash contents of the blend samples showed an increasing trend as the substitution with fermented sorghum flour decreases. The fibre contents of all samples are within the recommended range of not more than 5g dietary fiber per 100g dry matter (FAO/WHO, 1994). There was no noticeable differences ($p<0.05$) among the samples. The ash content could be used as a determinant for the mineral component in the flours thus; the higher the ash content of the blends, the higher the mineral content of a product. Carbohydrate of the blend samples decreased as inclusion of fermented sorghum decreased. There was a noticeable difference ($p<0.05$) in the samples. However, sample E (60:40) had the lowest, while, sample A (100% fermented sorghum flour) scored highest. The differences in result could be attributed to highest ratio of fermented sorghum flour in which, fermentation activates starch hydrolyzing enzymes such as α-amylase and maltase (Elkhlifa *et al.,* 2004). Fermentation also leads to enhancement of carbohydrate accessibility, thus; sorghum provides more soluble carbohydrate to consumers.

Table 1: Proximate Composition of Fermented Sorghum and Roasted Pigeon Pea Flours (%)

Samples	Moisture	Protein	Fat	Fibre	Ash	Carbohydrate
A	$7.62^{b}\pm0.566$	$8.65^{d}\pm0.156$	$5.40^{a}\pm0.007$	$1.48^{c}\pm0.007$	$2.23^{d}\pm0.000$	$76.11^{a}\pm0.198$
B	$8.19^{a}\pm0.014$	$12.26^{c}\pm0.000$	$4.31^{b}\pm0.007$	$1.49^{c}\pm0.014$	$2.56^{c}\pm0.021$	$72.69^{b}\pm0.000$
C	$7.15^{c}\pm0.014$	$16.75^{b}\pm0.156$	$4.28^{b}\pm0.021$	$2.23^{b}\pm0.014$	$3.21^{b}\pm0.064$	$68.62^{c}\pm0.085$
D	$6.70^{e}\pm0.424$	$18.72^{a}\pm0.148$	$3.69^{c}\pm0.007$	$2.39^{b}\pm0.007$	$3.48^{a}\pm0.028$	$67.42^{d}\pm0.219$
E	$6.90^{d}\pm0.021$	$18.94^{a}\pm0.150$	$3.69^{c}\pm0.001$	$2.60^{a}\pm0.028$	$3.53^{a}\pm0.014$	$66.95^{e}\pm0.127$

NOTE: A=100% fermented sorghum flour; B= 90% fermented sorghum: 10% roasted pigeon pea flours; C= 80% fermented sorghum: 20% roasted pigeon pea flours; D= 70% fermented sorghum: 30 % roasted pigeon pea flours; E= 60% fermented sorghum: 40% roasted pigeon pea flours

Functional property of Fermented Sorghum and Roasted Pigeon Pea Flours

The functional properties of the flour blends are presented in Table 2. The bulk density increased from 0.44 to 0.87g/cm3, which showed an increasing trend with increase in roasted pigeon pea flours. Sample E (60:40) had the highest bulk density with a noticeable difference ($P<0.05$) from other blends, while samples A (100% fermented sorghum) and C (80:20) showed no significant differences. The least and common values shared among sample A (100% fermented sorghum) and C (80:20) signify low bulk density in fermented sorghum flour. Mbaeyi (2005) justified the statement in the production of flaked breakfast using pigeon pea and sorghum flour. Values ranging between 0.5341 and 0.7260g/cc were reported with highest in pigeon pea and least in sorghum flours. The low bulk density recorded among the blends which occurred in sample B (90:10) could be an added advantage in the formulation of baby foods. The bulk density of a food material is important in relation to its packaging (Bello and Okazie, 1982). Water absorption capacities of the blends increased with increasing inclusion of roasted pigeon pea flours and the differences in the value were between 90 and 127%. Also, all the flour blends absorbed more water than oil with the exception of sample A (100% fermented sorghum). However, the blends of flour are not significantly different ($p>0.05$) from each other. Value obtained in this study is lower relative to 7.00 – 8.50g/g (Mbaeyi, 2005). The oil absorption capacities (OAC) ranged from 0.40 to 1.05 % with highest values in samples A (100% fermented sorghum) and lowest in C (80:20). The highest value exhibited in sample A (100% fermented sorghum) could be attributed to the abundance of oil in sorghum. Ubor and Akobundu (2009) suggested that OAC are lipophilic in nature, where the constituents (flavour) and blends are potentially useful in the structural interaction in food especially in flavour retention, improvement of palatability and extension in shelf life of bakery foods. All blend samples with the exception of sample C (80:20) showed no significant differences ($P>0.05$). The packed density of the samples ranged from 0.74-0.77g/mL with sample B (90:10) having the highest value. Meanwhile, the samples were not significantly different ($P>0.05$) from each other.

Table 2: Functional Property of Fermented Sorghum and Roasted Pigeon Pea Flours

Samples	OAC (%)	WAC (%)	Bulk density (g/mL)	Packed density(g/mL)	Swelling capacity
A	$1.05^{a}\pm0.332$	$0.90^{a}\pm0.638$	$0.47^{d}\pm0.332$	$0.75^{a}\pm0.020$	$4.94^{abc}\pm0.106$
B	$0.85^{a}\pm0.035$	$1.02^{a}\pm0.292$	$0.44^{d}\pm0.010$	$0.77^{a}\pm0.015$	$4.47^{c}\pm0.431$
C	$0.40^{b}\pm0.071$	$1.19^{a}\pm0.982$	$0.47^{c}\pm0.010$	$0.74^{a}\pm0.023$	$4.60^{a}\pm0.269$
D	$0.67^{ab}\pm0.130$	$1.27^{a}\pm0.012$	$0.48^{b}\pm0.005$	$0.76^{a}\pm0.009$	$4.75^{bc}\pm0.552$
E	$0.69^{ab}\pm0.007$	$1.32^{a}\pm0.099$	$0.81^{a}\pm0.007$	$0.76^{a}\pm0.005$	$5.43^{ab}\pm0.071$

NOTE: A=100% fermented sorghum flour; B= 90% fermented sorghum: 10% roasted pigeon pea flours; C= 80% fermented sorghum: 20% roasted pigeon pea flours; D= 70% fermented sorghum: 30 % roasted pigeon pea flours; E= 60% fermented sorghum: 40% roasted pigeon pea flours

The swelling capacity of the flour increased with increasing ratio in roasted pigeon pea. The higher the substitution levels of roasted pigeon pea flour, the higher the rate at which the flour swells (Abayomi *et al*., 2013). They differ significantly ($p<0.05$) from each other.

Proximate Composition of Cookies

Table 3 presents the proximate composition of cookies made from fermented sorghum and roasted pigeon pea blends. Moisture is a crucial aspect in flour which appreciably alters the life span of food product. Moisture, protein, fibre and ash content among enriched cookies increased with increasing varying level of roasted pigeon pea, while sample X (100% wheat flour) exhibited lowest value. Cookie sample X was made from100% wheat flour. The moisture content of the cookie samples obtained was below the bakery product ranging from 14 – 18%, which could apparently prolong the shelf life of the products (Coutinho *et al.,* 2013). The protein content in sample X (100% wheat flour) is relatively low compared to other samples. This is because other samples contained protein-rich crop material (roasted pigeon pea) which increased with increase in the substitution level of roasted pigeon pea flour, thus; enhancing the nutritional composition of the products. Increase in ash content is a good indicator that the cookies could be a good source of minerals. Samples D (70:30) and E (60:40) are not significantly different ($p>0.05$) to each other in the ash value obtained, meanwhile, other samples are significantly different ($p<0.05$). Fat content of cookies ranged from 21.92 to 33.79 with sample X (100% wheat flour) having lowest and sample E (60:40) exhibited highest contents. The highest content in sample E (60:40) could be attributed to the highest varying ratio of roasted pigeon pea. Legumes are oil-rich crop material relative to cereal (Sotunde *et al.,* 2021). Carbohydrate content of sample X (100% wheat flour) was highest among cookies samples, thus; the lower the substitution of fermented sorghum flour, the lower the carbohydrate content.

Table 3: Proximate Composition of Cookies (%)

Sample	Moisture	Protein	Fat	Fibre	Ash	Carbohydrate
X	2.78^{e}±0.134	6.90^{f}±0.156	21.92^{f}±0.050	2.91^{f}±0.021	1.16^{e}±0.000	63.25^{a}±0.071
A	2.75^{a}±0.014	8.87^{e}±0.156	30.41^{d}±0.014	8.5^{e}1±0.014	1.55^{d}±0.028	52.13^{b}±0.028
B	2.81^{de}±0.050	9.63^{d}±0.000	32.90^{b}±0.050	9.62^{d}±0.021	1.88^{c}±0.007	48.31^{d}±0.113
C	3.00^{b}±0.028	10.01^{c}±0.000	29.90^{e}±0.021	9.81^{c}±0.014	2.10^{b}±0.042	49.75^{c}±0.500
D	3.65^{c}±0.057	11.49^{b}±0.156	32.81^{c}±0.007	11.89^{b}±0.021	2.26^{a}±0.064	46.51^{e}±0.035
E	4.20^{d}±0.085	12.37^{a}±0.156	33.79^{a}±0.014	13.41^{a}±0.014	2.30^{a}±0.078	43.11^{f}±0.156

NOTE: X= Wheat flour, A=100% fermented sorghum flour; B= 90% fermented sorghum: 10% roasted pigeon pea flours; C= 80% fermented sorghum: 20% roasted pigeon pea flours; D= 70% fermented sorghum: 30% roasted pigeon pea flours; E= 60% fermented sorghum: 40% roasted pigeon pea flours

Physical properties of the cookies

Colour is one of the most critical quality attributes of food products (Aly and Seleem, 2015). Numerous studies have shown that visual acceptance is the first thing consumers rely on when making choices in food (Mares and Campbell, 2001). Food colour is so influential, it can even change the way consumers perceive taste and quality in foods and provides some indication of quality in the starting materials (Mares and Campbell, 2001). However, degree of lightness and yellowness in sample C (80:20) were highest and redness had optimum value in sample E (60:40) (Table 4). The diameter of cookies sample ranged from 78.00 to 81.33 with no noticeable differences ($p>0.05$) among the samples. The thickness showed some variations in the values obtained with the least value recorded in sample C (80:20). Spread ratio is another parameter used to study the rising of cookies and its quality. Spread ratio of sample A (100% fermented sorghum) increased with the highest varying level of fermented sorghum flour. The increase signifies binding properties of the flours and texture of the cookie. However, the highest value observed in sample A (100% fermented sorghum) could be ascribed to decrease in proportion of roasted pigeon pea flour, and increase in fermented sorghum flour indicating starch polymer molecules are more tightly bound with granules and swelling is limited in composite cookies with roasted pigeon pea when heated.

Table 4: Physical Property of the Cookies

Sample	L	A	B	Diameter (mm)	Thickness (mm)	Spread ratio
X	34.00^{b}±0.135	9.21^{a}±0.125	16.09^{b}±0.119	81.00^{a}±1.000	29.33^{b}±1.155	27.64^{ab}±1.162
A	34.08^{b}±0.196	9.21^{a}±0.125	16.09^{b}±0.119	81.67^{a}±2.887	32.33^{a}±2.516	28.40^{a}±2.756
B	36.48^{a}±0.490	10.51^{a}±0.465	17.46^{a}±0.441	78.00^{a}±2.000	33.00^{bc}±1.000	26.03^{b}±1.427
C	37.00^{a}±0.970	10.65^{a}±0.344	17.53^{a}±0.680	78.33^{a}±2.887	26.33^{c}±2.082	26.80^{ab}±1.373
D	32.65^{b}±0.538	9.69^{a}±0.180	15.36^{b}±0.136	81.00^{a}±1.000	30.00^{ab}±1.000	27.02^{ab}±0.779
E	33.90^{b}±1.731	12.20^{a}±5.149	15.21^{b}±1.321	81.33^{a}±3.786	30.33^{ab}±0.577	27.81^{ab}±1.030

NOTE: A=100% fermented sorghum flour; B= 90% fermented sorghum: 10% roasted pigeon pea flours; C= 80% fermented sorghum: 20% roasted pigeon pea flours; D= 70% fermented sorghum: 30 % roasted pigeon pea flours; E= 60% fermented sorghum: 40% roasted pigeon pea flours

Sensory Evaluation of Cookies

The sensory evaluation of cookies samples is presented in Table 5. Colour is an important sensory attribute of any food because of its influence on acceptability. *An old Adage says eye accepts the food before the mouth, is very true*. The colour of sample A (100% fermented sorghum) was superior to the other formulated cookies, moreover cookies produced from the fermented sorghum and roasted pigeon pea were not significantly different (P>0.05) to each other. Another attribute that influence the acceptance of cookies even before tasted is the flavour. Highest score of 7.65 (like moderately) was obtained from wheat cookies in term of flavour. The formulated cookies are not significantly different from each other. Cookies made from 100% wheat flour (sample X) tasted better than any of the formulated cookies with highest value of 8.35. Texture is also one of the pivotal qualities of the cookies, because it prolongs the shelf life and enhances the acceptability of cookies samples. Cookies made from wheat flour have the highest texture score of 7.50, which means it is liked moderately. Also, the blend samples A (100% fermented sorghum), B (90:10), C (80:20) and E (60:40) showed no significant differences (P<0.05) among each other, while, sample D (70:30) is significantly different to other blend samples. The result shows that the quality of colour, flavour, crispness, texture and taste determine the overall acceptability of the cookies. The overall acceptability shows that sample X (100% wheat flour) scored highest followed by sample B (90:10). The highest rating recorded for sample X (100% wheat flour) is expected as panelists are more familiar with wheat product.

Table 5: Sensory Evaluation of Cookies

Sample	Taste	Colour	Flavour	Crispiness	Texture	Overall Acceptability
A	6.75^{b}±1.29	6.25^{b}±1.410	6.40^{b}±1.273	6.95^{bc}±1.050	7.1^{ab}±1.483	6.75^{b}±1.164
B	7.0^{b}±0.918	6.5^{b}±1.432	6.65^{b}±1.040	7.20^{b}±0.700	7.33^{ab}±0.979	7.15^{b}±0.988
C	6.7^{b}+±1.129	6.60^{b}±0.995	6.45^{b}±1.234	6.65^{bc}±1.226	6.9^{ab}±1.119	6.95^{b}±0.999
D	6.55^{bc}±2.038	7.00^{b}±1.414	5.95^{b}±1.761	6.70^{bc}±1.129	6.45^{c}±1.904	6.50^{b}±1.469
E	6.05^{c}± 1.146	6.80^{b}±1.152	6.40^{b}±0.940	6.40^{c}±1.095	7.10^{ab}±1.400	6.45^{b}±0.686
X	8.35^{a}±0.671	8.45^{a}±0.605	7.65^{a}±0.933	8.10^{a}±0.911	7.50^{a}±1.400	8.30^{a}±0.571

NOTE: A=100% fermented sorghum flour; B= 90% fermented sorghum: 10% roasted pigeon pea flours; C= 80% fermented sorghum: 20% roasted pigeon pea flours; D= 70% fermented sorghum: 30 % roasted pigeon pea flours; E= 60% fermented sorghum: 40% roasted pigeon pea flours

Conclusion

This study investigated the effect of varying ratio of flours in cookies making. The substitution of roasted pigeon pea with fermented sorghum flour improved the protein content of the blends and cookies. Irrespective of the highest protein content in 60% fermented sorghum and 40% roasted pigeon pea cookies samples, the proportion of 90% fermented sorghum and 10% roasted pigeon pea blends was generally accepted after 100% wheat flour cookies. However, the processing of sorghum and pigeon pea improved the nutrient content of cookies samples, and provide a diet with good proportion of fat and protein. Further studies are required on protein digestibility, microbial quality and storability of the flours and cookies for the possibility of commercialization.

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