RESEARCH PAPER

Ve-Degree, Ev-Degree, and Degree-Based Topological Indices of Beta-Carotene

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Abstract
The purpose of this paper is to introduce and investigate the study of Ve-Degree, Ev-Degree, and Degree-Based Topological Indices of Beta Carotene ($C_{40}H_{56}$). Topological indices are vital devices for investigating chemical compounds to comprehend the fundamental topology of chemical structure. The design of the quantitative structure property/activity relationships for compounds using theoretical methods relies on appropriate molecular structure representations. Graph theory helps us to understand the chemical structure and link between certain topological indices of some know derived graphs. In this paper we determine Ve-Degree, Ev-Degree, Degree-Based topological indices Beta Carotene, topological indices are the Zagreb index, General Randic index, Modified Zagreb index, forgotten topological index, these indices are very helpful to study the characterization of the structure.

Keywords: Topological index, Ve-Degree, Ev-Degree, Degree-Based topological indices Beta Carotene, topological indices are the Zagreb index, General Randic index and Modified Zagreb index

How to cite this article: Sangeetha G, Kavitha J, Suma T, Mahalakshmi, Joseph S. Ve-Degree, Ev-Degree, and Degree-Based Topological Indices of Beta-Carotene. Int J Drug Deliv Technol. 2026;16(31s):977-984. DOI: 10.25258/ijddt.16.31s.105.

1. Introduction

Topological indices are defined as numerical values associated with chemical structure, which is used for correlate the numerous characteristics such as chemical structure, chemical reactivity and physical properties. Topological indices have been used to explain and improve the statistical features of drugs. Graph theory is based on vertices and edges, in chemical graph theory ,vertices represent items and edges represent bonding, In graph theory [J. Kavitha et al] we understand the terms of Quantitative structure-property relation (QSAR) and Quantitative structure-activity relation (QSPR) for structure or formula of compound.
Beta-Carotene belongs to a family of organic compounds called the carotenoids, it is found in number of plants, bacteria, algae and fungi- pumpkins, apricots, sweet potatoes, nectarines carrots etc. In its pure form, Beta-carotene occur ass purple crystal shaped like thin leaflets. Beta carotene plays an important role in photosynthetic,the process by which plant covert water and carbon dioxide into carbohydrates and oxygen. In non-photosynthetic bacteria anf fungi, beta-carotene protects the organism against the harmful effects of light and oxygen
Beta-carotene also acts as an antioxidant, a substance that attacks free radicals in the body that may cause cancer. It may also protect against heart disease and strengthen the body's immune system. Beta-carotene was first isolated by the German chemist Heinrich Wilhelm Ferdinand Wackenroder (1789–1854), who extracted the compound from carrot roots in 1831. The compound was first synthesized in 1950 by the Swiss chemist Paul Karrer (1889–1971).
Beta-carotene has two uses: in vitamin supplements and as a food additive. Anyone who eats a healthy diet that includes foods rich in vitamin A, such as fish oil, liver, eggs, butter, and orange or yellow vegetables and fruits, will get adequate amounts of beta-carotene. However, many people take vitamin supplements to ensure that they have enough beta-carotene (as well as other vitamins) in their daily diet. Although some warnings have been issued about taking too much vitamin A, there is no clinical evidence that an overdose of the vitamin does any long-term harm to a person.
The compound has also been used in experiments to test its effectiveness against certain diseases, such as lung cancer. In such cases, it has been found to be more harmful than beneficial, increasing the risk of cancer and death among people participating in the studies.
The concepts of the topological index was introduced by Wiener[H.Wiener et al].Topological indices are categorized in a variety of groups, such as degree-based,

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distance-based and counting -based [I.Gutman et al and M Randic et al] .Degree-based topological indices [B. Furtula et al] have been studied extensively to test the properties of compound and drugs as it is useful to make up the medicinal and chemical experimental .
Definition of degree concepts ,ev-degree and ve-degree, some basis mathematical propertices are studied in[M. Chellali T.W et al] . The ve-Degree of the vertex *u* denoted by D_{ve}(u) equals the number of different edges that is incident to any vertex from the closed neighborhood of u. The ev-Degree of the edge *e* denoted by D_{ev}(e) equals the number of vertices of the union of the closed neighborhood of u and v. The graph Beta carotene chemical structure is a simple undirected graph. A graph is a combination of nonempty set u and e . The members are vertices and edges respectively.

2. Preliminaries

Basic concepts, Consider a graph G with u vertex set and E edge set.The degree is the number of edges incident to vertex u, denoted as D(u). The ve-degree of vertex u is the number of edges which are incident to any vertex of close neighborhood of u, denoted by D_{ve}(u).The number of vertices is the union of closed neighborhoods of u and v is the ev-degree of edge e=uv, denoted D_{ev}(e) .

The first Zagreb index[I.Gutman et al] introduced in 1972 is defined as
$M_1(G) = \sum_{v\in V} D(v)^2 = \sum_{uv\in E}(D(u) + D(v))$.

The ve-degree Zagreb bets index of graph G is defined as
$M^{\beta ve}(G) = \sum_{uv\in V}(D_{ve}(u) + D_{ve}(v))$.

$$M^{\alpha ve}(G) = \sum_{v\in V} D_{ve}(v)^2.$$

The ev-degree F index is defined as
$F_1^{ev}(G) = \sum_{e\in E} D_{ev}(e)^3$.

The ve-degree Zagreb alpha index of graph G is defined as

The ev-degree Zagreb index of graph G is defined as

$$M^{ev}(G) = \sum_{e\in E} D_{ve}(e)^2.$$

The Randic index[5] is defined as

$$R(G) = \sum_{uv\in E} (D(u) \times D(v))^{-(\frac{1}{2})}.$$

The ve-degree Randic index of graph G is defined as

$$R^{ve}(G) = \sum_{v\in V} D_{ve}(v)^{-(\frac{1}{2})} .$$

The ev-degree Randic index is defined as

$$R^{ev}(G) = \sum_{e\in E} D_{ve}(e)^{-(\frac{1}{2})} .$$

The ve-degree modified Zagreb index is defined as

$$M^{mve}(G) = \sum_{v\in V}\left(\frac{1}{D_{ve}(v)^2}\right).$$

The ev-degree modified Zagreb index is defined as

$$M^{mev}(G) = \sum_{e\in E}\left(\frac{1}{D_{ev}(e)^2}\right).$$

The F index [6] is defined as

$$F(G) = \sum_{v\in V} D(v)^3 = \sum_{uv\in E}(D(u)^2 + D(v)^2).$$

The ve-degree F index is defined as

$$F_1^{ve}(G) = \sum_{v\in V} D_{ve}(v)^3.$$

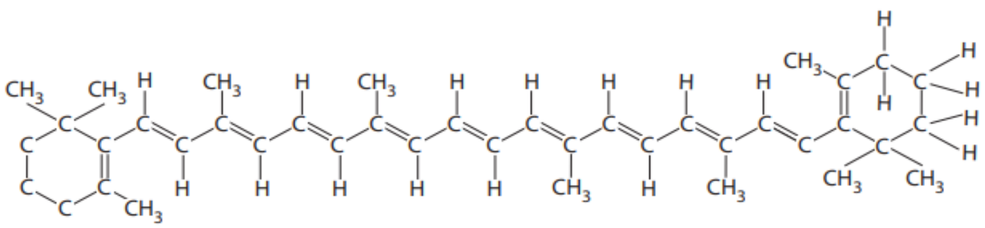

FIGURE 1: 2D Structure of Beta carotene.

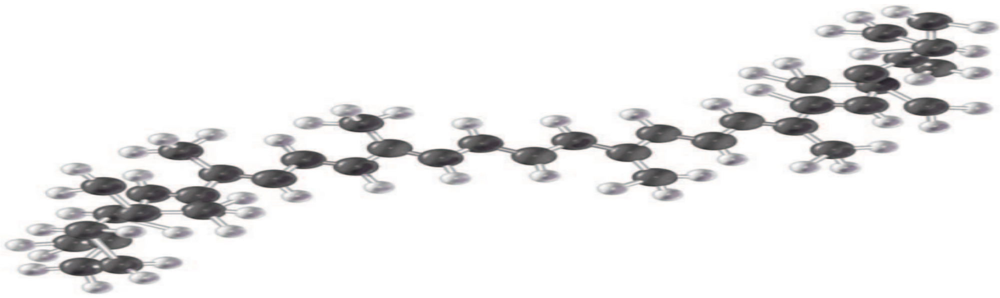

FIGURE 2: 3D Structure of Beta carotene.

TABLE 1: Edge division of Beta carotene.

(D(u),D(v))	(1,3)	(1,4)	(2,2)	(2,3)	(2,4)	(3,3)	(3,4)	(4,4)
Edge partition	$E_1(G)$	$E_2(G)$	$E_3(G)$	$E_4(G)$	$E_5(G)$	$E_6(G)$	$E_7(G)$	$E_8(G)$
Frequency	19	10	2	3	1	19	3	3

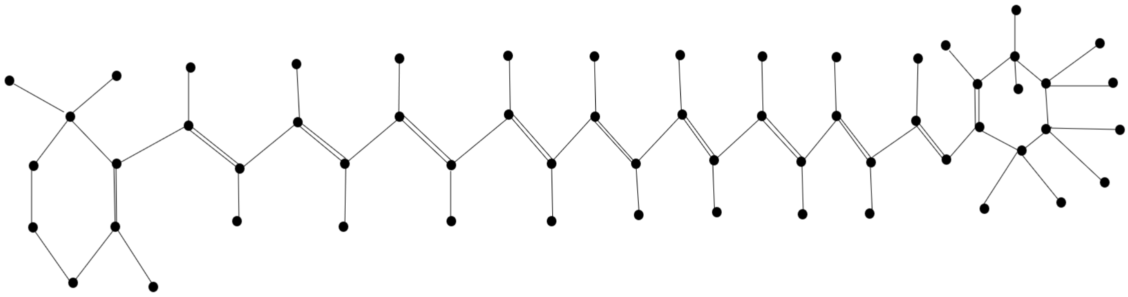

FIGURE 3: 2D Structure of Beta carotene-vertices and Edges-skectial structure.

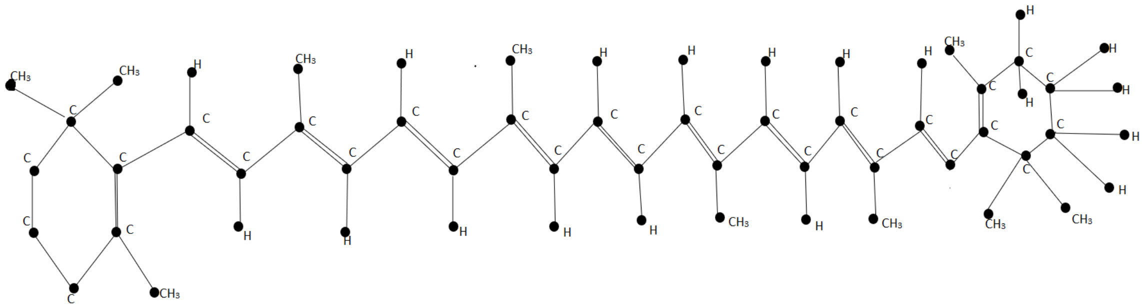

FIGURE 4: Structure of Beta carotene -($C_{40}H_{56}$).

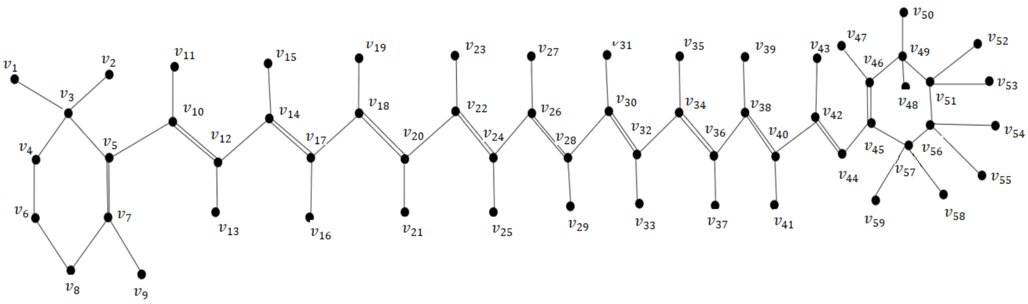

FIGURE5 : Structure of Beta carotene -($C_{40}H_{56}$)- vertices .

3. Methods

To calculate the topological indices, we will use the degree checking technique, edge partition technique degree of neighbors strategy and vertex segment techniques.

Proof of the Topological Indices

D-Based Zagreb Index: We calculat degree-based Zagreb index using Table 1.

$$M_1(G) = \sum_{uv\in E(G)} \big(D(u) + D(V)\big).$$
$$= 19(1 + 3) + 10(1 + 4) + 2(2 + 2) + 3(2 + 3) + 1(2 + 4) + 19(3 + 3) + 3(3 + 4) + 3(4 + 4)$$
$$= 314$$

Ev-D-Based Zagreb Index: We calculate ev-degree Zagreb index using Table 2

$$M^{ev}(G) = \sum_{e\in E(G)} D_{ev}(e)^2.$$
$$= 21(4)^2 + 13(5)^2 + 20(6)^2 + 3(7)^2 + 3(8)^2$$
$$= 1720$$

Ve-Degree-Based Zagreb Index: Using Table 3, we calculate ve-degree Zagreb Alpha indices.
Zagreb alpha index is

$$M_1^{\alpha ve}(G) = \sum_{v\epsilon V(G)} D_{ve}(v)^2$$
$$= 19 \times (3)^2 + 10 \times (4)^2 + (4)^2 + (5)^2 + 2 \times (6)^2 + 2 \times (6)^2 + 16 \times (7)^2 + (8)^2 + (9)^2 + (10)^2 + (7)^2 + 2 \times (9)^2 + 2 \times (10)^2$$
$$= 1956$$

TABLE 2: Ev-degree of Beta carotene.

(D(u), D(v))	Ev-degree	Frequency
(1,3)	4	19
(1,4)	5	10
(2,2)	4	2
(2,3)	5	3
(2,4)	6	1
(3,3)	6	19
(3,4)	7	3
(4,4)	8	3

TABLE 3: Ve-degree of end vertex of each edge of Beta carotene.

(D(u), D(v))	Ve-degree	Frequency
(1,3)	(3,6)	2
(1,3)	(3,7)	16
(1,3)	(3,8)	1
(1,4)	(4,7)	2
(1,4)	(4,9)	4
(1,4)	(4,10)	4
(2,2)	(4,6)	1
(2,2)	(4,5)	1
(2,3)	(5,6)	1
(2,3)	(6,6)	1
(2,3)	(6,9)	1
(3,3)	(6,10)	1
(3,3)	(7,10)	1
(3,3)	(7,7)	15
(3,3)	(6,7)	1
(3,3)	(8,9)	1
(3,4)	(7,9)	1
(3,4)	(9,9)	1
(3,4)	(9,8)	1
(4,4)	(9,10)	2
(4,4)	(10,10)	1

TABLE 4: Vertex-degree and corresponding frequency.

D(u)	Total vertex
1	29
2	4
3	21
4	5

TABLE 5: Ve-degree of Beta carotene.

D(u)	Ve-degree	Frequency
1	3	19
1	4	10
2	4	1
2	5	1
2	6	2
3	6	2
3	7	16
3	8	1
3	9	1
3	10	1
4	7	1
4	9	2
4	10	2

Zagreb beta index can be calculated by using Table 3

$$M_1^{\beta ve} = \left(D(u) + D(v)\right)$$
$$= 2(3+6) + 16(3+7) + 1(3+8) + 2(4+7) + 4(4+9) + 4(4+10) + 1(4+6) + 1(4+5) + 1(5+6) + 1(6+6) + 1(6+9) + 1(6+10) + 1(7+10) + 15(7+7) + 1(6+7) + 1(8+9) + 1(7+9) + 1(9+9) + 1(9+8) + 2(9+10) + 1(10+10)$$
$$= 758$$

D-Based General Randic Inde: Using Table 1, We calculate D-based general Randic index.

$$R_\alpha(G) = \sum_{uv\epsilon E(G)} \left(D(u) \times D(v)\right)^\alpha.$$
$$= 19(1+3)^\alpha + 10(1+4)^\alpha + 2(2+2)^\alpha + 3(2+3)^\alpha + 1(2+4)^\alpha + 19(3+3)^\alpha + 3(3+4)^\alpha + 3(4+4)^\alpha$$

For $\alpha = 1$,

$$R_1(G) = 19(1+3)^1 + 10(1+4)^1 + 2(2+2)^1 + 3(2+3)^1 + 1(2+4)^1 + 19(3+3)^1 + 3(3+4)^1 + 3(4+4)^1$$
$$R_1(G) = 314$$

For $\alpha = (\frac{1}{2})$,

$$R_{\frac{1}{2}}(G) = 19(1+3)^{\frac{1}{2}} + 10(1+4)^{\frac{1}{2}} + 2(2+2)^{\frac{1}{2}} + 3(2+3)^{\frac{1}{2}} + 1(2+4)^{\frac{1}{2}} + 19(3+3)^{\frac{1}{2}} + 3(3+4)^{\frac{1}{2}} + 3(4+4)^{\frac{1}{2}}$$
$$R_{\frac{1}{2}}(G) = 136.48$$

For $\alpha = \frac{-1}{2}$,

$$R_{\frac{-1}{2}}(G) = 19(1+3)^{\frac{-1}{2}} + 10(1+4)^{\frac{-1}{2}} + 2(2+2)^{\frac{-1}{2}} + 3(2+3)^{\frac{-1}{2}} + 1(2+4)^{\frac{-1}{2}} + 19(3+3)^{\frac{-1}{2}} + 3(3+4)^{\frac{-1}{2}} + 3(4+4)^{\frac{-1}{2}}$$
$$R_{\frac{-1}{2}}(G) = 26.67$$

For $\alpha = -1$,

$$R_{-1}(G) = 19(1+3)^{-1} + 10(1+4)^{-1} + 2(2+2)^{-1} + 3(2+3)^{-1} + 1(2+4)^{-1} + 19(3+3)^{-1} + 3(3+4)^{-1} + 3(4+4)^{-1}$$
$$R_{-1}(G) = 11.98$$

Ev-D-Based General Randic Index: Using Table 2, we calculate D-based general Randic index.

$$R_\alpha^{ev}(G) = \sum_{e \epsilon E(G)} D_{ev}(e)^\alpha$$

$$= 21(4)^\alpha + 13(5)^\alpha + 20(6)^\alpha + 3(7)^\alpha + 3(8)^\alpha$$

For $\alpha = 1$,

$$R_1(G) = 21(4)^1 + 13(5)^1 + 20(6)^1 + 3(7)^1 + 3(8)^1$$

$$R_1(G) = 314$$

For $\alpha = \frac{1}{2}$,

$$R_{\frac{1}{2}}(G) = 21(4)^{\frac{1}{2}} + 13(5)^{\frac{1}{2}} + 20(6)^{\frac{1}{2}} + 3(7)^{\frac{1}{2}} + 3(8)^{\frac{1}{2}}$$

$$R_{\frac{1}{2}}(G) = 136.48$$

For $\alpha = \frac{-1}{2}$,

$$R_{\frac{-1}{2}}(G) = 21(4)^{\frac{-1}{2}} + 13(5)^{\frac{-1}{2}} + 20(6)^{\frac{-1}{2}} + 3(7)^{\frac{-1}{2}} + 3(8)^{\frac{-1}{2}}$$

$$R_{\frac{-1}{2}}(G) = 26.67$$

For $\alpha = -1$,

$$R_{-1}(G) = 21(4)^{-1} + 13(5)^{-1} + 20(6)^{-1} + 3(7)^{-1} + 3(8)^{-1}$$

$$R_{-1}(G) = 11.98$$

Ve-Degree-Based General Randic Index: Using Table 3,we calculate general Randic index:

$$R_\alpha^{ve}(G) = \sum_{uv \epsilon E(G)} \big(D(u) + D(v)\big)^\alpha$$

$$= 2(3+6)^\alpha + 16(3+7)^\alpha + (3+8)^\alpha + 2(4+7)^\alpha + 4(4+9)^\alpha + 4(4+10)^\alpha + (4+6)^\alpha + (4+5)^\alpha + (5+6)^\alpha + (6+6)^\alpha + (6+9)^\alpha + (6+10)^\alpha + (7+10)^\alpha + 15(7+7)^\alpha + (6+7)^\alpha + (8+9)^\alpha + (7+9)^\alpha + (9+9)^\alpha + (9+8)^\alpha + 2(9+10)^\alpha + (10+10)^\alpha$$

For $\alpha = 1$,

$$R_1(G) = 2(3+6)^1 + 16(3+7)^1 + (3+8)^1 + 2(4+7)^1 + 4(4+9)^1 + 4(4+10)^1 + (4+6)^1 + (4+5)^1 + (5+6)^1 + (6+6)^1 + (6+9)^1 + (6+10)^1 + (7+10)^1 + 15(7+7)^1 + (6+7)^1 + (8+9)^1 + (7+9)^1 + (9+9)^1 + (9+8)^1 + 2(9+10)^1 + (10+10)^1$$

$$R_1(G) = 758$$

For $\alpha = \frac{1}{2}$,

$$R_{\frac{1}{2}}(G) = 2(3+6)^{\frac{1}{2}} + 16(3+7)^{\frac{1}{2}} + (3+8)^{\frac{1}{2}} + 2(4+7)^{\frac{1}{2}} + 4(4+9)^{\frac{1}{2}} + 4(4+10)^{\frac{1}{2}} + (4+6)^{\frac{1}{2}} + (4+5)^{\frac{1}{2}} + (5+6)^{\frac{1}{2}} + (6+6)^{\frac{1}{2}} + (6+9)^{\frac{1}{2}} + (6+10)^{\frac{1}{2}} + (7+10)^{\frac{1}{2}} + 15(7+7)^{\frac{1}{2}} + (6+7)^{\frac{1}{2}} + (8+9)^{\frac{1}{2}} + (7+9)^{\frac{1}{2}} + (9+9)^{\frac{1}{2}} + (9+8)^{\frac{1}{2}} + 2(9+10)^{\frac{1}{2}} + (10+10)^{\frac{1}{2}}$$

$$R_{\frac{1}{2}}(G) = 216.0$$

For $\alpha = \frac{-1}{2}$,

$$R_{\frac{-1}{2}}(G) = 2(3+6)^{\frac{-1}{2}} + 16(3+7)^{\frac{-1}{2}} + (3+8)^{\frac{-1}{2}} + 2(4+7)^{\frac{-1}{2}} + 4(4+9)^{\frac{-1}{2}} + 4(4+10)^{\frac{-1}{2}} + (4+6)^{\frac{-1}{2}} + (4+5)^{\frac{-1}{2}} + (5+6)^{\frac{-1}{2}} + (6+6)^{\frac{-1}{2}} + (6+9)^{\frac{-1}{2}} + (6+10)^{\frac{-1}{2}} + (7+10)^{\frac{-1}{2}} + 15(7+7)^{\frac{-1}{2}} + (6+7)^{\frac{-1}{2}} + (8+9)^{\frac{-1}{2}} + (7+9)^{\frac{-1}{2}} + (9+9)^{\frac{-1}{2}} + (9+8)^{\frac{-1}{2}} + 2(9+10)^{\frac{-1}{2}} + (10+10)^{\frac{-1}{2}}$$

$$R_{\frac{-1}{2}}(G) = 15.58$$

For $\alpha = -1$,

$$R_{-1}(G) = 2(3+6)^{-1} + 16(3+7)^{-1} + (3+8)^{-1} + 2(4+7)^{-1} + 4(4+9)^{-1} + 4(4+10)^{-1} + (4+6)^{-1} + (4+5)^{-1} + (5+6)^{-1} + (6+6)^{-1} + (6+9)^{-1} + (6+10)^{-1} + (7+10)^{-1} + 15(7+7)^{-1} + (6+7)^{-1} + (8+9)^{-1} + (7+9)^{-1} + (9+9)^{-1} + (9+8)^{-1} + 2(9+10)^{-1} + (10+10)^{-1}$$

$$R_{-1}(G) = 4.80$$

D-Based Modified Zagreb Index: Using Table 4, we calculate D-based modified Zagreb index

$$M^m(G) = \sum_{v \in V(G)} \frac{1}{D(v)^2}$$
$$= \frac{29}{1^2} + \frac{4}{2^2} + \frac{21}{3^2} + \frac{5}{4^2}$$
$$= 32.64$$

Ev-D-Based Modified Zagreb Index: Using Table 2, we calculate ev-degree modified Zagreb index:

$$M^{mev}(G) = \sum_{e \in E(G)} \frac{1}{D_{ev}(e)^2}$$
$$= 21 \times \frac{1}{4^2} + 13 \times \frac{1}{5^2} + 20 \times \frac{1}{6^2} + 3 \times \frac{1}{7^2} + 3 \times \frac{1}{8^2}$$
$$= 2.592$$

Ve-Degree-Based Modified Zagreb Index: Using Table 5. We calculate ve-degree modified Zagred index

$$M^{mve}(G) = \sum_{v \in V(G)} \frac{1}{D_{ve}(v)^2}$$
$$= \frac{19}{3^2} + \frac{10}{4^2} + \frac{2}{2^2} + \frac{3}{3^2} + \frac{1}{4^2} + \frac{19}{3^2} + \frac{3}{4^2} + \frac{3}{4^2}$$
$$= 6.11$$

D-Based F Index: Using Table 4, we calculate D-based F index.

$$F(G) = \sum_{v \in V(G)} D(v)^3$$
$$= 29 \times 1^3 + 4 \times 2^3 + 21 \times 3^3 + 5 \times 4^3$$
$$= 948$$

Ev-D-Based F Index: Using Table 2, we calculate ev-degree F Index

$$F_1^{ev} = \sum_{e \in E(G)} D_{ev}(e)^3$$
$$= 21 \times 4^3 + 13 \times 5^3 + \times 20 \times 6^3 + 3 \times 7^3 + 3 \times 8^3$$
$$= 9854$$

Ve-Degree-Based F Index: Using Table 5, we calculate ve-degree F Index.

$$F_1^{ve}(G) = \sum_{v \in V(G)} D_{ve}(v)^3$$
$$= 19 \times 3^3 + 10 \times 4^3 + \times 2 \times 2^3 + 3 \times 3^3 + 1 \times 4^3 + 19 \times 3^3 + 3 \times 4^3 + 3 \times 4^3$$
$$= 2211$$

TABLE 6: Numerical calculations of Topological indices for Beta carotene.

Topological indices	D-based	Ve-degree	Ev-degree
$M_1(G)$	314	1956/758	1720
$R_1(G)$	314	758	314
$R_{\frac{1}{2}}(G)$	136.48	216	136.48
$R_{-\frac{1}{2}}(G)$	26.67	15.58	26.67
$R_{-1}(G)$	11.98	4.80	11.98
$M^m(G)$	32.64	6.11	2.592

In Table 6, all the indices are shown ,The different behaviors of the indices are seen .In table 6 results of these Topological indices are given.

3. Conclusion

In this study, we compute various topological indices for beta-carotene, including the D-based first Zagreb index, ve-degree Zagreb alpha index, Zagreb beta index, ev-degree Zagreb index, Randić index, ve-degree Randić index, ev-degree Randić index, modified Zagreb index, ve-degree modified Zagreb index, ev-degree modified Zagreb index, F-index, ve-degree F-index, and ev-degree F-index. QSPR/QSAR-based topological studies play an important role in predicting the properties of chemical compounds. Topological indices help in analyzing chemical compounds without the need for laboratory testing, which is often expensive and time-consuming. Future work can be extended to investigate topological indices for other chemical compounds.

4. References

1. H.Wiener. Structural determination of paraffin boiling points. *Journal of the American Chemical Society*. 1947; 69(1):17-20.
2. I.Gutman, E.Milovanovic, I. Milovanovic. Beyond the Zagreb indices. *AKCE International Journal of Graphs and Combinatorics. 2018:* 17(1):74-85.
3. M. Chellali T.W, Haynes, S. T, Hedetniemi, T.M.Lewis. On ve-degrees and ev-degrees in graphs. *Discrete Mathematics. 2017;* 340(2): 31-38.
4. I.Gutman, N.Trinajstic. Graph theory and molecular orbitals. Total φ -electron energy of alternant hydrocarbons. *Chemical Physics Letters. 1972;.*17(4): 535-538.
5. M Randic. Characterization of molecular branching. *Journal of the American chemical society*. 1975; 97(23): 6609-6615.
6. Furtula, I. Gutman. A forgotten topological index. Journal of Mathematical Chemistry.2015; 53(4):1184-1190.
7. J. Kavitha, Suma T, Mahalakshmi, Praveena Kumara K.M. and Sudha J. An Efficient DNA Computing Model for Harmonious Colouring Problem, Journal of Information Systems Engineering and Management, 2025, 10(41s): 1011-1018.