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Research Article

PHYSICO-CHEMICAL PROPERTIES AND FATTY ACIDS COMPOSITION OF JATROPHA CURCAS SEED OIL IN JALINGO METROPOLIS, TARABA STATE, NIGERIA.

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ABSTRACT

Jatropha curcus is a perennial shrub belonging to the family of *Euphorbiacea*. It is native to tropical and subtropical regions and is widely distributed in many Countries. The present study evaluates the physicochemical properties and fatty acids composition of *Jatropha curcas* seed oil. Jatropha seeds were collected from Jalingo metropolis and was de-shelled to obtain the endocarp and properly picked to separate it from dirt's. The clean de-shelled seeds were processed mechanically to obtain the oil. Results for the physicochemical properties of the oil indicated that *Jatropha* seed oil contains (117.81 mgKOH/g) Saponification value, (9.20 mgKOH/g) acid value, (0.50 mEq/kg) Peroxide value and (12.69 g/100g) Iodine value; quantitative phytochemical on the seed oil indicated the presence of flavonoids, alkaloids, tannins and saponins in varied concentrations. Fatty acids screening of Jatropha Seed oil extract revealed the presence of oleic acid (33.14%) and lenoleic (32.95%). These parameters obtained revealed that Jatropha curcas seed oil has good physicochemicals, possess some essential fatty acids.

Keywords: Physicochemical properties, fatty acids, *Jatropha curcas*

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Introduction

Jatropha curcas is a species of flowering plant in the spurge family, Euphorbiaceae, which is native to the American tropics, most likely Mexico and Central America (Wulchafo & Geja, 2019). It is a semi-evergreen shrub or small tree, reaching a height of 6 metres (20 feet) or more (Contran, 2013). It is originally native to the tropical areas of the Americas from Mexico to Argentina, and has been spread throughout the world in tropical and subtropical regions around the world. The specific epithet *"curcas"* was first used by Portuguese doc Garcia de Orta more than 400 years ago. Common names in English include physic nut, Barbados nut, poison nut, bubble bush or purging nut. In parts of Africa and areas in Asia such as India it is often known as "castor oil plant" or "hedge castor oil plant", but it is not the same as the usual castor oil plant, *Ricinus*

communis (though are in the same family but different subfamilies) (Gadekar, 2006; Ayoku, 2022). In parts of Africa, it is known as: tabanani, kidi, bagani in Senegal, Gambia, Guniea, Sierra Leone and Ivory Coast; kpoti in Ghana and Togo; habb el meluk in Sudan; mupfure-donga, mupfure-wa-tshikhuwa, purgeerboontjie in South Africa and botute or omangba in Nigeria (Gbolade, 2009). The plant is resistant to a high degree of aridity which allows it to grow in deserts. It contains phorbol-esters, which are considered toxic (Goel *et al.*, 2016). However, edible (non-toxic) varieties native to Mexico also exist, known by the local population as *piñón manso, xuta, chuta, aishte*, among others (Martinez-Herrera *et al.*, 2010). *J. curcas* was believed to contain compounds such as trypsin inhibitors, phytate, saponins and a type of lectin known as curcin (Makkar *et al.*, 2009). The seeds contain 27 – 40% oil (average: 34.4%) that can be processed to produce a high-quality biodiesel fuel, usable in a standard diesel engine, though very purgative (Achten *et al.*, 2007). Edible (non-toxic) varieties, as those developed via selection by ethnic Mexican natives in Veracruz, can be used for animal feed and food (Atabani *et al.*, 2013).

Plate 1: *Jatropha curcas* seed

Plate 2: *Jatropha curcas* tree showing developing seeds

***Jatropha curcas* seed oil**

Jatropha curcas oil is a renewable energy and environmentally friendly alternative to petroleum-based fuels. Jatropha oil has a high octane rating, meaning it has good ignition quality and can be used directly in diesel engines without significant modifications (Goel *et al.*, 2016). It is biodegradable and emits fewer pollutants compared to diesel fuels, making it an attractive option for reducing carbon footprint (Goel *et al.*, 2016). In comparison, gasoline or diesel and Jatropha oil are both types of fuels commonly used in vehicles. Each fuel has its characteristics, advantages, and disadvantages (Gadekar *et al.*, 2006). Diesel fuel is derived from crude oil and is commonly used in diesel engines. Diesel has a higher energy density compared to petrol, which means it provides more energy per unit volume. Diesel engines are typically more fuel-efficient than petrol engines, meaning they consume less fuel per distance traveled. Diesel engines are known for their torque, making them suitable for vehicles that require heavy towing or hauling, such as trucks and large SUVs. However, diesel engines tend to produce more emissions, such as nitrogen oxides (NOx) and particulate matter (PM), which can contribute to air pollution therefore making them non-environmental friendly compared with *Jatropha curcas* oil which is a biofuel (Abdelgadir *et al.*, 2009). The use of biofuels can help mitigate the negative environmental impacts associated with traditional fossil fuel. This is one of the credentials that make *Jatropha curcas* oil highly relevant in the context of global sustainability and energy security (Aransiola *et al.*, 2014).

Materials and methods

Jatropha curcas seeds were collected from Jalingo metropolis of Taraba State, Nigeria. The seeds were de-shelled, cleaned and half

fried for 10 minutes adopted from Hussain *et al.* (2022) due to its volatile nature and were taken to a milling machine and later pound to paste.

Extraction methods

Extraction was done mechanically by continuously kneading the paste till it shows signs of oil coming out of it. Water was allowed to boil and about 100g of the kneaded paste of the *Jatropha curcas* was added to the boiling water and stirred continually for uniformity. This was allowed to boil for another 10 minutes with traces of oil forming on the surface of the water. The formed oil on the surface of the water was carefully scooped using a suitable spoon to obtain crude *Jatropha curcas* oil. The pure and clean oil were obtained after heating at a low temperature (35^{o}C) in a water bath for 2 hours, followed by careful decantation and filtration processes and was kept for analysis. The amount of oil extracted was determined using the equation;

Oil content (%) = Weight of oil extracted / weight of seed × 100

Determination of the Physicochemical Characteristics of the oils.

The extracted oil was immediately analyzed for chemical properties, such as: iodine, peroxide, acid and saponification value, while specific gravity, viscosity refractive index and colour were examined for the physical properties. Estimation of the percentage free fatty acids as oleic acid was done following the method of Ibeto *et al*. (2012). The refractive indices of the oil (at room temperature) was determined with an Abbe refractometer and the specific gravity measurement (also carried out at room temperature), using specific gravity bottle. The state and colour of the oil were noted, using visual inspection at room temperature. Viscosity and yield were determined, following the method described by Contran, (2013).

Determination of Iodine Value

One (1) gram of samples (W) was dissolved in 15mL carbon tetrachloride in a conical flask. 25.0 mL of 0.2N Hanus reagent (prepared by dissolving 9g of iodine trichloride in a mixture of 700 mL glacial acetic acid (purity at least 99%) and 300 mL carbon tetrachloride) was added from a burette. The flask was closed, mixed, and allowed to stand in the dark at about 20^{o}C for 1 hour. After standing, 20 mL potassium iodide solution and approximately 150 mL water was added. The iodine liberated by the process was titrated with sodium thiosulphate solution while shaking and starch indicator was added towards the end of titration (and volume S was recorded). Blank determination was carried out with the same quantities of reagents at the same time and under the same conditions (and volume B was recorded). Finally, the iodine value was calculated using (Equation 2).

$$Iodine\ Value = \frac{12.69\times(S-B)\times N}{W} \ldots\ldots\ldots (2)$$

Where, W = weight (g) of sample taken, S=Volume (mL) of thiosulphate solution used in test, B=Volume (mL) of thiosulphate solution used in blank and N =Normality of thiosulphate solution.

Determination of Acid Value

Two (2) grams of the oil sample was weighed into a 250 mL conical flask and dissolved in 25 mL of alcohol. Two drops of phenolphthalein indicator were added. The contents were titrated alcoholic KOH. Blank titration was performed on 100 mL of the titration solvent and 0.5 mL of the indicator solution, adding 0.1 mL increments of the 0.1 M KOH solution. The KOH solution was standardized frequently to detect morality change of 0.0005. The volume(S) of 0.1M KOH for the sample titration and volume (B) for the blank was noted. The total acidity (Acid Value) - **AV (**mg KOH/g)**)** was calculated using (Equation 3):

$$Acid\ value\ = \frac{56.1 \times (S - B) \times M}{W} \ldots\ldots (3)$$

Where; W = sample weight, S = Volume of KOH used for the sample (mL), B = Volume of KOH used for the blank (mL), and M= Molar Concentration of KOH used.

Determination of Free Fatty Acids (FFA) profile

One (1) gram of oil sample was weighed into a titration vessel. The sample was dissolve into 50 mL of solvent mixture (1:1ethanol and diethyl ether). Phenolphthalein solution (0.2 mL) was added and titrated while shaking with 0.1N potassium hydroxide solution until a pink colour persisted for at least 10 seconds. Simultaneously a blank test was carried out without any sample. Free fatty acids of the oil sample were determined by the calculation as**:**

$$FFA\ (\%) = \frac{\mathrm{S} \times \mathrm{N} \times \mathrm{MW}}{10 \times W} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where: N = normality of KOH (0.1N), S=titre value of KOH use, MW= molecular weight of fatty acid and W= Weight of sample.

Calculations for different components of the free fatty acids values were determined by substituting each of the acid molecular weights in the equation using the following molecular weights:

Determination Saponification value.

Half gram (0.5g) of the oil was weighed into a 250 mL conical flask fitted with an air condenser. It was dissolved in 10ml alcohol and 10ml of 2.5 KOH Solution. The flask was refluxed on a heating mantle for about 2 hrs, it was cooled and 2 drops of phenolphthalein was added and titrated with standard 1 m oxalic acid until the pink color disappeared The same procedure and the same reagents was performed without the sample to determine the titre value for the blank.

W= Weight of oil

V1=Volume of 1m oxalic acid for blank

V2=Volume of lm oxalic acid for sample. Using the formula Sap Value = 56 (V1 – V2) X 100 /200 X W

Determination of Peroxide value

An amount of 3g of oil sample was transferred into a 250 mL Erlenmeyer flask. The sample was dissolved with 10 mL of chloroform by swirling the solution-sample mixture. Then 15 mL of acetic acid and 1 mL of KI solution were added and the mixture was placed in a dark place for 15 minutes. After the 15 minutes' period, 1 mL starch solution was added and titrated with 0.01N sodium thiosulfate until blue color disappeared. A blank determination was

carried out without a sample. The peroxide value of the samples was determined as:

$$PV = \frac{(S - B) \times T \times 100}{m} \ldots\ldots\ldots\ldots (5)$$

where

S = volume of thiosulfate solution required to titrate the sample [mL],

B = volume of thiosulfate solution required to titrate the blank determination [mL]

T = titre of the sodium thiosulfate solution [normality]

m = Mass of sample (g).

Specific gravity

The specific gravity of the oil sample was determined using a density bottle according to the methods described by AOAC, (2000). The oil was vacuum-filtered to remove any suspended particles. The weight of 50 mL empty density bottle was recorded and the density bottle was filled with water. An equivalent quantity of oil was replaced with the water in the same bottle and weighed. The specific density of the oil was calculated using the expression;

$$Specific\ Density = \frac{W1 - W0}{W2 - W0} \ldots\ldots\ldots (7)$$

where;

W_o = Weight of empty density bottle (g), W_1 = weight of density bottle filled with water (g) W_2= weight of density bottle filled with oil (g).

Test for Flavonoids

Flavonoid content was determined using the method of Aiyelaagbe and Osamudiamen (2009).

Little quantity of each powder was dissolved in water and filtered and 2 ml of 10 % aqueous sodium hydroxide was added and a yellow coloration was observed. Few drops of hydrochloric acid were then added and a change in color from yellow to colorless confirmed the presence of flavonoids

Test for Alkaloids

Alkaloid contents were determined using the method ascribed to Aiyelaagbe and Osamudiamen (2009). 0.2 g each powder was stirred with 5 ml of 1 % aqueous HCl on water bath and then filtered. Each of the filtrates (1 ml) was taken into two separate test tubes. To the first portion, a few drops of Dragendorff's reagent were added. The formation of an orange-red precipitate shows a positive result for alkaloids. To the second portion, few drops of Mayer's reagent (1.36 g mercuric chloride and 5 g of potassium iodide dissolved in 100 ml distilled water) were added. The presence of buff-colored or yellow-cream precipitate confirmed the presence of alkaloids.

Test for Tannins

Tannin content was determined as ascribed by Aiyelaagbe and Osamudiamen (2009). Each of powder (0.5 g) was stirred with 10 ml of distilled water and filtered. Few drops of 1 % ferric chloride solution were added to 2 ml of the filtrate. The formation of blue-black, green or blue-green precipitate, indicates the presence of tannins.

Test for Saponins

Saponin contents were determined using the method as described by Aiyelaagbe and Osamudiamen (2009). One gram of each of powder was boiled with 5 ml of distilled water and filtered. Exactly 3 ml of distilled water was further added to the filtrate and

shaken vigorously for about five minutes. Formation of a stable persistent froth, indicate the presence of saponins.

Fatty acids composition was carried out using standard analytical methods.

Results

The results for the physicochemical properties of *Jatropha curcas* seed oil is shown in Table 1. It has a saponification value of 117.81 mgKOH/g, 9.20 mgKOH/g acid value, 0.50 mEq/kg Peroxide value and 12.69 g/100g Iodine value (see Table 1 and 2).

Quantitative phytochemical analysis of the seed oil revealed the presence of flavonoids, alkaloids, tannins, and saponins at varying quantities (see Table 3).

Fatty acid analysis of Jatropha Seed oil extract revealed the presence of oleic acid (33.135%) and linoleic (32.95%) (see Table 4).

Table 1: Physicochemical properties of *Jatropha curcas* seed oil

Saponification Value (mgKOH/g)	Acid Value (mgKOH/g)	Peroxide value (mEq/kg)	Iodine value (g/100g)
117.81	9.20	0.50	12.69

Legendary: (AV = 9.20), (SV = 117.81), (PV = 0.50), (IV = 12.69)

Table 2. Physicochemical parameters of *Jatropha curcas* seed oil in comparison with standard values of diesel.

S/N	Parameters	Values of *Jatropha* oil	Values of Diesel
1	Acid value (mgKOH/g)	9.20	0.50
2	Saponification value (mgKOH/g)	117.81	190.00
3	Peroxide value (mEq/kg)	0.50	0.60
4	Iodine value (g/100g)	12.69	50.00

Table 3: Phytochemical contents in *Jatropha curcas* seed oil

Flavonoids (%)	Alkaloids (%)	Tannins (%)	Saponins (%)
7.50	5.11	9.21	13.07

Table 4: Fatty acid compositions *Jatropha curcas* seed oil

Sample	Oleic Acid (%)	Linoleic Acid (%)
Jatropha Seed Oil	33.14	32.95

Discussion

Some physicochemical properties, the acid, saponification, peroxide, and iodine value of *Jatropha curcas* seed oil were determined to be 9.20 mgKOH/g, 117.81 mgKOH/g, 0.50 mEq/kg, and 12.69 g/100g, respectively. These findings were juxtaposed with the standard specifications for diesel, where the acid value should be less than 0.5 mgKOH/g, the peroxide value should be ideally 0.6 mEq/kg, and the iodine value should ideally be 50 g/100g (Atabani, 2013).

The acid value of a substance, indicates the amount of acidic substances present in the oil (Rahman *et al.,* 2022. With an acid value of 9.20 mgKOH/g, we can infer that *Jatropha* oil contains a significant amount of free fatty acids. This can have both positive and negative implications depending on its intended use. On the positive side, the high acid value in *Jatropha curcas* seed oil, is an indication that it's suitable for certain industrial applications where acidity is desirable, like the production of biodiesel (Carels, 2009; Edrisi *et al*., 2015). In biodiesel production, free fatty acids can be converted into biodiesel through a process called transesterification. Therefore, oils with higher acid values can sometimes be more cost-effective for biodiesel production as they require less pre-treatment to remove free fatty acids. However, on the negative side, high acidity can also indicate poor quality or improper storage of the oil. Elevated acid values can lead to undesirable flavors and odors in food products if the oil is intended for culinary use. Additionally, high acidity can accelerate the degradation of the oil, reducing its shelf life and stability (Sharma and Duraisamy, 2019). Relatively higher acidic value in *Jatropha curcas* seed oil, compared to the standard petrol and diesel, which ideally should be 0.5 mgKOH/g, may impact on the stability and combustion efficiency of *Jatropha curcas* seed oil as a fuel source. The elevated acid content could potentially affect its stability and corrosiveness in engines and fuel systems, necessitating further investigation into acid neutralization processes during biodiesel production.

The result of the saponification value of *Jatropha curcas* seed oil revealed its potential for use in biodiesel production. The value provides valuable information about the oil's composition and potential applications. The saponification value represents the amount of potassium hydroxide (KOH) required to saponify or neutralize one gram of the oil and it is significant in the soap-making industry, as it indicates the oil's suitability for soap production (Sharma and Duraisamy, 2019).

Oils with higher saponification values typically contain more fatty acids, making them ideal for soap-making because they yield more soap per unit weight of oil. In the case of *Jatropha curcas* seed oil, its relatively high saponification value suggests that it is a good candidate for soap production . Its fatty acid composition likely includes a significant proportion of long-chain fatty acids, which are crucial for soap formation. These fatty acids react with alkali (KOH) during the saponification process to produce soap and glycerin.

Moreover, the saponification value can also offer insights into the oil's potential for other industrial applications, such as biodiesel production. While biodiesel production primarily relies on the transesterification of triglycerides into biodiesel, the saponification value can still be relevant as it indicates the oil's overall fatty acid content (Sharma and Duraisamy, 2019). However, it's essential to consider other factors, such as the oil's acid value and impurities, when determining its suitability for specific applications (Edrisi *et al*., 2015).

It is noteworthy that the value for conventional diesel (around 190 mgKOH/g), could affect fuel's performance in terms of lubricity and combustion characteristics (Mujtaba *et al.,* 2020). This finding aligns with the observations made by Patel *et al.* (2017), who emphasized the significance of saponification value in determining the suitability of vegetable oils for biodiesel production. They stated that, lower saponification value of *Jatropha curcas* seed oil may influence its compatibility with diesel engines and could necessitate adjustments in fuel formulation and engine calibration for optimal performance.

The peroxide value of oil is a crucial parameter used to assess the extent of primary oxidation in the oil (Ibeto *et al*., 2012). A low peroxide value indicates that the oil has undergone minimal oxidation and is relatively fresh. This is desirable for both culinary and industrial applications, as it ensures the oil's quality, flavor, and nutritional value are preserved. In culinary applications, oils with low peroxide values are preferred because they have a longer shelf life and are less likely to develop off-flavors and odors associated with rancidity. Fresh *Jatropha curcas* seed oil with a low peroxide value can be used in cooking, salad dressings, and other food preparations without negatively impacting the taste or aroma of the final dishes (Ibeto *et al*., 2012). In industrial applications, such as biodiesel production, oils with low peroxide values are also desirable because they are more stable and less prone to degradation during processing and storage. Oxidized oils can lead to increased acidity, viscosity, and formation of harmful compounds, which can affect the quality and efficiency of biodiesel production (Becker *et al.,* 2013). To maintain a low peroxide value in *Jatropha curcas* seed oil, proper storage and handling practices are essential. Exposure to light, heat, and air can accelerate oxidation, leading to an increase in peroxide value over time. Therefore, storing *Jatropha* oil in a cool, dark place in airtight containers can help preserve its freshness and quality. Regular monitoring of peroxide value is also crucial for quality control purposes. Elevated peroxide values may indicate that the oil has started to oxidize and

requires immediate attention, such as refining or antioxidant supplementation, to prevent further deterioration (Becker *et al.,* 2013). The peroxide value of *Jatropha* oil, at 0.50 mEq/kg, suggests a relatively low level of oxidative rancidity compared to the standard range of 10 - 20 mEq/kg for diesel. This could imply better oxidative stability, which is advantageous for fuel storage and transportation (Becker *et al.,* 2013).

The iodine value of *Jatropha curcas* seed oil was 12.69 g/100g, and it is a measure of the oil's unsaturation level. This value is significant because it provides insights into the oil's fatty acid composition and its potential applications as biodiesel. A low iodine value suggests that the oil contains fewer unsaturated fatty acids, while a high iodine value indicates a higher proportion of unsaturated fatty acids. In the case of *Jatropha curcas* seed oil, its relatively low iodine value indicates that it contains a lower concentration of unsaturated fatty acids compared to other oils. In biodiesel production, oils with lower iodine values are preferred because they produce biodiesel with better oxidative stability and lower susceptibility to polymerization during storage (Ibeto *et al.,* 2012). Therefore, Jatropha oil's lower iodine value makes it a favorable feedstock for biodiesel production, contributing to the development of sustainable energy solutions (Carels, 2009; Edrisi *et al*., 2015).

The quantitative phytochemical test of the oil extracts indicated the presence of flavonoids in a moderate quantity 7.50%, alkaloids 5.11%, tannins 9.21% and saponins 13.07%.

The significance of flavonoids present in this oil as a naturally occurring compound makes it potential for antioxidant properties because they play a role in protecting it from oxidative damage which can cause degradation of cells (Akbari *et al.,* 2022). Flavonoids could contribute to the oil's colour and taste depending on the specific type of flavonoid. This could potentially prolong its shelf life and prevent it from going rancid. The antioxidant and anti-inflammatory properties of flavonoids can help improve the quality and stability of the biofuel, making it suitable for use in internal combustion engines (Corte-Real *et al*., 2016). Additionally, the potential of flavonoids to reduce harmful emission and improve the ignition quality of the fuel makes them an attractive option for biofuel production. The presence of flavonoids in the oil makes it fit for the biofuel production because it helps improve the combustion characteristics of the fuel, it can help to reduce the formation of harmful emission such as particulate matter and nitrous oxide when the fuel is burned. It also helps to reduce oxidative degradation of the oil during storage thereby making the biofuel more stable and less prone to spoilage (Kumar and Tewari, 2015).

Alkaloids which are nitrogen-containing compounds in this oil have a wide range of biological activities including been toxic, sedative or hallucinogenic, its presence in this study makes it potentially dangerous for human consumption or use especially if the alkaloids are highly concentrated. Alkaloids in the oil like phorbol and fufofuran makes it toxic for both humans and animals. This percentage could limit the safe use of the oil if ingested orally or applied on the skin. It is

important to be cautious when using plant products that contain high alkaloid contents such as *Jatropha curcas* seed oil (Mamta and Jyoti, 2012).

Tannins are commonly found in the bark of trees, woods, leaves, buds, fruits and seeds of plants. They are used in photography, as mordant in dyeing and beer by precipitating proteins out of them and as astringents in medicine. Tannins have been reported to exert other physiological effects such as to accelerate blood clotting, reduce blood pressure, decrease serum lipid level and immuno-responses (Obasi *et al*., 2011).

Saponins in the oil make it more effective as a surfactant or emulsifier in certain applications such as in the production of detergents or emulsified food products. This content of saponins can cause foaming and lathering which could be undesirable in some applications and can affect the stability of the oil as saponins have a destabilizing effect on oil-water emulsion and it could be toxic for humans and animals (Sarma and Babu, 2011).

Flavonoids and saponins are the phytochemicals that make the seed oil of *Jatropha curcas* fit and suitable for the production of biofuel because flavonoids act as antioxidants that can increase the stability and shelf life of the biofuel while saponins are surfactants that improves the miscibility of the oil with water, making it easier to blend with diesel fuel (Song and Ying, (2017)).

Jatropha curcas seed oil mainly consists of oleic and linoleic acids. This is important to consider for biofuel production because these fatty acids affect the viscosity and stability of biofuels (Kumar & Das, 2018). Oleic acid is a monounsaturated fatty acid that contributes to lower viscosity in biodiesel. Biodiesel produced from feedstock with high oleic acid content, such as olive oil, canola oil, or high oleic sunflower oil, typically has better cold-weather performance due to its lower cloud point and pour point. Regarding stability, oleic acid is less susceptible to oxidation than polyunsaturated fatty acids like linoleic acid, resulting in greater oxidative stability for biodiesel with higher oleic acid content (Ewunie *et al*., 2021).

CONCLUSION

In conclusion, *Jatropha curcas* seed oil obtained from Jalingo metropolis has good physicochemical property, phytochemicals and fatty acid – oleic and linoleic acids which are good credentials in biodiesel production.

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