Uses of Gibberellic Acid for increasing grape production

Abstract

Grapes are one of the most delicious fruit and have been farmed from thousands of years, growing from wild vine. Plant hormone is used for increase size and yield. This study goes into the significance influence of Gibberalic Acid (GA_3) on grape farming, showing the ways in which this plant hormone has transformed the agricultural industry. Gibberellic acid is a hormone that is found naturally in plants and is essential for controlling several physiological functions. Many studies have been conducted on its use in grape cultivation. The main factor is growth and development of grape is vine. In grapes GA_3 affects everything from flowering to fruit ripening. Enhancing yield is one of the main ways that GA_3 helps with grapes production. GA_3 encourage the growth of cluster by inducing cell elongation and division, which leads to increasing yield. In addition to satisfying consumers demand, the rise in grape yield helps for grape grower's bottom line. Roles of application of GA_3 on grape vine are different depends on their stages of flowering and fruit setting. It is also gave positive effect on rachis elongation which helps to get Healthy and export quality production. Overall, this review concluded that the Gibberellic Acid (GA_3) is an important component linked with improving quality, size of berry, higher production.

Keywords: Gibberellic Acid, Plant hormone, Cell elongation, Rachis elongation, High production, Quality.

1. Introduction

Grape is one of the most important fruit crop in India. Grapes are non-climacteric fruit crops having the perennial climbing vines with deciduous woody growth. It is a cross-pollinated crop having simple, lobed, cut and serrated leaves (rarely compound). It's having the watery or fleshy pulp, stone and skin with calcium, Iron, Phosphorous and Vitamins B_1 and B_2 [1]. The practice of growing grapes is known as viticulture. There are almost 10,000 different grape types worldwide [2].The variation occurs in white, red, and green color as well as seedless and non-seedless type. They are also widely consumed in a variety of ways including fresh, raisins, wine, vinegar, molasses, grape juice and other products like oil for medicinal purpose. The seed lessness types are a natural wonder, but current processed and table grapes varieties are the consequence of triploid development by hybridization. Because they are triploid in nature, they may also be taken through cotyledon. Selflessness can also be caused by epigenetic alteration that occurs during or before seed development. However, seedless grapes are having market demand hence; use of Gibberellic acid (GA) becomes priority to have seedlessness. Gibberellins are a class of about 130 tetracyclic diterpenes with

primary growth active structure such as GA_1, GA_3, GA_4 and GA_7 [3].There is fair amount of published data on the effect of various PGRs, such as Gibberellic acid (GA_3) and Salicylic acid (SA) on grapevine yield. But little about the way they affect the accumulation of antioxidants such as stilbenes and flavonoids, antioxidant capacity, enzyme activity particularly in local grown cultivar [4]. Grape is the most significant commercial crops raised in India, particularly in Maharashtra. Consumers from all over the world are enjoying grapes for their taste and for the wide range of nutrients they contain. Table grapes include nutrients that are beneficial to human health, such as sugar, minerals, enzymes, vitamins and acid. Archeological evidence suggests that humans first cultivated grapes around 6500 B.C, during the Neolithic era B.C. [5]. China is the world's leading producer of grapes, while India ranked 7th in the world. In India Maharashtra, Tamil Nadu, Andhra Pradesh, Karnataka and are the major grape growing states and Maharashtra state reported 70.67 percent share in production of grape [6]. Due to favorable climatic condition and quality grape production, grape planting is expanding throughout India's sub-tropical and tropical regions, it is significant fruit crop that is profitable over the world, with an average yield of 21.00MT/ha, the land under grape cultivation contributes to an annual production 31.25 lakh MT [7].

The effect on plant or part of plant of PGRs may change with the variety of plant. PGRs are also known as bio-stimulates and bio-inhibitors exist inside the plant cell to either stimulate or inhibit particular enzymes or enzyme systems and to control the metabolism of plant [8] Gibberellic acid is most often used as a reagent in chemical thinning. Berry thinning enhances berry weight and soluble solids, while decreasing bunch weight and loosening the bunch [9]. Spraying at bloom and fruit set stage promoting growth, and positively effects on lengthening cluster, berry size in a bunch thinning of seedless grapes [10]. Berries can be thinned individually with the application of gibberellic acid, which is potential alternative and involves less labour [11].

The discovery of GA_3 by Japanese farmers showed the role that plant pathologists have played in PGR research [12]. At the beginning of 20th century, Japanese farmers, Kurosawa noticed that the some plants in the rice field were taller, thinner and whiter than the typical plants; they also had leaves that were noticeably longer and narrow leaves that significantly outgrew those of their unaffected neighbors, in addition to occasionally being fruitless. They give this disease name "bakanae" which means foolish seedlings [8].

Plant physiologist discovered that a substance released by the pathogenic fungus *Giberella fujikuroi* caused similar functions in rice plants. Japanese scientists were able to extract impure crystals of two fungal "compounds" with action that promoted plant development in 1930s by cultivating this fungus in lab and examining the culture filtrate. One of them given the name gibberellin due to the fact it was isolated from the fungus Gibberella [13].

2. Manufacturing of Gibberellins

The GA_3 is most usually created when the Gibberella is fermented on an industrial scale for application in horticulture, agriculture and other field of science. The first GA to be identified from a plant extract was GA1, which was found in 1958 in the immature seeds of the vuner bean (phaseolus cocineus). A method was developed in 1968 to number them (GA_2-GA_4) in the sequence of their discovery as increasing number of GAs from Gibberella and various plant sources were classified [13]. The first commercially available GAs is GA_3 [14]. It is a group of diterpenoid acid which acts as a growth regulators for plants and has an impact on a variety of higher plant development process. Gibberellic acid is one of them has received the most attention [15].

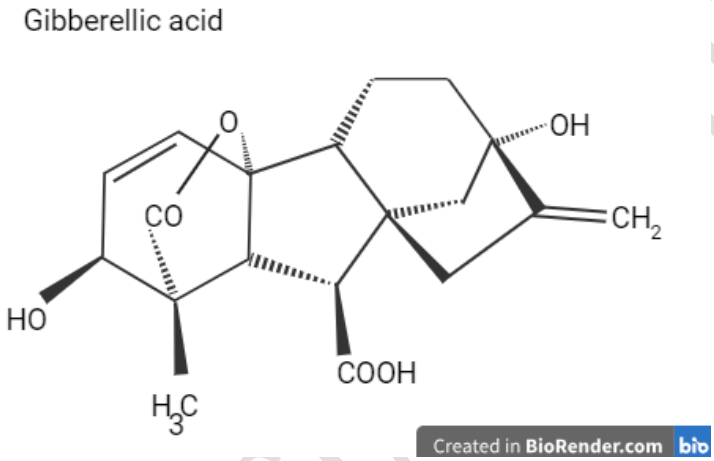
3. Importance and Application of Gibberellic acid

Gibberellic acid is a plant growth hormone that plays a crucial role in various aspects of plant development. It influences germination, blooming, sex expression, enzyme induction, leaf and fruit senescence, stem lengthening, removal of dormancy and elimination of dormancy. GA_3 is highly valuable PGR that has many agricultural uses [15]. Additionally Gibberellic acid can be used to induce parthenocarpy [16].In the cultivation of wine grape, the influence of GA_3 on bunch compactness and rachis elongation are rarely reported. Prior to grape anthesis 50-100mgL^{-1} GA_3 was applied, which extended inflorescence, bunches and reduce cluster compactness in Cabernet Franc and Cabernet Sauvignon grapes [17]. Jung and Hur (2020) reported that the seeded grape bunches can be treated with gibberellic acid to induce seedless grape berries. They concluded that the treatment of gibberellic acid leads to change metabolite content in the cluster when the application of GA_3 was done during the day before flowering for making seedlessness. [18] they found that, GA_3 is best for productivity of grapevine variety Tarnau. Application of GA_3 concentration @100 mg/l up to plant starts flowering, it helps in increasing the mass 18% of 100 berries, @25 mg/l up to weight of 100 berries becomes 185g. This study was conducted for to identify the influence

of growth regulator (GA_3) on fertility of seedless variety and result of this study shows that the use of GA_3 at suitable concentrations helps in increasing fertility by 12.4% of vine bushes.

Application of GA_3 @20 mg/l is effective for increasing weight of cluster and berries [19]. Its performance is better in enhancing the morphological traits of cluster and berries. GA_3 is also having effect on reducing bunch compactness in grapes [20].

Fig 1 Chemical structure of Gibberellic acid



4. Role of GA_3 on different Flowering Stages

GA_3 is commonly used for plant growth by application at proper concentrations and timing. It helps in berry elongation applied at various stages of flower. The specific timing and concentration of GA_3 application should be based on the grape variety, local climatic conditions and the desired outcomes. [1] they told that the distinct GA_3 concentration at 15, 20 and 25 ppm were administered to grape cv. Perlet as bloom treatments in two distinct doses, according to [21] when they utilized the second spray as the post-bloom treatment, which was administered with the support of the first spray at 70-80 % bloom, they observed the highest berry weight, length and width was recorded at 25 ppm. Another study was done by Khan *et al.* (2009) in 2009 on a 20 year old table grape vineyard at NARC to evaluate how the table grape variety i.e. Flame Seedless responded to foliar spray of GA_3. They applied GA_3 twice, first at 80% bloom and second at just after fruit set. Applied GA_3 concentrations are 15 ppm, 20 ppm and 25 ppm at both stage, they found the application of GA_3 at 25 ppm reported maximum cluster weight and berry length, width, TSS in Flame Seedless grapes [22].

Table No.1: Stages of GA_3 application for Berry elongation

Sr. No	Concentration of GA_3	Stages of Application
1	GA_3@10 ppm	10 % Flowering
2.	GA_3@15 ppm	50 % Flowering
3.	GA_3@20 ppm	90 % Flowering

Fig 2 : Stages at 50% Flowering

The growing of the berries and their ripening are the first and second different phases of berry development. Ripening includes a number of coordinated and genetically physiological, biochemical, and developmental processes [23]. Different cultivar of grape having different period of time required for complete development of berry, however, it is possible to anticipate that it will take around 100 days from full blossoming till complete maturity [24].

5. Effect of GA_3 on Fruit set

Application of GA_3 play important role during fruit set in grape berries. First spray of GA_3 is done at the parrot green stage at 21-24 days after pruning. Second application of GA_3 is in the form of dipping which can be applied after 4-5 days after spraying of first GA_3 application. After the berry set at size 3-4 mm application third is done which is in the form of Spray of 40 ppm and last spray is done after fruit size become 6-7 mm [25].

Table No: 2. Application Gibberellic acid on fruit set.

Sr. No.	Days after pruning	Concentrations of GA_3	Growth stage
1	**21-24**	**10 ppm**	Spray at Parrot green (pre-bloom)stage
2	**23-27**	**15 ppm**	Dipping at 2nd pre bloom stage
3	**48-50**	**40 ppm**	After 3-4 mm berry set
4	**60-62**	**30 ppm**	**After 6-7mm berry set**

Fig 3 : Berry size: 3-4 mm

fig 4 : Berry size: 6-8 mm

The another investigation was carried out during 2017-18, 8th year old grapevine grafted on freedom rootstock grown in a private vineyard, Egypt, Cultivar Red Globe. The research outcomes show that @1ppm GA_3 + Urea treatment greatly enhanced the total number of lateral branches and leaf area as compared to other treatments. (Farid and Ashraf 2019). To improve berry size, GA_3 is applied on grape during fruit set [26]. Crimson Seedless might lose quality from excessive fruit set. Application of GA_3, trunked girdling and other methods to increase berry size, however, are less successful and may lead to unsatisfactory cluster

compactness when fruit set is high. They studied effect of GA_3 with different concentration at bloom stage and they found that the single application of GA_3 at 2.5 $g.ha^{-1}$ near full bloom is helps to minimize the fruit set and also helps in increasing the berry size, cluster weight [27].

6. Effect of GA_3 on rachis elongation in Table Grapes

The applications of GA_3 at different stages are essential for rachis elongation. During 2016-17 and 2018-19, this research was conducted at experimental vineyard plot of ICAR-Indian institute of Horticulture research. They studied the influence of GA_3 on rachis elongation of vine. They reported that, @5 ppm application of GA_3 reported the highest total rachis length of (124.90) cm compared to all concentrations [28].

Table No.3 Application of GA_3 at the time of rachis elongation:

Sr. No.	Stage	Concentration of GA_3	Method of application
1	Parrot green stage	10 ppm	Spray
2	4-5 days after earlier spray	15 ppm	Spray
3	**4-5 days after above spray**	**20 ppm**	**Spray or dip**

[29]

Rachis development plays important role in flowering and berry setting and gibberellic acid is given externally for having rachis growth intern avoiding bunch compactness [29]. Through their control over any of three elements of disease triangle, Grape grower can reduce the risk of bunch rot, through shoot thinning, leaf removal that reduce canopy density and hence, promote air flow in the fruit zone, canopy environment may be modified. The degree rachis elongation, rather than the cluster length or shoot length, best indicates when gibberellin should be applied. Gibberellin is applied externally to the leaves during cluster elongation stage, where it amplifies the internal gibberellin supply and has no impact on yield. The quality of wine remains unaffected [30]. GA_3 is frequently used to produced larger berries and promote seedlessness in them. However few reports of GA_3 effects on main stem

of cluster (rachis) and bunch compactness in wine grape production have been made. This study was conducted in the jiaodong peninsula, china on two cultivars “Cabernat Franc” and “Cabernat sauvignon”. Result of given study shows that the 50 and 100 mg L^{-1} having significant elongation of rachis for both cultivars [17].

7. Effect of Gibberellic acid on physical, chemical properties and bunch compactness

During year 2018-2019, this study was conducted at the vineyard of Egypt, this study is investigated to understand effect of GA_3 on reducing the compactness coefficient of cluster and to know the changes in physical and chemical properties of cluster of Thompson Seedless. This result obtained from this experiment showed that the application of GA_3 at the ¾ recommended dose + 0.5 ppm brassinolide and then at the ½ recommended dose + 1.0 ppm was effective. Treatment with brassinolide was more successful in enhancing the cluster characteristics and grapes appearance, and it was preferred for achieving significant value of physical and chemical parameter of cluster and berries [20]. One more study done in Egypt during 2018 and 2019 on Thompson Seedless cultivar (H4 strain) which is grafted of freedom rootstock for the same parameter as experiment done by Belal (2019) And from their study they found that GA_3 concentration increase, the total chlorophyll content decreased, but application of GA_3 for thinning and enlarging treatments was more effective than other method for thinning and focus on only with pruning weight. The findings also indicated that the ideal GA_3 dose was 20 ppm at full bloom for thinning and 30 ppm GA_3 for size and to achieve high cluster, weight, yield per vine, and low compactness as well as the highest TSS, TSS/acid ratio, and lowest acidity good [10]. While comparing with three varieties (Sultanina-C, Flame Seedless and NARC Black), They obtained medium loose bunches in Flame Seedless and Sultanina-c that increase TSS to bring about maturity, but which also observed a decline in bioactive chemical and the activity of main antioxidant enzymes [31]. During 2010-2011, field trial was carried out for to identify the best result from comparison of different concentration of GA_3 with control. Result obtained from that study was application of GA_3 at 25 ppm have recorded best result in comparison with control. Additionally, spraying of 20 ppm also having best results, such as lowest weight loss observed and giving effective impact on reducing decay percentage up to 3rd week storage of grapes [33].

This research was carried out to know the biochemical changes occur in the plant due to the plant growth regulators, especially GA_3 and CPPU and their impact on bunches, berry and

yield characteristics in Tas-A-Ganesh grape on Dogridge rootstock at NRC of Grapes, Pune Maharashtra for three years 2011-12, 2012-13 and 2013-14. The result obtained from their study shows that the treatment of GA_3 at 40 ppm and CPPU at 2ppm is more superior to yield and quality parameters [34]. Other study is investigated by Khot *et al.* (2014) at same location in 2013-14 this study aims to know importance of foliar application of GA_3 and CPPU on yield, quality, photosynthesis and biochemical changes in grapes, they reported that the application of 40 ppm gibberellin alone or in mixture with 2 ppm CPPU from all treatments to be effective for improving leaf photosynthesis, biochemical changes, yield and quality parameters in Thompson Seedless grape [35]. The fruit physical properties were effectively enhance by combining GA_3 and BA at various concentrations at two phases (pre-bloom and berry set), i.e., 30, 40, 10 ppm BA concentrations [36]. Another study was conducted at Arabia, Egypt and Iran. This investigation was carried out during two successive seasons 2018-19 in private orchard located in El-Khatatba region, minufyia governorate, Egypt. Their study was on, how GA_3 and Hand thinning improves the physical and chemical characteristics, yield and bunch compactness of sultanina grapevine. Result showed that the application GA_3 at 30 ppm is effective for reducing the cluster compactness and improves physical and chemical parameters [9].

According to Cengiz Ozer and Onur Ergonul (2021), they reported that application of GA3@ 40 ppm used for thinning purpose particular for removal of 1/3 of the basal parts of cluster at full bloom stage and 3-5 mm berry size in four different table varieties like Guz Gulu, Suleymanpasa, Beyazi, Tekirdag Misketi and Ozer Beyazi [36].

8. Effect of Gibberellic acid on shelf life

The research was conducted to know the effect of pre harvest foliar application on yield, quality and shelf life of grapes. Result obtained from this study shows that the pre harvest application of Gibberellic acid, CPPU and PUT had a positive effect for extending shelf life [37]. During 2016-17, research was conducted by Hoda A. Khalil in the private farm of Marriot region, Egypt. Due to use of growth regulators in the first year, berry firmness after storage was unaffected and during second season, spraying with GA_3, CPPU and GA_3 + CPPU maintain berry firmness than control. Results reported that all treatments are effective for reducing weight loss and decreasing the unmarketable berries as compared to untreated control and pre-harvest application of GA_3 and CPPU at the beginning stages of fruit enlargement had a positive impact on yield, berry size, cluster physical characteristics and

shelf life of fruit [38]. According to Ahmad *et al,* (2005), they reported that the application of GA_3 is effective for extending shelf life of perlette grape. They applied different concentrations of GA_3 with different techniques. From this study result recorded that the application of GA_3 at 40 ppm + girdling have minimum physiological loss in weight during storage, at room temperature, Thus it helps to extending shelf life up to three days. Application of GA_3 @40-50 ppm + CPPU 1-2 ppm applied at 3-4 and 6-7 mm berry size used for reducing dry drops can enhance shelf life of grapes [39]. They studied that the impact of application PGRs on Superior Seedless variety at full bloom stage to knowing the effect of foliar application on quality and storage capacity of grapes. Result stated that the single application of GA_3 with IBA is giving best effect on improving quality and cold storage capacity of grapes.

9. Effect of Gibberellic acid on Yield

The research was conducted to know the effect of GA_3 on yield of grapevine. This result can help researchers and grape producers enhancing growth regulators and floral cluster thinning procedure to increase the output and quality [40] According to their study, foliar application of GA_3 at 10 ppm when the shoot length was 10-15 cm, 20 ppm at full bloom and 40 ppm when the berry diameter reached at 5mm resulted in the heaviest yield weight. Also the bunch weight, bunch width and length (cm) are improved by this treatment (Application of GA_3), [41]. [42] They studied that the impact of GA_3 on yield and quality of Tas-A-Ganesh variety of grapes. They found the positive correlation with bunch, berry and biochemical characteristics in relation to yield. Also they obtained that application of GA_3 at 40 ppm was best reported for Yield, quality and biochemical characteristics in Tas-A-Ganesh. [43] they investigated that the relation between yield and biochemical changes as well as bunch, berry characteristics. They carried out their experiment on Tas-A-Ganesh grape grafted on Dogridge rootstock during 2012 and 2013 at Pune. They applied GA_3 with combination of CPPU @ 40 ppm at 1, 2, 3 ppm respectively as a bunch dip at 3-4 and 6-7 mm size of berry stage. They found positive correlation with bunch, berry and biochemical characteristics in relation to yield. Also they obtained that application of GA_3 at 40 ppm and at 2 ppm CPPU was best for yield, quality and biochemical characteristics in Tas-A-Ganesh. According to Dokoozlian and peacock, they reported that the single application of GA_3 at near full bloom stage helps to minimize fruit set, and it also in increasing berry size without affecting marketable yield [43]. Khalil. (2020) she obtained that the GA_3 application with CPPU

reported that positive impact on the yield [38]. Similar result obtained by Marzaouk and Kassem (2011) they proved that GA_3 and CPPU are having leading impact on yield as compared with untreated controls [37]. According to [44] they conducted experiment on to study the effect of GA_3 on growth parameters of Fantasy Seedless. They applied spray of GA_3 treatments once at flowering stage, and recorded data at the time of harvest, the result of their study showed that the treatments of GA_3 at @25 ppm was during flowering stage increased yield per vine, berry and bunch weight and stimulate gas exchange parameters as compared to other treatments. [45] They studied the impact of GA_3 and CPPU on Quality parameters and Gas exchange parameters in relation to yield of Crimson Seedless. They found that the foliar application of GA_3 with CPPU have leading effect on yield and quality parameters. Similar result was found in Manjri Naveen in Pune condition by [41]. According to Pahi *et al.* (2020) they investigate that the effect of GA_3 application on yield. Present reported from this study they was the application of GA_3 given twice @25 ppm, i.e. first application at 70-80% bloom and second application at post bloom stage, showed gives better yield and quality in grapes similar study was done by the [22] on Flame Seedless. They applied the different treatments of GA_3 (15 ppm, 20 ppm, 25 ppm) first at 80% bloom and second at just after fruit set and result reported that the application of GA_3 @ 25 ppm shows best performance with relation to better yield and quality. [46] They studied the application of GA_3 at different concentration with three frequencies, i.e. 0 ppm, 10 ppm, 20 ppm, 30ppm concentration with single, double and triple frequencies. This research was conducted to identify the effect of GA_3 on yield and quality of Zark grapes. Their investigation shows that the Application of GA_3 @30 ppm was increases yield as compared to other treatments.

10. Problems in grape production solved by application of Gibberellin acid

Gibberellic acid addresses several issues in grapes cultivation. Its application includes improving fruit size, cluster loosening and promoting seedlessness in grapes. The quality of table grape (Vitis venifera L) can be lowered by excessive fruit set, which produce tiny berries, compact cluster that are more susceptible to suffer bunch rot at harvest. An investigation carried out on crimson seedlessshowed that this cultivar may be treated with single application of 2.5g.ha^{-1} near full bloom to decrease fruit set and enhance berry size without having an adverse effect on packable yield or cluster number per vine of following year [27]. Some grapevine varieties have extremely compact cluster, which have an unfavorable effect on their quality and marketability. Another study was conducted on Yaghouti table grape variety to investigate the effect of mechanical and chemical thinning

with GA_3 application on berry size [47]. All thinning treatments enhance TSS and color. Result of this study shows that sevin treatment at 750 mg/l in combination with GA_3 and hand thinning in addition to GA_3 is generally recommended to increase grapevine berry quality [47].Quality is main factor of grape production. Lower quality effect on market value of grapes, this study was conducted at Nepal during (2020) to improve quality of fruit and increase yield. Findings obtained by this research, is enhancing the berry characteristics, GA_3 impacted on qualitative characteristics of grape berries in var. Himrod and had impact on bunch weight for growing season [48]. The Grapes' quality and production may be increased by foliar application of only gibberellic acid at various doses during various growth development stages [1]. From their studies they found that the foliar application of GA_3 @ 25pm increases the cluster weight, berry weight, length, etc. This was similarly reported by Khan *et al.* (2009) that the GA_3 have best performance in increasing berry weight, cluster weight, etc [49] The comparison of GA_3 and girdling for improving fruit quality and productivity of pruned cane of Thompson seedless was also reported [49], using four different treatments. He reported that the grapevine treated with GA_3 and GA_3+Girdle treatment have a significant impact on grapevine output, they may be advantageous in the commercial production of Thompson Seedless grapes. [50] They studied the effect of GA_3 on cluster rot of 'Sauvignon Blanc' grapes. The experiment was carried out during 2016-2017 season production of grapes. The application of GA_3 reported that the (21.34) % fungus Botrytis Cinerea affected vines had reduced berry drop (14.88) %.

11. Conclusion and future proposal for future research

This study concludes that the application of GA_3 has shown significant benefits in enhancing grapes yield, quality, and shelf life. Various concentrations and application timing of ga3 have been found to positively impact grape characteristics such as yield weight, berry size cluster physical attributes and biochemical properties.

Future research could focus on finding better ways to use Gibberellic Acid to help grapevines grow even more effectively. Researchers can see how it can improve grape yield and quality. Researchers could also look into combining GA_3 with other substances to see if they work together to make grapes even better. Additionally, long term studies could be conducted to understand how GA_3 affects grapevines over time. By exploring these areas, we can learn about how GA_3 can be used to enhance grape production and meet consumer preferences.

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