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REGULAR ARTICLE

COMPARATIVE ANALYSIS OF AROMA PROPERTIES OF *Pleurotus ostreatus* INDUSTRIAL STRAINS

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ABSTRACT

Flavor properties of mushrooms are an important criterion that determines the selection of strains for industrial cultivation. The purpose of the study was to determine growth parameters and aroma profile of six most common industrial *Pleurotus ostreatus* (Jacq.) P. Kumm. strains in the process of intensive cultivation on sunflower husk. To achieve this purpose, methods of sensory profile analysis and ultraviolet spectroscopy were used.
Sensory profile analysis of flavor showed that fruit bodies of the IBK-1535 and IBK-1543 strains had the highest intensity of the mushroom note of aroma.
Spectrophotometric analysis demonstrated that mushroom hexane extracts had light absorption maxima in the ranges of 207-210 nm and of 250-290 nm. Thus, the spectrum of the strain IBK-1535 had the highest intensity in the whole range of wavelengths.
The screening of *P. ostreatus* strains allows us to recommend the IBK-1535 and IBK-1543 strains, which have a high growth rate and productivity, as well as the most pronounced characteristic mushroom aroma, for industrial cultivation

Keywords: *Pleurotus ostreatus*, aroma note, flavor, sensory profile analysis, UV spectroscopy

INTRODUCTION

The genus *Pleurotus* is considered one of the most important genera of edible mushrooms, is the second most important commercial mushroom in the world **(Maftoun *et al.*, 2015)**. This is mainly due to the high nutritional value and medicinal properties of this species **(Shnyreva and Shnyreva, 2015)**.
According to the latest data, more than 70 species of the genus *Pleurotus* are described. They have a large variety of morphological forms. Such species as *P. ostreatus*, *P. florida*, *P. sajor-caju*, *P. citrinopileatus*, *P. pulmonarius*, *P. eyngii*, *P. cystidiosus*, *P. sapidus*, *P. abalones*, *P. salmoneostramineus*, *P. ferulae* are cultivated in industrial volumes **(Vieira *et al.*, 2013)**.
Among them, the species *Pleurotus ostreatus* (Jacq.) P. Kumm. is one of the most popular object of the world mushroom growing, cultivated in more than 70 countries of the world, is an economically viable, high-yielding and technological edible mushroom **(Sanchez 2010)**. It began to grow in Germany during the First World War, and after the introduction of industrial cultivation of the mushroom – in Hungary, in the second half of the last century, when its distribution on the planet began as an agricultural product **(Suhomlyn *et al.*, 2017)**.
P. ostreatus is unpretentious to mushroom cultivation conditions, does not require special composts, has a high rate of mycelium growth **(Chang *et al.*, 2004).** Fruit bodies of this mushroom have high levels of protein, fiber, carbohydrates, minerals and vitamins, as well as low levels of lipids **(Deepalakshmi *et al.*, 2014)**. A large number of researches by scholars from all over the world indicate a wide range of biological activity of *P. ostreatus*. It has biotechnological application in medicine and is a promising medicinal mushroom **(Papaspyridia *et al.*, 2011; Paul *et al.*, 2017)**.
One of the main criteria for the quality of edible mushrooms is their flavor **(Cho *et al.*, 2008)**. The peculiar aroma properties largely determine the demand for certain types of mushrooms. In the kitchens of many countries, mushrooms are a delicacy and appreciated because of their unique taste and aroma **(Ashmore *et al.*, 2014).**
During industrial cultivation, farmers often face a choice not only of fast-growing and highly productive species and strains of mushrooms. An important role is also played by the presence of certain morphological characteristics, such as color and size of the pileus, stipe length, etc. The flavor properties of mushrooms are also an important criterion for selection.
The aim of this study was to determine aroma properties of the most common industrial *P. ostreatus* strains from the mushroom collection of the M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine **(Bisko *et al.*, 2016)**.

MATERIAL AND METHODS

Mushroom strains

Six strains of the edible mushroom *Pleurotus ostreatus* (Jacq.) P. Kumm.: IBK-549, IBK-550, IBK-551, IBK-1535, IBK-1543 and IBK-2275 from the mushroom collection of the M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine were objects of the study **(Bisko *et al.*, 2016)**.

Solid-phase cultivation

The sunflower husk was the substrate for the production of fruiting bodies. Preparation and sterilization of substrates were carried out according to commonly accepted methods **(Buhalo *et al.*, 2004)**. The substrate was evaporated for 2 hours, $CaCO_3$ was added in an amount of 1 % to the mass of the substrate and sterilized twice autoclaving at 121 °C for 30 minutes with an interval of 24 hours. The cooled substrate was spawned with *P. ostreatus* mycelium in an amount of 5 % by weight of the substrate. Spawn mycelium was obtained on barley grain. Cultivation was carried out in glass jars at 26-28 °C and 70-80 % humidity to the full mycelial overgrowth of the substrate. Containers with the substrate were transferred to a growth room with a temperature of 15-16 °C, humidity of 80-90 % and 8-hour photoperiod after full growth of the substrate by mycelium. The 1st and 2nd flushes were harvested. Mushrooms were dried at 40-45 °C in a dry oven for 24-48 hours.

Sensory profile analysis

The sensory profile of the aroma of dried mushroom samples was studied according to ISO 13299:2016.
The panel consisted of 5 experts trained for organoleptic analysis. First, the characteristic attributes of the aroma were determined, and then the intensity of each of them on a 5-point scale: 0 – not present; 1 – just recognizable or threshold; 2 – weak; 3 – moderate; 4 – strong; 5 – very strong. The studied samples were evaluated three times.
Microsoft Office Excel 2007 software was used to construct the aroma profiles of dried mushroom samples.

Spectrophotometric analysis

For a spectrophotometric study, the dried fruiting bodies of the 1st flush were crushed on an electric mill to a powder. 1 g of the obtained material was placed in the extractor, then 100 cm^3 of solvent were added (the hydromodule was 1:100). Hexane was used as a solvent. Extraction was carried out at boiling point (69°C) of the solvent for 30 minutes. The extracts were cooled in a fume hood, filtered through a paper filter on a Buchner funnel and transferred quantitatively into a volumetric flask of 250 cm^3. Then the solvent volume was adjusted to the mark. Absorption spectra were recorded using a spectrophotometer SF-2000 in the 200-350 nm wavelength range. Pure hexane was used as a comparative solution.

Statistical analysis

The obtained data were processed statistically using one-way analysis of variance (ANOVA), as well as Tukey's Post Hoc Test. All samples were carried out in

triplicate. Values are presented as means ± standard error of the mean. Differences at $P \leq 0,05$ were considered to be significant.

RESULTS AND DISCUSSION

Profile analysis of the mushroom aroma

During the sensory analysis by the panel, the following attributes of the aroma of dried mushroom samples were determined: mushroom, sweet, woody, herbaceous, sour, fish, meat, earthy, floral, and putrescent.
The results of sensory analysis of dried samples of different strains of *P. ostreatus* are presented in circle plots at Figure 1.

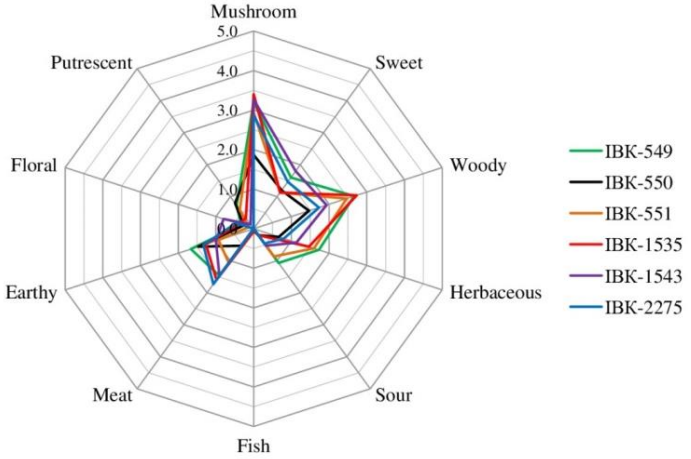
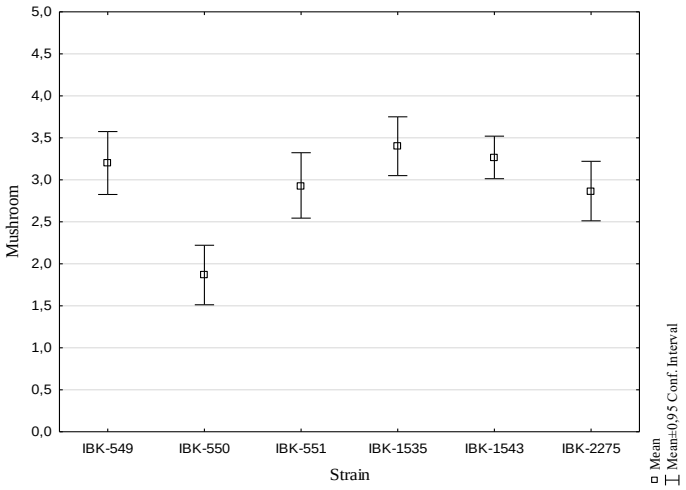
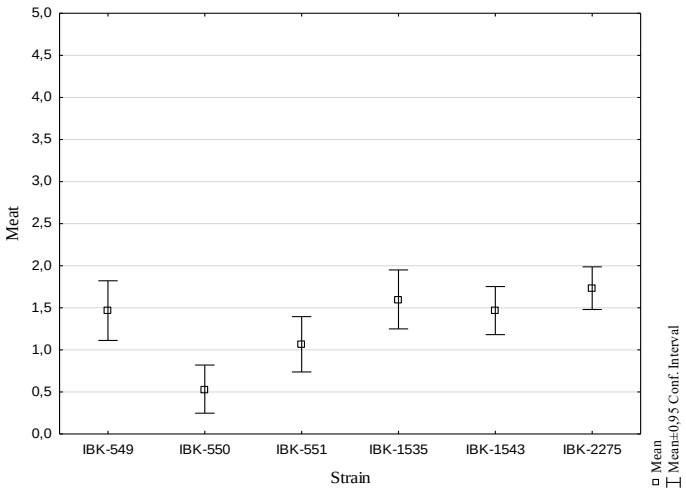
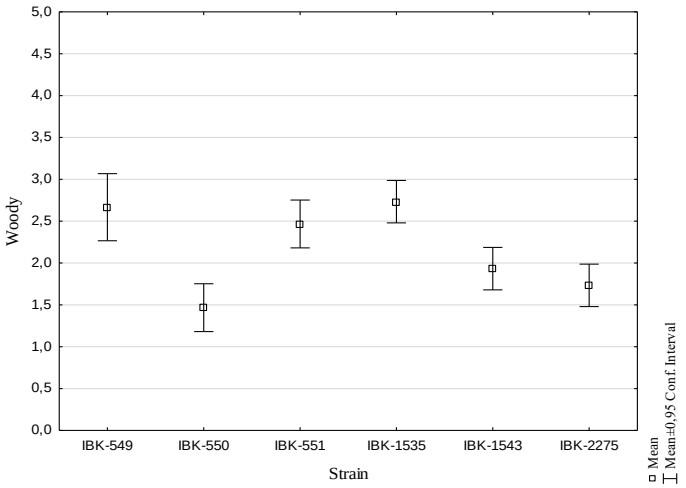


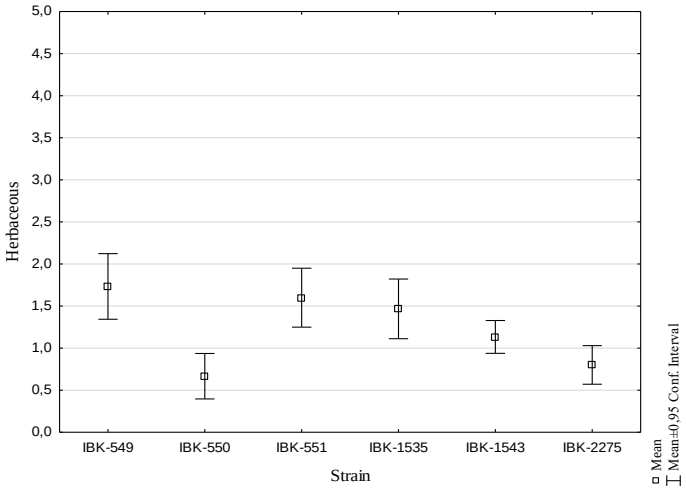
Figure 1 Sensory profiles of aroma of dried samples of *P. ostreatus* strains

From the provided data it can be noted that the aroma profile of mushroom samples differed in intensity (the area of the inner surface of the diagram), depending on the cultivated *P. ostreatus* strain, and also had certain features of the ratio of the characteristic attributes of the aroma for some strains.
Fruit bodies of the IBK-1535 and IBK-1543 strains had the highest intensity of the mushroom component of the aroma. The index of this attribute for the strain IBK-550 was in 1,5-1,8 times lower compared to other strains.
The highest intensity of wood note was observed in 1,4-1,9 times for the strain IBK-1535, and herbaceous and earthy notes – for IBK-549 (in 1,2-2,6 times), compared with other strains.
Meat notes were more pronounced in the fruit bodies of the strain IBK-2275 (in 1,1-3,3 times), and the least – in IBK-550 (in 2,0-3,3 times).
With regard to the sweet and floral attributes of the flavor, the highest (in 1,6-3,0 times compared with other strains) their intensity was noted for the fruit bodies of the strain IBK-1543.
Statistical analysis of the sensory profile data in the form of box plots is presented in Figures 2 and 3.









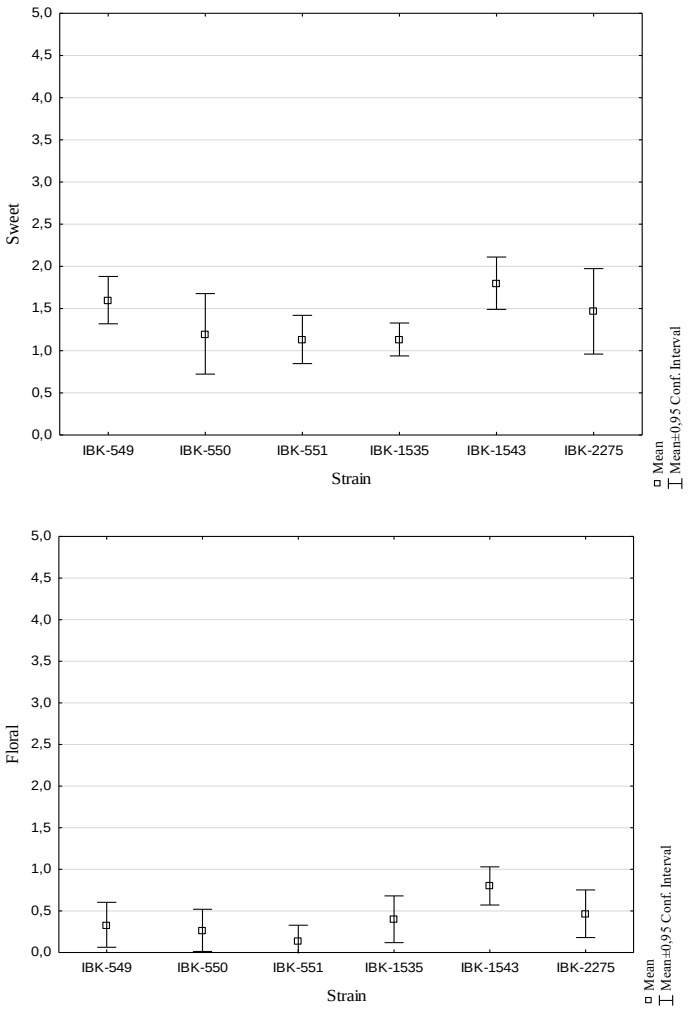
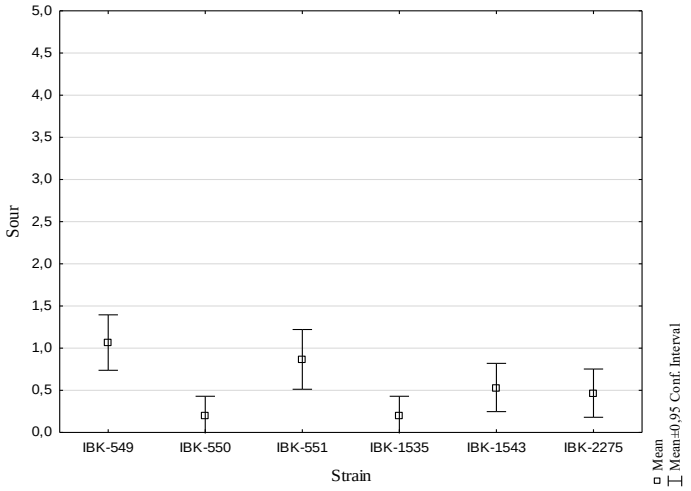
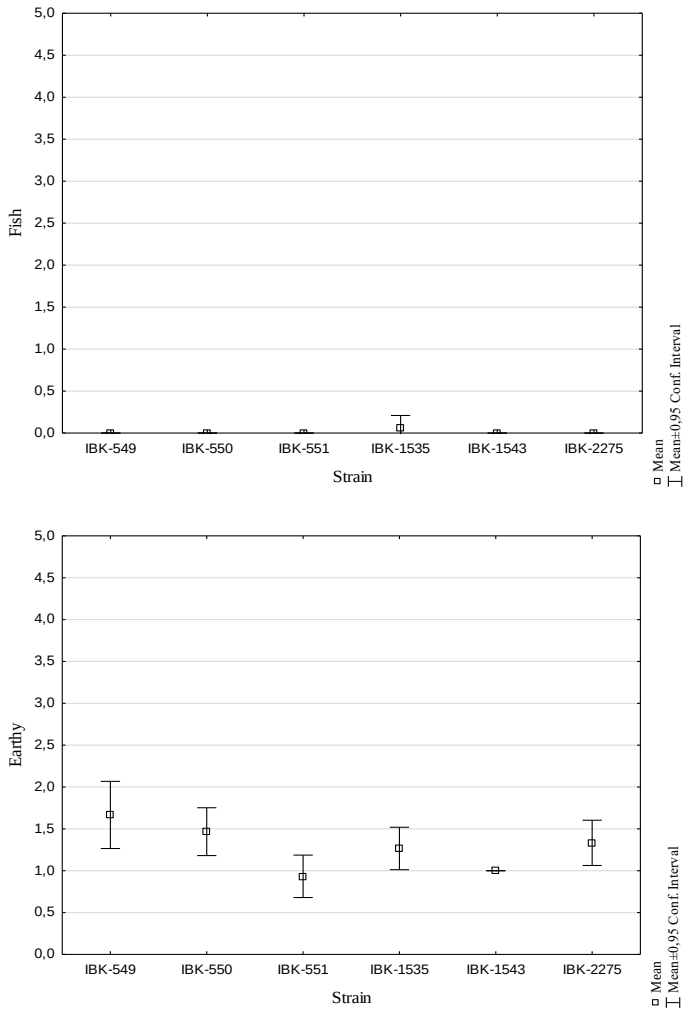


Figure 2 Box plots of mushroom, meat, woody, herbaceous, sweet, and floral, aroma attributes of *P. ostreatus* strains





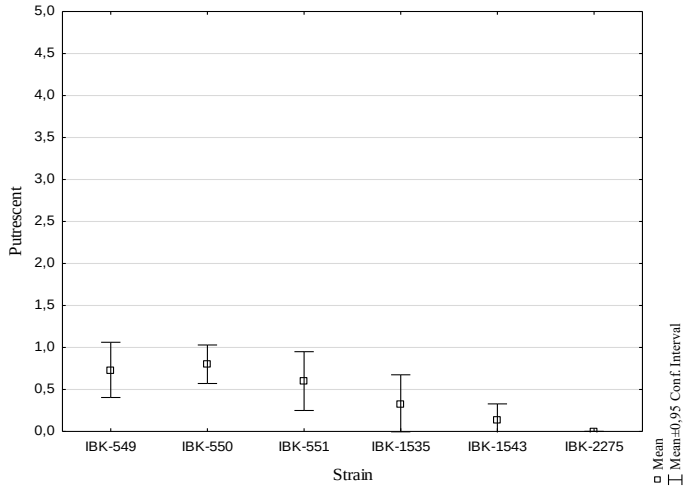


Figure 3 Box plots of sour, fish, meat, earthy, and putrescent attributes of *P. ostreatus* strains

In general, it should be noted that the strain IBK-550 was characterized by the lowest aggregate intensity of all identified components of the flavor. This is also clearly illustrated by the graphic representation of its profile in Figure 2 (the smallest area of the profile). In addition, this strain had the most pronounced sour and putrescent notes of aroma among all investigated *P. ostreatus* strains.
The strains IBK-549, IBK-551 and IBK-2275 can be characterized as having an average intensity of flavor among the examined strains.

The most pronounced characteristic *P. ostreatus* flavor was observed for the fruit bodies of the IBK-1535 and IBK-1543 strains.

Ultraviolet spectroscopy

The registered UV absorption spectra of hexane mushroom extracts are presented in Figure 4.

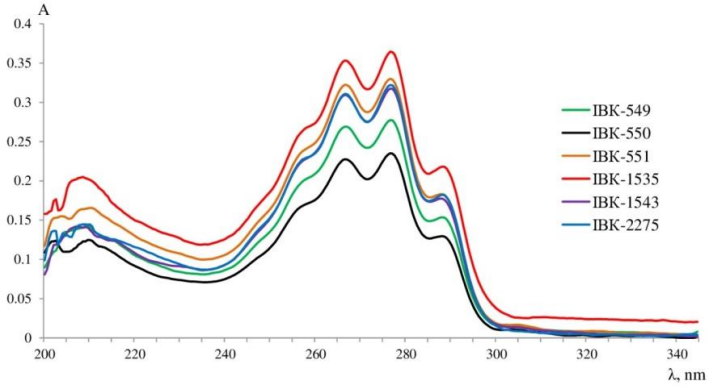


Figure 4 UV spectra of hexane extracts of dried samples of *P. ostreatus* strains

Hexane extracts of dried samples of *P. ostreatus* fruit bodies had light absorption maxima in the ranges of 200-210 nm and of 250-290 nm.

Analysis of volatile aroma substances of *P. ostreatus* showed that 1-octene-3-ol is the main compound providing its flavor. Its content in hexane extract is about 59,3 %. Also such compounds as 1-octen-3-one (1,2 %), 1-octan-3-one (5,3 %), 3-octanol (5,8 %), n-octanal (1,3 %), (E)-2-octenal (1,2 %) and n-octanol (1,1 %) are identified **(Nyegue *et al.*, 2003)**. Similar results are shown in the works of other authors **(Beltran-Garcia *et al.*, 1997; Zawirska-Wojtasiak *et al.*, 2009)**.

The UV absorption spectrum of 1-octene-3-ol in hexane (which has an ethylene chromophore) was obtained in our previous study. It has a light absorption maximum at 205-207 nm **(Vlasenko *et al.*, 2017)**.

Aliphatic aldehydes and ketones (carbonyl chromophore), which are present in extracts of *P. ostreatus*, have an absorption band in the range of 250-290 nm. Its position depends on the solvent and on the nature of the substituent near the α-carbon atom **(Vlasenko *et al.*, 2017)**.

The results demonstrated that the received spectra of hexane extracts of *P. ostreatus* strains differed in intensity of light absorption maximum. Thus, the spectrum of the strain IBK-1535 had the highest intensity in the whole range of wavelengths. Its optical density was in 1,4-1,6 times higher at 207-210 nm, and in 1,2-1,6 times higher in the range 250-290 nm than that of other strains. The spectrum of the hexane extract of the strain IBK-550 had the lowest optical density.

The received data of the spectroscopic analysis are fully consistent with the sensory analysis of the aroma compounds of the examined *P. ostreatus* strains.

CONCLUSION

This study allowed to characterize the most common industrial P. ostreatus strains in such an important consumer property as flavor of mushroom fruit bodies.

Using the methods of sensory profile analysis and ultraviolet spectroscopy, the intensity and main attributes of the aroma of the studied *P. ostreatus* strains were determined. The results demonstrated that among the investigated strains can be identified those which had the greatest intensity of flavor (IBK-1535 and IBK-1543).

The study was aimed at selecting *P. ostreatus* strains for industrial cultivation, which have the most pronounced characteristic aroma. This, in turn, will contribute to solving one of the main tasks of modern biotechnology for the cultivation of macromycetes – increasing the demand for edible mushrooms not only in Ukraine, but also in other countries.

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