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Mini Review

Nutritional and Biological properties of *Vicia faba* L.: A perspective review

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Abstract

Recently, traditional medicine has regained a vigorous hold over the modern health care therapeutics. *Vicia faba (V. faba)*, a legume with medicinal properties, has an outstanding production scale in approximately 58 countries and rating third in engenderment. Faba bean magnification is facilitated at any climatic and soil conditions. It functions as a precursor for dopamine, a neurotransmitter and in the atmospheric nitrogen fixation thereby incrementing the soil fertility. The plant system is a reliable, facile, sensitive and efficient biological system. Despite its nutritional properties and medicinal values as noted in many countries, including India, *V. faba* is flouted from being cultivated as a major crop. This review article majorly fixates nutritional and medicinal properties, thereby incrementing its future aspects in potential utilization in medicine and agriculture.

Introduction

Since 5000 BC, the use of medicinal plants has been documented in various scriptures around the world (Dhami and Mishra, 2015). Worldwide, medicinal Plants and Plant Extracts were widely used by many populations across the world. It pays a particular attention in the scientific community owing to its characteristics like simplistic preparation, less in cost, eco cordial and treatment where no side effects. In the medicinal plants, leaves, stem, root, fruit, and seed can be studied discretely or whole plant can be taken as sample and extractions can be made in different solvents utilizing various techniques (Gajalakshmi *et al*., 2013; Van, 2015). Medicinal plant products like glue, resins, metabolites and latex have been utilized as elements in medicine and is commercially available in markets as powders, tablets, oils, emollients, etc (Charaka and Sofovora, 2000). Medicinal plants were possessed with a substantial amount of phytochemicals. It is believed these phytochemicals are responsible for its biological activities. Categorically the compounds present in medicinal plants can be studied further and investigated for its property (Gajalakshmi *et al*., 2011).

Like medicinal plants, legumes are the nutritional products with high consequentiality, which got many health benefits to mankind. Legumes are the major source of alimentation for humans. Legumes

Figure 1. The structure of the fruit *(Vicia faba)*

are opulent in nutrition quantity, concretely high in proteins and carbohydrates. Medicinally, legumes are believed to decrement the incidence rate of the major diseases like cancer, heart and neurodegenerative diseases. The reason for its medicinal property could be due to the presence of the poly phenols, with a high antioxidant activity (Ramos, 2007).

Broad bean is a significant vegetable consumed by the majority of people in the world. The legume is botanically called as *Vicia faba*, is shown in Figure 1. Faba bean belongs to genes *Vicia* and family Fabaceae (Leguminosae) (Akpinar *et al*., 2001).The fruit has many prevalent names such as Broad bean, Horse bean, Windsor bean, Tick bean, Fava bean, etc. In Hindi, the national language of India, *V. faba* is called as 'kalamatar and bakala' (Singh *et al.*, 2013). It has four subspecies, namely minor, equaine, Major and paucijuga (Hossain and Mortuza, 2006).

The plant *V. faba* was originated from the East and it is widely consumed in South America and interestingly it has capability to grow in all climatic conditions. It is popularly cultivated in India

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(Marcello and Elena, 2017). Particularly, the cold climatic conditions are very auspicious for them to grow in countries like Jujuy and Argentina, where the temperature is usually low. The crop was cultivated ecumenical and its output was majorly optically discerned in many countries. Among those, china upper side in the engenderment (60%) of *V. faba* crop than any other country in the world. The countries like Ethiopia and England were the major importers. Egypt was the major importer of *V. faba* in the form of dry beans from Australia (Azaza *et al.*, 2009; Chillo *et al.*, 2010; Kaur *et al*., 2014). Despite of its ability in growth, additionally, a study conducted between 2015 and 2016, shows intercropping of vegetables like carrot and cabbage can be done in *V.faba* Plantation in order to ensure beneficial horticulture production (Liga *et al*., 2017).

The *V. faba* fruit has many medicinal properties, people whom consumes it on a quotidian substratum will have more health benefits as it was utilized since long time as a drug to treat kidney, liver and ocular perceiver diseases (Duc, 1997; Crepon *et al*., 2010; Kopke and Nemecek, 2010). But it should be taken into consideration, the place where the plant grows because it was reported that *V. faba* plant grown in high radiation back soil shows less quantity of antioxidant and flavonoids content when compared with the plants grown in healthy soil (Jouni *et al*., 2012). So, the medicinal and nutritional benefits, from the plant, which grow in radiation soil, will not be effective in treating the patient.

The *V. faba* can be visually perceived as a critical crop for its properties, and it is discussed in detail here. It draws a special attention by researchers as it contains consummate properties such as nutrition, medicine and also the crop was being utilized for the testing system was discussed below in detail as shown in Figure 2.

Nutritional properties

In many countries, only eighteen species of this plant have been cultivated widely. But, globally, it has been found that there are more than 80 different species of *V. faba*. This plant was widely cultivated by the farmers because the yield of the crop is more and it can be stored for a long period of time. The conveyance is very facile, where the farmers get more benefits than any other crop. For farmers, regardless of these commercial benefits, the plant got faculty to fine-tune atmospheric nitrogen, which ultimately increases the soil fertility, as well, it is prominently known to be covered crop as it averts the soil erosion. Apart from these, the special feature of *V. faba* is, frugal in cost and a good source of protein. The

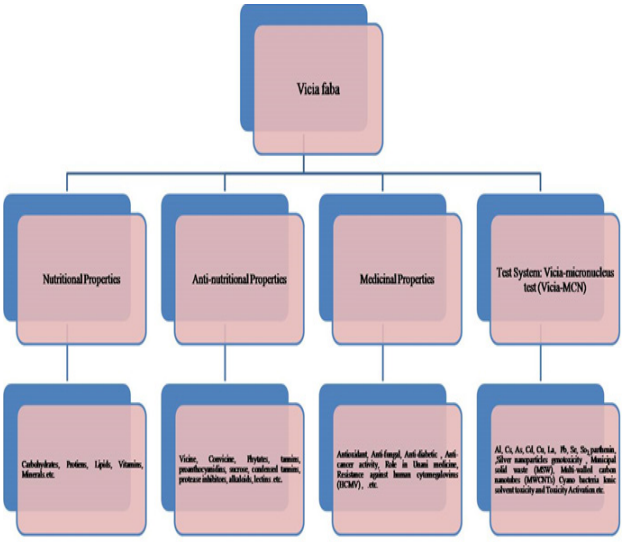

Figure 2. An overview of the multifunctional properties of *Vicia faba* used in various applications.

protein content was equipollent to the protein content of meat and fish. Hence, it is popularly verbalized as "poor man's meat" (Fruhbeck *et al.*, 1997; Macarulla *et al*., 2001). In Mediterranean region, in view of its superior yield and alimenting value, the fruit is prevalent protein-affluent diet for humans as well it is widely utilized as animal feed. In Egypt, *V. faba* is one of the paramount crops, and it is consumed by the people in the form of cakes, pasty and soup (Hendawey and Younes, 2013).

The analytical data of *V. faba* fruit exposed that, the fruit contains a high nutritional value and opulent in proteins, carbohydrates, in volute vitamins, folic acid, niacin, and vitamin C, dietary fiber and macro and micro nutrients. Majorly, the seedy part of the *V. faba* was opulent in carbohydrates (51-68%), followed by proteins (20-41%) as shown in Figure 3. The fractions of proteins were isolated from the components the *V. faba*, and it was composed of globulins (79%), albumins (7%) and glutelins (7%). The proteins were extracted from the seeds of *V. faba* using various solvents. Among, maximum of 92% of protein was extracted from the seed flour through alkaline extraction. Where, smaller amount of anti-nutrition contents like vicine and covicine, ABTS radical-scavenging activity, high lipid contents were also found. In addition high amounts of poly phenols were abundant in hexane extraction (Vioque *et al*., 2012). Poly phenols were high in the seeds were abundant (Pastor *et al*., 2011). Apart from major nutrition, micro nutrients were also present in the fruit. The consequential minerals were such as Ca, P, K, Mg, Na, S, Al, B, Ba, Co, Cr, Cu, Fe, Ga, Li, Mn, Ni, Pb, Sr, Zn listed in Table 1. This data of *V. faba* is a designation that *V. faba* was an opulent diet for the consumption of humans and as well as to the

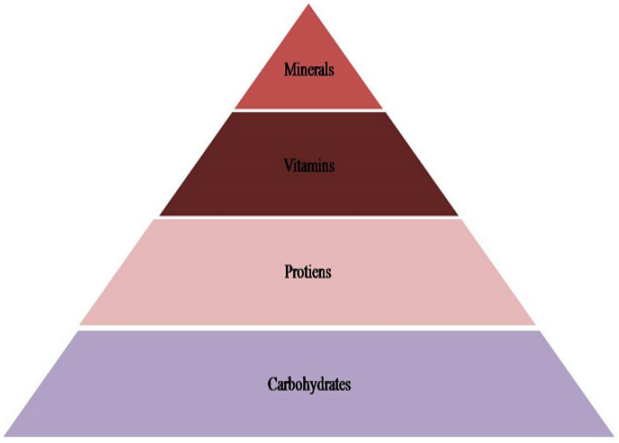

Figure 3. The Pyramid shows the hierarchical relationships of nutritional factors present in seeds of *Vicia faba.*

Table 1.Chemical constituents of *Vicia faba*

Chemical constituents	Type and amount present
Carbohydrates	51 to 68%
Proteins	20 to 41% [globulins (79%), albumins (7%), glutelins (7%)]
Lipids	2.30 to 3.91 %
Saturated fatty acids	Pamitic acid, Stearic acid
Unsaturated fatty acids	Myristic, pentadecanoic, arachidic, behenic acids, oleic acid, linoleic acid and linolenic
Vitamins	Folic acid, Niacin, Vitamin C
Minerals	Ca, P, K, Mg, Na, S, Al, B, Ba, Co, Cr, Cu, Fe, Ga, Li, Mn, Ni, Pb, Sr, Zn

animals (Hacıseferoğulları *et al*., 2003; Hossain, *et al*., 2006; Yang *et al*., 2011; Giménez *et al*., 2012). The enhancement will be most beneficial in the cases like Parkinson's disease. Recently, 134 bioactive compounds were biologically active compounds were newly identified. This is an important discovery can also have an impact in nutrition and medicine (Ibraham *et al*., 2017).

The nutritional aspects were also confined to the regions, germination time and variety. In a recent study, many nutritional content variations were observed in seed characteristics, phenolic, phytate, phytase, and antioxidant properties in thirteen low tannin faba bean. These genotypes were found only in two locations on the north central Alberta. In detail, the multivariate data analysis was carried out utilizing principal component analysis (PCA) on 19 components of *V. faba*. This analysis showed high phenolic component, which was relatively identically to the tannin quantity, high phytase activity and low phytic acid (Oomah *et al*., 2011). Whereas, the germinating seeds of *V. faba* contains high phytase activity. The phytase content in *V. faba* was higher than other cereals such as wheat, barley, and spelt (Greiner and Jany, 1997).

The biologically important lipid levels were abundant in *V. faba* seeds. The seed oils were found to be opulent in total lipid content (2.30 to 3.91%). While, saturated adipose acids like pamitic acid, stearic acid and unsaturated adipose acids myristic, pentadecanoic, arachidic, behenic acids, oleic acid, linoleic acid and linolenic were present. The high lipid contents values were utilizable in engendering high energy calories for humans (Akpinar *et al*., 2001).

Though *V. faba* is preloaded with many nutritional components, incipient components like c-aminobutyric acid (GABA) were synthesized after germination and the substrates for GABA synthesis and polyamine contents were found to be elevated under hypoxia conditions. The GABA has many health benefits to humans. It acts as neurotransmitter, which could transfer nerve impulse and also it aids in regulating blood pressure, heart rate, palliates pain and apprehensiveness (Yang *et al*., 2013). These findings conclude that *V. faba* is an essential diet for the human with many nutritional and health benefits.

The health benefits can be further elongated by incrementing the functional property of *V. faba*, by a process called succinylation. In this process, analysis such as chemical, Viscometry, Analytical Ultracentrifugation, Ultraviolet and Fluorescence Spectroscopy, and Differential Scanning Calorimetry (DSC) were performed. Practically, maximum of 60-80% of succinylation can be achieved in *V. faba* (Schwenke *et al.,* 1998). In other means, the nutritional property of *V. faba* can also be enhanced by elicitors like Fish Protein Hydrolysates (FPH), Lactoferrin (LF) and Oregano Extract (OE) as these stimulate the phenyl propanoid pathway and shikimate pathway (Randhir and Shetty, 2003) also by fermentation process (Carlo *et al*., 2017).

Despite of its high nutritional value, *V. faba* additionally contains many anti-nutritional constituents like vicine [2, 6 diamino-4, 5-dihydroxy pyrimidine, 5 (B-glycopyransoide)], convicine [2, 4, 5-tri hydroxy- 6 -pyrimidine, 5 (B-glycopyransoide)] and these two compounds can cause fatal disease called favism. Apart from these two compounds, in integration less quantity of other anti-alimental factors such as phytates, tannins, proanthocyanidins, sucrose, condensed tannins, protease inhibitors, alkaloids, lectins were present and no deleterious effects were found by these compounds (Torres *et al*., 2010; Coda *et al*., 2015). In contrast to this, the *V. faba* diet was found to enhance the Iron (Fe) absorption in humans. The incipient nutritional recipe from *V. faba*

flour increases the bioavailability of Fe in humans. It is well-known that Fe is a paramount component in hemoglobin and lack of Fe causes anemia, a prevalent alimental disorder in the macrocosm. The deficiency of Fe is customarily observed in infants, enceinte and menstruating women. This recipe was recommended for those people who are a risk of anemia and withal those who are under treatment for anemia. Further, it was withal found that *V. faba* treated with phytase can be utilized as a bio indicator to determine the iron bioavailability in humans (Luo and Xie, 2012).

In order to curb the anti-nutritional factors in *V. faba* different methods were currently in use. The methods are debulling, sousing, air relegation, extrusion or heat treatment and advanced methods like genetic modification will withal reduce the anti-alimental factors from *V. faba* (Coda, *et al.*, 2015). In addition, it was observed in a study, that the anti-nutritional factors in legumes can be modified with γ-aminobutyric acid (GABA) and diamine oxidase (DAO). It withal makes *V. faba* plant to utilize minerals abundantly and which leads the plant to grow expeditiously (Yang *et al*., 2011). Employing the above methods makes *V. faba* fine tune and its benefits can be potentially used for various applications. Recently, molecular marker SNP 316, Intron of Medtr2g009270 (1,851,012 bp) was identified in order to differentiate between low and high Vicine-Covicine content of faba bean genotypes. This marker can be used in seed selection for agriculture, also majorly to the patients anguish to favism (Melody, 2017).

Recent days, nanotechnology has been majorly reflected by the researchers. The nanotechnology-predicated drug formulation can be prosperously considered for better treatment and ailments in future for sundry diseases (Roopan *et al.*, 2016). So far no work has been reported utilizing *V. faba*. Hence, application of nanotechnology in *V. faba* is valued in the future.

Biological properties and Clinical applications

Biologically, the legume *V. faba* has faculty to decrement the complication and the progress of certain diseases. It plays a consequential role as adjuvant in remedying of consequential diseases like AIDS, hypertension, heart, renal, liver and Parkinson's disease (Fernandes and Banerji, 1995; Jordinson *et al.*, 1999; Ye *et al*., 2001; Hornykiewicz, 2002; Ye and Ng, 2002; Ellwood *et al*., 2008).

Antioxidant properties

Antioxidants plays a very crucial role in humans, which engulf the free radicals and protect from various diseases (Saha *et al*., 2015).The fruit *V. faba* enriched with antioxidants and those antioxidants diffuse the reactive free oxygen radicals by engulfing it. In a study, purest form of poly phenolic compounds was isolated from *V. faba* in order to evaluate to its chemo preventive properties against topoisomerases. Whereas, effect of nine poly phenolic compounds was evaluated, among nine poly phenolic compounds, few compounds inhibited all enzymatic activities and some of the compounds inhibited some categorical enzyme among wheat germ topoisomerases (IC_{50}:120-350 µg), human topoisomerase (IC_{50}: 110-260 µg), and human topoisomerase (IC_{50}: 240-600). This faculty in inhibition of topoisomerases by polyphenolic compounds from *V. faba* indicates its potential as an anti-cancer agent (Tselepi *et al*., 2011).

Phenolic antioxidant activity and levo-dihydroxy phenylalanine (L-DOPA) present in *V. faba* seeds can be stimulated by exposing it to short pulse of microwave along with heat stress. In a study, it was been noted phenolic contents, glucose-6-phosphate dehydrogenase, guaiacol peroxidase, superoxide dismutase were increased, when the seeds were exposed to short pluse of microwave with heat stress for eight days. In integration, 59% increase in L-DOPA, 700% increase in phenolic content was observed (Randhir *et al*., 2003). The L-Dopa is a major component in medicines, which is utilized to treat Parkinson's disease. Hence *V. faba* can be recommended as major dietary supplement for the people affect with Parkinson's disease (Ray and Georges, 2010). Also, synthesis of DOPA through Pentose phosphate pathway can be enhanced in *V. faba* sprouts by elicitors like H_2O_2, ascorbic acid, cranberry juice powder, ellagic acid and rosmarinic acid (Vattem *et al*., 2005; Randhir *et al.*, 2006; Randhir and Shetty, 2007). The enhancement will be most beneficial in the cases like Parkinson's disease.

Anti-fungal activity

The anti-microbial activity with the potential antioxidant activity of victuals can be acclimated to discover a novel medical formula (Saha and Rajeswari 2015). The 15KDa trypsin inhibitor from *V. faba* was isolated through liquid chromatography and termed it as Egypt trypsin inhibitor (VFTI-E1), which showed a vigorous antifungal activity against fungus valsamali (Fei *et al*., 2011). Chymotrypsin inhibitor, Chitinase, Wyerone, and Wyerone epoxide were some of compounds isolated from *V. faba* was proven to be vigorousanti-fungal agents (Fawcett *et al.*, 1969; Hargreaves *et al.*, 1976; Ye *et al.*, 2002; Wang *et al.*, 2012).

Resistance against human cytomegalovirus (HCMV)

The *V. faba* plant was resistant to human cytomegalovirus (HCMV), the HCMV is a pathogen that causes infections in people and its astringency in those who are immune deficient and withal causes birth defects. By utilizing PCR and dot-blot hybridization it is identified that three out of five *V. faba* plant shown resistant against HCMV and the protein responsible for resistance is pp-150. ELISA and flow cytometry analysis has shown HCMV pp-150 concrete antibody (IgG, IgA) and IFN-g engendering T cells in the mice, when it is immunized with pp-150 transgenic *V. faba* seeds. This transgenic *V. faba* can be utilized in the revelation of edible vaccine against HCMV infection (Yan *et al.*, 2010).

Anti-diabetic activity

The antioxidant opulent *V. faba* has anti-diabetic activity which is proved *in vivo* experiment. Diabetes mellitus is an endocrine disorder, caused due to impairment in the secretion of insulin hormone, the etiology of this disorder is may be due to the viral infection, autoimmune disease, and environmental elements. While in the patients who consume the poor nutrition were eventually suffering with the complications, but in the patients consume antioxidant opulent *V. faba* in the diet was devoid of complications. Because, the *V. faba* with antioxidants undergo free radical scavenging activity, which proportionally avails in rejuvenation of β-cells of the pancreas and withal bulwarks cytotoxic streptozotocin effect, which is ultimately the key to controlling diabetes mellitus. And it was believed that two anti-nutritional compounds, such as, vicine and divicine present in *V. faba* may be the key factor for the anti-diabetic activity (Fatima and Kapoor, 2006; Yang *et al*., 2006; Hussein, 2012).

In a recent study, crystalline compounds of vicine and divicine are isolated and tested for its anti-diabetic activity in animal models. The study shows a rapid decline in blood glucose as well as in lipid levels. Interestingly, an increase in insulin hormone levels, high density lipoproteins, ferritin, hemoglobin, superoxide dismutase, catalase, glutathione peroxidase, and glutathione -S –transferace was observed. The salutary effects were high in ethanolic extract of *V. faba*. The above data substantiates the anti-diabetic and hypolipidemic activity of *V. faba*. Consequently, *V. faba* consumption can be recommended to diabetic patients (Hussein, 2012).

Anticancer activity

The *V. faba* fruit was promising candidate for anticancer activity. Colon cancer is one of major causes for high mortality rate in Britain. The *V. faba* fruit show potential anticancer activity on colon cancer. Particularly, the lectin present in *V. faba* emasculates colon cancer cells of malignant phenotype by incrementing morphological differentiation into to gland like structures. This, in turn, results in cessation of colon cancer progression (Jordinson, *et al*., 1999). In animal models, *V. faba* protein hydrolzates show anticancer activity in low doses (10 mg/kg body weight). The anti cancer activity was found to be predominant in normocholesterolemic diet group than in normocholesterolemic diet group (Erika *et al*., 2016). It is believed that the bioactive compounds present in *V. faba* fruit inhibit the subgroup of matrix metalloproteinases activity was key mechanism for the anticancer activity. It is known, the metalloproteinases are factors related to cancer growth and metastization (Lima *et al*., 2016). It is suggestive that, *V. faba* can be utilized as medical supplements in the treatment of colon cancer.

Role in favism

Favism, a condition characterized by hemolytic anemia, is an inherited disorder affecting the people with deficiency of glucose-6-phosphate dehydrogenase (G6PD) enzyme, a recessive sex-linked trait. Ecumenical, millions of people were affected with this disorder and the prevalence of favism was high in the Thailand (Laosombat *et al.*, 2006). It was believed that these two anti-alimental glucosides are responsible for this disease. Consumption of *V. faba* by the people with glucose-6-phosphate dehydrogenase enzyme deficiency was at high risk to this disease. This disorder makes patients prone to protozoal disease like malaria (Mavelli *et al.*, 1984; Torres *et al*., 2010; Crépon *et al*., 2010; Hendawey *et al*., 2013).

Tullio *et al.* in 1983 studied the effect of *V. faba* in the G6PD deficiency children, for a period of four years (1965-1979) at children's hospital, Sassari. The children consumed fresh *V. faba i*s more susceptible to hemolytic anemia associated with the elevation in serum liver enzymes. They found that male children were more prone to this disease with female children. However, there was no evidence from mother to child transmission and withal variations among blood groups of the patients (Meloni *et al.*, 1983). Similarly, the occurrence of favism was found higher in males than females, also categorically to the children who are below two years old (Laosombat *et al.*, 2006). Hence, patients G6PD deficiency should avoid taking *V. faba* in the diet.

Role in Parkinson's disease (PD)

The patients with PD can potentially have benefits in consumption of *V. faba*, as it is enriched with L-dopa (Natelson, 1969). Marcus Guggenheim identified L-dopa from *V. faba* in 1913 for the first time (Guggenheim, 1913). L-dopa is synthesized from the amino acid tyrosine and it is a precursor for neurotransmitter dopamine. L-dopa is a major component in medicines, which is utilized to treat PD (Ray *et al*., 2010). The entire parts of the plant were rich in L-dopa particularly the pods and young beans (50-100 mg approximately) and the consumption of these parts will increase L-dopa level in blood (Vered *et al*., 1994; Mohseni and Golshani, 2013). In humans, it was noticed that L-dopa level remains elevated for 6 hours in blood after consumption (Garland *et al*., 2013). In a study, after the consumption of 250 gms of cooked *V. faba*, after 12 hours, high amount of L-dopa was found in blood and which is proportionally equal to the clinical improvement of the PD patients (Rabey *et al.*, 1992).

Similarly, kempster *et al.* in 1993 investigated the efficacy of *V. faba* pods as single-dose studies in patients with PD. In detail, they had treated the six patients with *V. faba* pod (100-200 mg) mixed with carbide (25-50 mg). The pod was found to be containing high amount of L-dopa when compared with the seed. High calibers of L-dopa content was found in blood circulation and also positive motor replication was noticed. This is a designation that *V. faba* is an efficacious natural medicine with standard pharmaceutical drug (Kempster e*t al*., 1993). Hence, *V. faba* has been recommended as a major dietary supplement in patients with PD.

Apart from this, in Unani medicine, cooked *V. faba* (with or without meat) was given as medication for a cough and in determining inflammations. The flowers have been used for dressing inflammations, warts, and burns (Khare, 2007). In view of these health benefits *V. faba* should be recommended as a major diet source for human consumption and further, the studies should be carried out at the molecular level for better understanding.

Conclusion

Medicinal plants like *V. faba* potentially play a vital role as sizably voluminous number medicinal plant varieties available globally, which could be revolutionizing the therapeutic drug treatments. *V. faba* has been an unrecognized aliment crop, where more attention should be given to this crop. This review article highlights the few aspects of *V. faba,* such as nutritional factors, biological and therapeutic applications. In conclusion, *V. faba* has been alimentally affluent with carbohydrates, proteins, lipids and other micronutrients. It additionally contains anti-alimental compounds like vicine and covicine and its role in favism has been discovered. These anti-nutritional factors can be decremented by utilizing sundry methods like debulling, sousing, air relegation, extrusion or heat treatment and genetic modifications. Biologically, *V. faba* was enriched with antioxidant properties and plays potent role against the diseases such as colon cancer, diabetes mellitus. It has shown anti-fungal activity and additionally shows a resistance against human cytomegalovirus (HCMV). Thus, *V. faba* can be visually perceived as a critical crop for its alimental, medical and agricultural aspects, draws a special attention by researchers. Despite of this, there is a desideratum of the hour to isolate and further evaluate the bioactive compounds present in *V. faba* at molecular levels for sundry biomedical applications and it should be further assessed for its propitious attributes.

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