

RESEARCH ARTICLE

Economic Benefits and Adoption of Orange-Fleshed Sweetpotato Production Enterprise among Farmers

J. C. Udemezue¹, C. J. Eluagu¹, N. T. Azodo¹, F. N. Odia², N.A. Onwuneme¹

¹National Root Crops Research Institute Umudike, PMB, 7006 Umuahia, Abia State, Nigeria, ²Department of Agricultural and Bioenvironmental Engineering Technology, Delta State Polytechnic, Ogwashi Uku, Nigeria

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ABSTRACT

The income generation and employment status of root and tuber crops in Nigeria today are not a paradox per say but a reality that secured about 50% jobs for the majority of youths in the rural areas. Orange-fleshed sweetpotato (OFSP) varieties have the complimentary capacity to diversify Nigerian economy into multiple facet one for nation building. Therefore, they are the entry points for development through income and employment generation as well as poverty reduction. In rural area like Nigeria, most households cannot afford food products rich in Vitamin A and this gave rise to the introduction of biofortified agricultural products such as OFSP varieties (OFSVs). OFSP is an improved breed of sweetpotato (*Ipomoea batatas* [L.] Lam.) that can be cultivated in tropical and semi-tropical regions of the world for food and source of income, especially among the rural dwellers. Vitamin A deficiency is a major risk factor for children, pregnant and lactating women and can even lead to premature death as well as untimely blindness if care is not taken. In the light of this, this paper used analytical approach to review the following; potentials of OFSP variety, OFSVs in Africa, tips for marketing and popularizing OFSP, determinants, and levels of adoption of OFSP production in Nigeria and Ghana.

Key words: Farmers, potentials, adoption, marketing, orange-fleshed sweetpotato

INTRODUCTION

Sweetpotato which is one of the most important but underutilized food crops in the world has now attracted people's concern globally to feed the low-income earners across the world (Adesina *et al.*, 2019). This is because the special nutrition need by people has shifted their focus to the adoption of orange-fleshed sweetpotato (OFSP) for consumption due to its high content of Vitamin A. Sweetpotato (*Ipomoea batatas*) is among the world's most important and underutilized food crops, covering around 3.2 million hectares in sub-Saharan Africa (SSA), with an estimated production of 13.4 million tons of roots in 2005 (Andrade *et al.*, 2009).

According to Udemezue (2019), Nigeria is the second largest producer of sweetpotato in the world after China with an annual output of 3.46 million metric tons/year. Sweetpotato (*I. batatas* L.) is a dicotyledonous plant from the morning glory family (Convolvulaceae), which produces roots that are edible (Yahaya *et al.*, 2015). It has the ability to thrive in less fertile soils, but beyond this, the broad agro-ecological adaptability of the crop makes it a food security and staple crop as it can be grown in all of Nigeria's 36 states (eHealth Africa, 2016; Maru, 2017; Sugri *et al.*, 2017). As a staple crop, it has been fortified in key vitamins, especially Vitamin A and minerals whose deficiency in most rural diets continues to pose a very serious constraint to human health and economic development (Global Panel, 2015; Chah *et al.*, 2020).

Vitamin A deficiency (VAD) is a major risk factor for pregnant and lactating women and also a leading

Address for correspondence:

J. C. Udemezue,
E-mail: udemezuej@gmail.com

cause of visual impairments such as xerophthalmia, corneal scars, and corneal xerosis (Tariku *et al.*, 2016). In extreme cases, it leads to premature death in children and pregnant women (United State Agency for International Development, 2016). Globally, about 3 million preschool children have been reported to present ocular signs of VAD (Mendu *et al.*, 2019). In SSA, it has been estimated that 43 million children under the age of 5 are Vitamin A deficient (Stathers *et al.*, 2018). In Nigeria, the prevalence of VAD affects 29.5% of her population, resulting to the World Health Organization listing Nigeria as one of the number one countries (eHealth Africa, 2016) with the highest risk of VAD (Kuku-Shittu *et al.*, 2016).

In rural Nigeria, most households cannot afford food products rich in Vitamin A and this gave rise to the introduction of biofortified agricultural produces like OFSP varieties (OFSVs) (Babatunde *et al.*, 2019). OFSP is an improved breed of sweetpotato (*Ipomoea batatas* [L.] Lam.) cultivated in tropical and semi-tropical regions of the world for food and source of income, especially among the rural dwellers (Adebisi, *et al.*, 2015; Nyor *et al.*, 2017). It can be grown in wide range of agro-ecologies and soil types. OFSP is easy to cultivate, it is a crop with immense ability to grow in marginal fields (Afuape, 2014). It can be vegetatively propagated and has fairly drought resistant ability once established. It has short maturity period compare to other root and tuber crops. These characteristics make OFSP an excellent food security crop in SSA (Nyor *et al.*, 2017).

In the 1990s, scientists at the International Potato Center (CIP) and National Root Crops Research Institute, Umudike, Nigeria, identified a group of OFSVs with high content of β -carotene (a chemical element used by the body to generate Vitamin A) and sufficient dry matter to satisfy consumer preferences and taste. Subsequent studies demonstrated that the consumption of just small amounts of foods derived from the new OFSVs could eliminate or greatly reduce Vitamin A deficiencies in both young children, pregnant and lactating women (HarvestPlus, 2003). In 2001/02, an international crop-based initiative to combat VAD in SSA was launched – known as VITAA or Vitamin A for Africa – involving agronomists, health experts, and nutritionists. This initiative was aimed at expanding

the impact of the OFSVs in seven countries: Kenya, South Africa, Tanzania, Ethiopia, Uganda, Ghana, and Mozambique.

According to Njoku and Umoh (2013), the first variety of OFSP was released in December 2012, and the second variety was released in June 2013 in Nigeria, particularly Kwara State, by “reaching agents of change organization” and over 20,000 farmers have since received at least one bundle of OFSP vines to plant and access its roots for either consumption or commercialization (Olapeju, 2015). The new OFSVs available in Nigeria are: Solo Gold (*UMUSPO4*): This was officially released in July 2018 making the total number of OFSVs in Nigeria to three. The other two are *UMUSPO3* referred locally as “Mothers Delight” and *UMUSPO1*, which is known as “King J.” “Solo Gold has special characteristics preferred by farmers such as a higher dry matter when compared to Mothers Delight and much higher beta carotene content when likened to King J. Also, it’s tolerant to sweetpotato weevil and resistant to sweetpotato viral disease. It matures in 3–4 months.” These characteristics make Solo Gold a good candidate for farmer and consumer adoption across Nigeria.

It is commonly consumed as a vegetable (boiled, fried, or roasted) as well as in different products through processing and value addition for improved household food intake. These foods include amala (swallows), puff-puff, chips, cake, gari, vegetable soup, doughnut, pottage, bread, chin-chin, juice, and kunu. OFSP products can be commercialized for income generation, job, and wealth creation for all, especially women and youth (Sweetpotato knowledge portal, 2020). In view of the above, this paper used available literature to assess the economic analysis and adoption of OFSP production enterprise in Nigeria.

POTENTIALS OF OFSP VARIETY (OFSPV)

The income generation and employment status of root and tuber crops in Nigeria today are not a paradox per say but a reality that secured about 50% jobs for the majority of youths in the rural areas. Root and tuber crops have the complimentary capacity to diversify Nigerian economy into multiple facet one for nation building. Therefore, root and tuber

crops are the entry points for development through income and employment generation as well as poverty reduction (Udemezue *et al.*, 2017)

According to Babatunde *et al.* (2019), deficiency in Vitamin A is one of the most prevalent problems, particularly in SSA. The functional consequences of VAD have been associated with 23% increase in preschool mortality in areas with endemic VAD. VAD is also widespread among young children in the developing world with approximately 127 million children under 6 years of age estimated to be affected. VAD can limit growth, weaken immunity, cause xerophthalmia leading to blindness, and increase mortality (McLaren and Frigg, 2001; Babatunde *et al.*, 2019). Poor households typically cannot afford to consume the highly bioavailable animal foods on a regular basis and so they prefer to go for the plant sources one of which is OFSP.

OFSP is like medicine, it contains high provitamin A that improves vision, strengthens the immune system, and helps the body to fight the disease; as an antioxidant, it detoxifies the body of free oxygen radicals that damage body cells, DNA, proteins, and lipids, prevents accelerated aging through its antioxidant activities (Afube, 2021). Sweetpotato roots vary in color, with the OFSP (*I. batatas* L.) being particularly rich in β carotene, the most important proVitamin A carotenoid. It is one of the starchy staple crops which contain ascorbic acid and amino acid lysine that is deficient in cereal-based diets like rice. It also contains soluble fiber which helps in reducing cholesterol concentration and antioxidant nutrients which can inhibit the development of coronary heart disease.^[1-8]

According to Williams *et al.* (2013), the leaves of OFSP contain chlorogenic acids, a phenolic compound responsible for suppressing obesity in humans. They also contain considerably higher amounts of minerals such as phosphorus, nitrogen, potassium, magnesium, copper, iron, and zinc than what is contained in commonly cultivated vegetables (Shi *et al.*, 2008). OFSVs have recently gained great attention as a means of reducing common health-related problems associated with VAD in low-income communities. This variety is believed to be the least expensive source of dietary Vitamin A available to poor families (Laurie *et al.*, 2013; Babatunde *et al.*, 2019). The potential of OFSPs contribution to food security, increased

incomes, and reduction of nutritional deficit is enormous. However, this is yet to be fully exploited in developing countries including Nigeria.

Beta-carotene is an organic, strongly colored red-orange pigment abundant in plants and fruits. Beta-carotene is what gives OFSP an orange color and is converted to Vitamin A in the body after consumption. The orange color of OFSP is indicative of the level of beta-carotene present; the more intense the color, the more Vitamin A present. OFSP also has powerful antioxidants that help prevent cancers, as well as natural sugars, which are slowly released into the bloodstream, helping to ensure a balanced source of energy, without the spikes in blood sugar that are sometimes associated with fatigue and weight gain.

In Nigeria, OFSP like other breeds of sweetpotato is grown in all parts of the country, but commercial cultivation appears to be large in Northern, semi-arid agro-ecological zone of the country covering Benue, Nasarawa, Plateau, Kogi, Kwara, and Niger states (Nyor *et al.*, 2017). Sweetpotato has a number of agricultural and industrial uses as well. Sweetpotato vines, leaves, and roots are used for animal feed for sheep, goats, and rabbits (Tewe *et al.*, 2003; Nyor *et al.*, 2017). Sweetpotato can also be exploited for ethanol and biofuel production. Sweetpotato can be processed to yield about 137 liters of ethanol per metric ton of sweetpotato tubers (Akoroda, 2009; Nyor *et al.*, 2017). Like other breeds of sweetpotato, OFSP can be grown under different production systems. While some farmers prefer sole cropping system, others intercrop sweetpotato with pigeon pea to ensure better environmental resource utilization, better yield stability, reduction in pests and diseases, and diversification of rural income.^[9-18]

Improving the efficiency with which farmers use the available resources is very crucial to increasing production, productivity, household income, food security, poverty reduction, and overall economic growth. An efficient OFSP enterprise will naturally attract more investment. The crop has the potential to diversify the farming system; spread risks contribute to food security and provide income opportunities for the most vulnerable farmers particularly. Therefore, if sweetpotato commercialization efforts are to be put in place, then a majority of the farmers would be better off (Udemezue *et al.*, 2018).

Forty-three million children under the age of 5 across SSA are Vitamin A deficient, as are large numbers of older children and adults, particularly pregnant women. VAD is one of the most damaging forms of undernourishment. It reduces immunity to disease, resulting in higher incidence of disease-related death, increased burdening of the already stretched health-care systems, and indirect costs related to lost productivity and lost economic development. Undernourished children are at a high risk of impaired mental development, which will eventually adversely affect their country's productivity and growth, as such children will be less innovative or able to respond opportunities even as adults than their healthy counterparts. A poor diet and frequent infections lead to VAD. Those at a particularly high risk of VAD are young children, due to their body's rapid growth, and pregnant or lactating women, who have special micronutrient requirements. VAD can be addressed in different and complementary ways: Taking supplement capsules, eating fortified foods, and adopting long-term, sustainable, food-based approaches where locally produced foods rich in Vitamin A are actively consumed as part of a balanced and diverse diet. Each of these strategies has advantages and shortcomings, which highlights the need for an integrated approach to addressing VAD (Stathers *et al.*, 2015). OFSP is not only a high-energy food but it also contains high levels of beta-carotene, which is converted into Vitamin A in our bodies. OFSP is a healthy, delicious, and affordable food that can be enjoyed in numerous forms. The roots can be eaten after boiling or roasting or mashed into a puree for use in a range of nutritious products including breads, chapatis, cakes, juices, and porridge. Sweetpotato is a low input, low risk crop that is grown widely across SSA. Throughout history, it has played an important role in saving people from famine. Sweetpotato produces more biomass and nutrients per hectare than any other food crop in the world. In most locations across SSA, an area of just 500 m² of OFSP crop can provide enough Vitamin A for a family of five each year. Across Africa, sweetpotato is grown mainly by women, and where market linkages are established, it can enhance women's incomes, in addition to serving its nutritional and food security roles (Stathers *et al.*, 2015).

OFSVS IN AFRICA

Sweetpotato is said to have been originated in Central America more than 10,000 years ago, the exchange and movement of its planting materials between farmers and locations throughout the years have showed that the thousands of varieties of sweetpotato have now existed across the world. These varieties differ in many ways, including leaf shape and color, vine structure, root shape, skin and flesh color, taste, texture, dry matter content, pest and disease resistance, and yield. The flesh of sweetpotato roots comes in an amazingly wide range of colors, from white, through yellow to deep orange and even deep purple, it also differs by taste, texture, and dry matter content. The colors are natural and not the result of genetic modification. The deeper the orange color of the flesh, the higher the beta-carotene content. The varieties farmers plant is influenced by the varieties they can access and what they plan to use the crop for instance, food, selling, processing, animal feed, etc., as well as the local pest and disease pressures, agro-ecological factors, climate, and the length of the growing season. Most locations have a few dominant sweetpotato varieties that farmers grow. However, researchers and farmers are constantly developing and evaluating new varieties, and the predominant varieties do change over time. Farmers obtain new varieties through neighbors, agricultural extension or NGO officers, traders, research stations, and specialized seed producers. Sweetpotato breeding programs work closely with farmers and consumers to select new varieties. Breeding a new sweetpotato variety is complex and expensive. It takes about 4 years and involves building crossing blocks; establishing seedling nurseries; and carrying out observations, yield assessment, and advanced and on-farm participatory trials before the official release of the variety. However, using popular varieties from neighboring countries are a good shortcut for acquiring new varieties. Some of the OFSVs recently released in different SSA countries are shown in Table 1. The OFSP for Africa catalogue for 2014 is available on the Sweetpotato Knowledge Portal (www.sweetpotatoknowledge.org) and has a contact list of breeders in these countries. The CIP Support Platform (cip-nbo@cgiar.org) can also assist investors in identifying

Table 1: Orange-fleshed sweetpotato varieties in sub-Saharan African countries

Countries	OFSP varieties released
Mozambique	Tio Joe, Namanga, Bela, Lourdes, Ininda, Irene, Cecilia, Erica, Delvia, Melinda, Amelia, Sumaia, Esther, Jane, Gloria (bred especially for drought tolerance)
Tanzania	Mataya, Kiegea, Ejumula
Nigeria	King J (Umuspo/1), Mother's Delight (Umuspo/3) and Solo-Gold(Umuspo/4)
Ghana-	Bokye, CRI-Apomuden
Burkina Faso	Tiebele, Bagre, Jewel, BF138, BF139 (registered in 2014)
Malawi	Zonden, Ana Akwanire, Kadyaubwerere, Mathuthu, Kaphulira, Chipika
Uganda	SPK004 (Kakamega), Ejumula, NASPOT 8, Vita (NASPOT 9 O), Kabode (NASPOT 10 O), NASPOT 12 O, NASPOT 13 O
Kenya	KENSPOT-3, KENSPOT-4, KENSPOT-5, SPK004 (Kakamega), Kabode (NASPOT 10 O), Vita (NASPOT 100)
Rwanda	97-062 (Gihingamukungu), SPK004 (Kakamega), Caceapedo, RW11-2560, RW11-4923 and RW11-2910 (Ndamirabana)
Ethiopia	Kulfo, Tulla, Birtukane, Kero, Guntute, Koka-12
Zambia	Zambezi, Kalunguwishi, Lukusashi
South Africa	Bophelo, Impilo, Khano, Serolane, Purple Sunset, Isondlo. USA cultivars being distributed are Resisto, Beauregard, W-119

Source: Stathers *et al.* (2015)

the best bet OFSVs for each specific African agro-ecology. Viruses and other diseases can dramatically reduce the yields of sweetpotato varieties, and so it is important to ensure that planting materials are disease free. Tissue culture can be used to produce large quantities of clean planting materials. The tissue cultured plantlets can then be hardened-off and grown in screen houses to produce a large quantity of disease-free planting materials for use in variety trials and for dissemination to trained farmer vine multipliers, who will then produce sufficient quantities of clean planting materials for the direct beneficiary households (Stathers *et al.*, 2015).

As performance of a variety varies depending on agro-ecological situations, there is a need for farmers and their agricultural service providers such as extensionists, NGOs, and researchers to test varieties so that they can select those that perform well in their specific locations and meet their intended use requirements. This should be done with a representative range of farmers, including both men and women, as some farmers may be more interested in varieties with market related characteristics, while others may be on root or vine

yield or cooking qualities. Once several suitable OFSVs have been identified, demonstration trials with promotional field days should be organized. Such events will provide many more farmers, traders, processors, and consumers with the opportunity to view, handle, and taste the OFSVs. Handouts can be prepared with photos, names, and characteristics of the different varieties and contact details of the vine multipliers who will later assist farmers and traders obtain the planting materials or roots.^[19-27]

TIPS FOR MARKETING AND POPULARIZING OFSP

OFSP can be marketed and promoted through radio or TV programs or jingles, billboards, community theater, songs or short videos with sticking messages that last, posters, and promotional materials with an inscription of OFSP production and use. Other approaches are using the orange color to create brand images, such as creating market stalls for selling OFSP, OFSP product labels and outfits for trained OFSP extension staff, establishing variety demonstration plots, organizing product tasting events, painting slogans on vehicles, caps, T-shirts and wraps worn by women, organizing stakeholder meetings with local leaders or health service professionals, running group nutrition sessions, cooking demonstrations and counseling sessions with parents of malnourished children, organizing field days and advertising campaigns with subsidized new OFSP products and planting materials, integrating OFSP information, and planting material vouchers and food-based nutrition training into child health days when Vitamin A capsules are being distributed. This can help promote more sustainable nutritional behavior for the whole family, all of whom require Vitamin A as well as other micronutrients as part of a healthy diet. Providing training tools and aids to extensionist and community health workers or OFSP promoters.

DETERMINANTS AND LEVELS OF ADOPTION OF OFSP PRODUCTION IN NIGERIA AND GHANA

Agricultural technology adoption study has many policy implications in agricultural development.

It serves as a tool for evaluating the distributional impacts of new innovations, for documenting the impact of an innovation or extension effort, for identifying and reducing the constraints to adoption, and as a research guide for prioritizing innovation (Langyintuo and Mungoma, 2008, in Udemezue, 2021). In the light of this, adoption is defined as a decision to make full use of an innovation or technology as the best course of action available. Therefore, adoption at the farm level indicates farmers' decision to use a new technology in the production process to set the desired result as intended by the researcher.

Many studies have sought to explain farmer adoption of new technologies, including specific traits of improved varieties. A study, which evaluated the effect of women farmers' adoption of OFSVs in raising Vitamin A intake, found that several of the new OFSVs grown in on-farm trials were adapted to the agro-ecological conditions with respect to yield, pest and disease tolerance, as well as having reasonable beta carotene content. This study further stated that women farmers were likely to adopt the OFSVs if the clones were sufficiently high in starch, low in fiber, and if they were introduced through community-level education programs that focused on the health of young children (Hagenimana and Oyunga, 1999). According to this study, the new OFSVs were widely accepted (with respect to their appearance, taste, and texture) by both producers and consumers, and substantially contributed to the alleviation of VAD.

A study of the key factors associated with the adoption of innovation in Latin America by Kosarek *et al.* (2001), reported that farmers' decision to adopt technology was determined by the expected returns (i.e., profitability) of the technology, the availability of hybrid seed, and risks associated with uncertainty regarding the expected outcomes of the new technology. They also found that the structure of the seed market, the organization of the seed industry, and the cost of technology generation and development were key determinants of the profitability of supplying improved technology. As for OFSP in Africa, the adopters were observed to have a relatively higher knowledge of OFSP production techniques than the non-adopters. This implies that the non-adopters had a fairly high knowledge of OFSP. The probable reason

for this is that since most non-adopters cultivated sweetpotatoes as a minor crop; their responses to the knowledge questions were not based on OFSP but on their experiences with sweetpotato production. This signifies that their inability to adopt is not a function of low knowledge of sweetpotato production practices but probably for other reasons (Chah *et al.*, 2020).

The adopters generally noted that OFSP had a sweeter taste, was fast maturing, and showed higher yields than other sweetpotato varieties. Fast-maturing variety makes it possible for farmers to grow 3–4 cycles in a year; this increases profit. In congruence to this, Foster and Rosenzweig (2010) highlighted that a key determinant of the adoption of a new technology is the net gain to the farmer from adoption. Stathers *et al.* (2013) also opined that farmers would be motivated to adopt sweetpotato varieties with higher yield potential, sweet taste, and earlier maturity date, in addition to other favorable characteristics.

The major motivating factors for adopting OFSP indicated that adopters of the biofortified OFSP cultivate the variety not necessarily because of its health benefits, in terms of combating VAD (which is one of the major reasons for promoting its adoption), but for the sweeter taste and marketing profit. An earlier finding in this study revealed that the farmers mainly sourced information on OFSP from fellow farmers and the later may emphasize the financial benefits of venturing into OFSP production since OFSP has a higher yield potential than the other sweetpotato varieties. In agreement, Jenkins *et al.* (2018) reported that farmers in Mozambique were more willing to adopt OFSP because it was increasingly seen as a crop for business given its higher value when compared with white-fleshed sweetpotato.

It is important to note that farmers' perception about the characteristics of a technology may either encourage or hinder its adoption (Okello *et al.*, 2015). Perceived difficulties inherent in a technology can hinder its adoption. The non-adopters of OFSP cited the complexity of carrying out the recommended production practices of OFSP as well as difficulty in integrating OFSP into their existing production system as major barriers hindering their adoption of OFSP. The cost of the technology is another factor a farmer puts into consideration before adoption.

The non-adopters of OFSP noted that the costs of herbicides, OFSP vines, and roots discouraged them from adopting it (Chah *et al.*, 2020).

According to Adekambi *et al.* (2018), the suitable parameter in adoption studies is the full population adoption rate which provides an estimate of the possible demand of the OFSPs by the farmers. The full population adoption rate for OFSP is estimated to be 61 and 42% in Ghana and Nigeria, respectively. This implies that the OFSP adoption rate in Ghana and Nigeria could have been 61 and 42% in 2016 if the whole population had been exposed to OFSPs, instead of the sample adoption rates of 51 and 33%, respectively. When compared to the current sample adoption rates, there is a substantial population adoption gap of 10% due to the fact that some farmers were not exposed to the OFSPs. These results indicate that the OFSP adoption rates could have been increased by 10% in 2016 if all farmers were aware of these varieties. At present, the adoption rate within a sub-population of farmers that are exposed to OFSPs is estimated to be 76% for Ghana farmers and 59% for Nigeria farmers, while the estimated potential adoption rate within the sub-population not yet exposed to OFSPs is 31 and 21% in Ghana and Nigeria, respectively. A comparative analysis shows that the Ghana farmers recorded better and higher adoption rates than their Nigerian counterparts. The adoption rate among the Ghana farmers exposed to OFSP is up to 76% higher than the rate recorded for Nigerian farmers (59% of the Nigerian farmers exposed to OFSP). This implies that the rate of adoption of OFSP in Africa is relatively high at the present due to its economic and health benefits.^[28-32]

CONCLUSION

Improving the efficiency with which farmers use the available resources is very crucial to increasing production, productivity, household income, food security, poverty reduction, and overall economic growth. An efficient OFSP enterprise will naturally attract more investment. The crop has the potential to diversify the farming system; spread risks contribute to food security and provide income opportunities for the most vulnerable farmers particularly. Therefore, if sweetpotato commercialization efforts

are to be put in place, then a majority of the farmers would be better off. Based on this premise, this paper reviewed potentials of OFSPv, OFSPs in Africa, tips for marketing and popularizing OFSP, determinants, and levels of adoption of OFSP production in Nigeria and Ghana.

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