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Research Article

On Computation of Entropy Measures and Molecular Descriptors for Isomeric Natural Polymers

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Glycogen is a polysaccharide that has a large number of highly branched polymers. It has a structure that is nearly identical to that of amylopectin. It can be found in practically all animal cells and some plant cells. Glycogen is a natural polysaccharide polymer with features that make it a good antiparticle carrier for cancer therapeutics. It is not only biocompatible by nature but also be chemically modified to accommodate additional molecular components. Topological indices are used to create quantitative structure-activity relationships (QSARs), in which the biological activity or other properties of molecules are linked to their chemical structure. We estimated certain $\widehat{K}$ Banhatti and Gourava indices of natural polymers of polysaccharides, namely, glycogen and amylopectin, which have therapeutic applications, extraordinary features, and fascinating molecular framework, in this study. We also discovered some relationships between $\widehat{K}$ Banhatti indices and information entropies, as well as a relationship between Gourava indices and their respective information entropies. In addition, we give a comparative analysis of these macromolecule families using graphs to highlight their nature.

1. Introduction

A polymer is a material made up of many repetitive subunits and consists of very massive molecules. Both synthetic and natural polymers perform crucial and pervasive character in daily occurrences due to their extensive range of characteristics. Polymers serve an important role in medication administration and prosthodontics materials, and their popularity has been phenomenal. Drug delivery and prosthodontics substances both rely on polymers, which have phenomenal popularity (Figure 1). Polymeric networks have features that are determined not only by their chemical framework but also by how isomer chains are connected together to form a network [1]. With regarded to their molecular chains, polymers are classified into four major categories.

Macromolecules (class of polymers) are found in practically every dietary item. Polysaccharides (branched or linear) such as starch and cellulose are found in the majority of foods. These polysaccharides have two basic biological functions: energy storage for metabolism and to provide structural support (cellulose). Cellulose is made out of the same substance as graphite and diamonds, but it has a different structure. The chemical formula of cellulose is $(C_6H_{10}O_5)_n$. It is a natural polymer of glucose. Monomers (monosaccharides) are tiny pieces that make up natural polymers, and glucose is the most fundamental component of cellulose [2]. Carbon, hydrogen, and oxygen are found in glucose, a form of sugar. These components combine to form a hexagonal structure with six carbon atoms and one carbon atom protruding from the end. To create many types of frameworks, distinct glucose rings can be connected at various carbons. Some ring segments are reversed, resulting in two separate types of glucose named as α-glucose and β-glucose. The alcohol OH linked to C_1 is downwards in α-glucose, while alcohol OH linked to C_1 is upwards in β-glucose. In amylopectin and glycogen, there are two types of glycosidic bonding: $\alpha(C_1 - C_4)$ and $\beta(C_1 - C_6)$ glycosidic bonding. Natural polymers, especially those

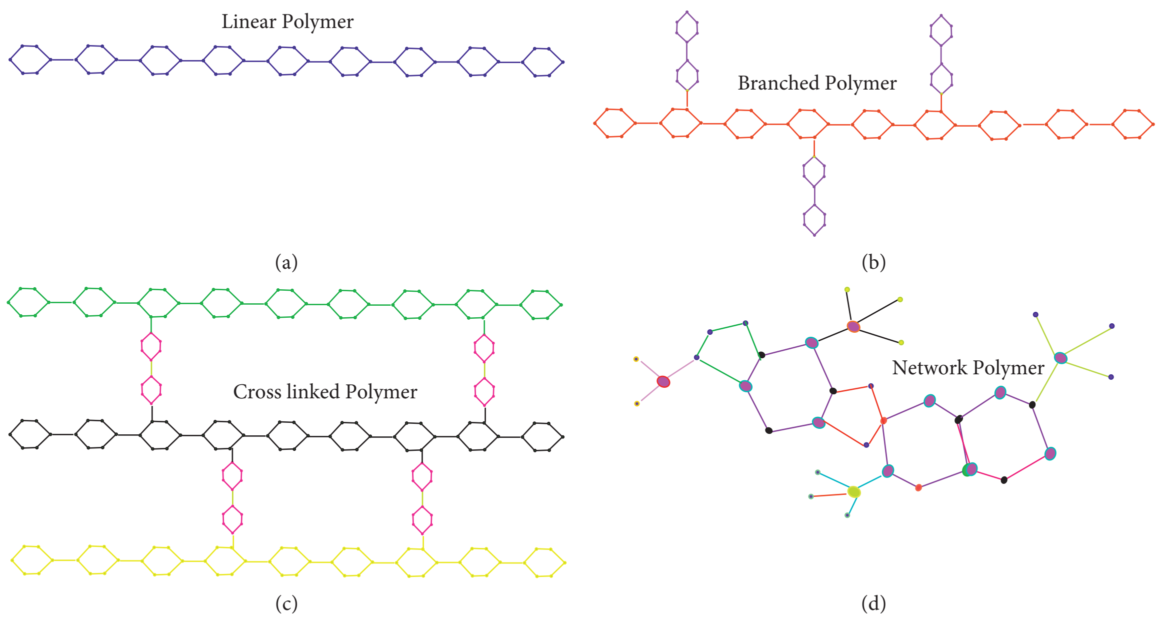


Figure 1: Depiction of polymers in terms of structural chains. (a) Linear polymer. (b) Branched polymer. (c) Cross-linked polymer. (d) Network polymer.

derived from carbohydrates, have been proven to have a wide range of pharmaceutical applications [3–5], as shown in Figure 2.

Mathematical chemistry has a section called chemical graph theory. It has a significant impact on the progress of chemical sciences. Physicochemical features of chemical substances are frequently characterized in chemical science using molecular-based structural descriptors, also known as topological indices. Vertices represent atoms, while edges represent bonds in a molecular graph. A topological index for a subatomic graph is an individual quantity that can be employed to characterize some aspects of the graph. In QSPR/QSAR research, a number of topological indices have been used [6–9]. A chemical graph $H = (V_H, E_H)$ is an ordered pair of two finite sets V_H and E_H, where V_H is the set of vertices (atoms) and E_H is the set of edges (bonds) in chemical graph H. The valence of molecules is usually portrayed by the vertex degrees [10, 11].

If $\theta = bw$ is an edge of graph H, then the vertex b and edge θ are incident as well as w and θ. Let $\psi(\theta)$ represents the degree of an edge $\theta = bw$ in H, which is computed as $\psi(\theta) = \psi(b) + \psi(w) - 2$. The multi-Banhatti indices are defined, as given in Tables 1 and 2, respectively:

In chemistry, information entropy [24, 25] is now used in two modes. First, it is a structural descriptor for assessing the complexity of chemical structures [26]. Information entropy is useful in this regard for connecting structural and physicochemical features [27], numerically distinguishing isomers of organic molecules [28], and classifying natural products and synthetic chemicals [29, 30]. The physicochemical sounding of information entropy is a different mode of application. As a result, Kobozev demonstrated its utility in analysing physicochemical processes that simulate information transmission [31]. Manzoor et al. [32] used

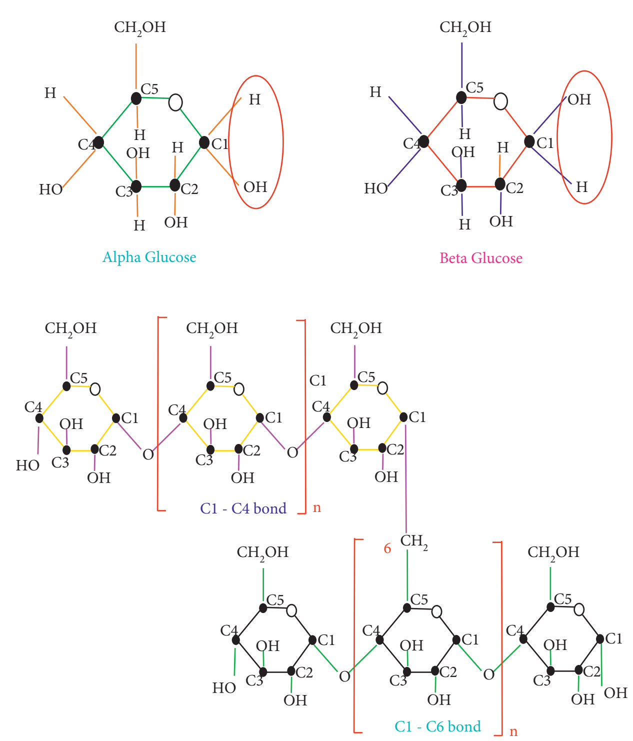


Figure 2: Fundamental unit of α-glucose and β-glucose with their connections.

entropy values to study organic compound chemical processes. The information entropy [33] based on Shannon's entropy [34] is described as

$$E(H) = \log_2(\Gamma_a) - \frac{1}{\Gamma_a}\sum_{i=1}^{j} F^i \Delta(b_i w_i) \log_2 \Delta(b_i w_i), \quad (1)$$

Table 1: Topological descriptors.

Banhatti topological descriptors	Expression
First $\widehat{K}$ Banhatti index $B_{\lambda}^{1}(H_1)$, where $\lambda = 1$ [12, 13]	$\sum_{\gamma\mu\in E(H_1)}[(\psi(\gamma)+\psi(\mu))+(\psi(\gamma)+\psi(\mu))]$
Second $\widehat{K}$ Banhatti index $B_{2}^{\lambda}(H_1)$, where $\omega = 1$ [12]	$\sum_{\gamma\mu\in E(H_1)}[(\psi(\gamma)+\psi(\mu))+(\psi(\gamma)+\psi(\mu))]$
Harmonic Banhatti index, $h_B(H)$ [14]	$\sum_{\beta\mu}2/(\psi(\beta)+\psi(\mu))$
Sum connectivity Banhatti index, $SB_{1}^{\frac{-1}{2}}(H_1)$ [15, 16]	$\sum_{\gamma\mu\in E(H_1)}[1/\sqrt{\psi(\gamma)+\psi(\theta)}+1/\sqrt{\psi(\mu)+\psi(\theta)}]$
First $\widehat{K}$-hyper Banhatti index, $HB_{1}^{2}(H_1)$ [17, 18]	$\sum_{\gamma\mu\in E(H_1)}[(\psi(\gamma)^2+\psi(\mu)^2)+(\psi(\gamma)^2+\psi(\mu)^2)]$
Second $\widehat{K}$-hyper Banhatti index, $HB_{2}^{2}(H_1)$ [4, 17]	$\sum_{\gamma\mu\in E(H_1)}[(\psi(\gamma)^2\times\psi(\mu)^2)+(\psi(\gamma)^2\times\psi(\mu)^2)]$
Modified first Banhatti index, $mB_{1}^{-1}(H_1)$ [14]	$\sum_{\gamma\mu\in E(H_1)}[(\psi(\gamma)^{-1}+\psi(\mu)^{-1})+(\psi(\gamma)^{-1}+\psi(\mu)^{-1})]$
Modified second Banhatti index, $mB_{2}^{-1}(H_1)$ [14]	$\sum_{\gamma\mu\in E(H_1)}[(\psi(\gamma)^{-1}\times\psi(\mu)^{-1})+(\psi(\gamma)^{-1}\times\psi(\mu)^{-1})]$

Table 2: Gourava topological descriptors.

Gourava topological descriptors	Expression
First Gourava index, $GV_1(H_1)$ [19]	$\sum_{\gamma\mu\in E(H_1)}[(\psi(\gamma)+\psi(\mu))+(\psi(\gamma)+\psi(\mu))]$
Second Gourava index, $GV_2(H_1)$ [19]	$\sum_{\gamma\mu\in E(H_1)}[(\psi(\gamma)+\psi(\mu))+(\psi(\gamma)+\psi(\mu))]$
Product connectivity Gourava index, $SGV(H_1)$ [20]	$\sum_{\gamma\mu\in E(H_1)}1/\sqrt{(\psi(\gamma)+\psi(\mu))\times(\psi(\gamma)\psi(\mu))}$
Sum connectivity Gourava index, $SGV(H_1)$ [21]	$\sum_{\gamma\mu\in E(H_1)}1/\sqrt{(\psi(\gamma)+\psi(\mu))+(\psi(\gamma)\times\psi(\mu))}$
First hyper-Gourava index, $GVh_1(H_1)$ [22]	$\sum_{\gamma\mu\in E(H_1)}(\psi(\gamma)+\psi(\mu))+(\psi(\gamma)\times\psi(\mu))$
Second hyper-Gourava index, $GVh_2(H_1)$ [23]	$\sum_{\gamma\mu\in E(H_1)}(\psi(\gamma)+\psi(\mu))\times(\psi(\gamma)\psi(\mu))$

where $\Gamma_a = \sum_{i=1}^{j} F^i\Delta(b_i w_i)$ is used for the topological indices, j is the number of edge types, F^i denotes the frequency of repetition, and $\Delta(b_i w_i)$ is the weight of edge bw in the graph.

2. Formation of Glycogen GL_{μ}^{γ} Network Planar Graph

Glycogen is a polycarbohydrate of glucose (form of energy storage in the body). Glycogen is generated and stored mostly in the liver and skeletal muscle cells of humans [35]. Other organs and cells, such as the kidneys, corpuscles, leucocytes, and neuroglia in the brain, contain small amounts of glycogen. Claude Bernard (French scientist) discovered glycogen, which is found mostly in the liver and muscles [36]. Natural polymers including cellulose, proteins, chitin, carbs, and glycogen are excellent sources of energy since they are essential for life to continue. The experiential formula for glycogen is $(C_6H_{10}O_5)_n$. Glycogen is a massive, complicated, and branching polymer made up of around 30,000 glucose monomers. It is made up of chains of glucose molecules connected linearly by $\alpha(C_1 - C_4)$ glycosidic connections. A chain of glucose split up after every ten to twelve residues via $\alpha(C_1 - C_6)$ glycosidic connections. In glycogen, this type of bonding results in forking and rambling patterns. On the other hand, cellulose (a natural polymer) contains $\beta(C_1 - C_4)$ glycosidic connections, resulting in a more rigid linear chain. As a result, cellulose are unable to be broken down in our stomachs. There is only one diminishing end to glycogen; however, there are many nonreductive ends. It is shown in Figure 3.

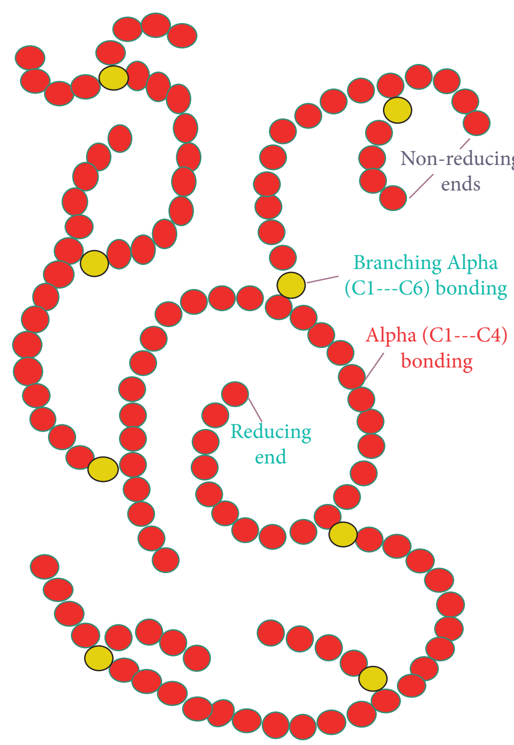


Figure 3: Molecular structure of the glycogen GL_{μ}^{γ} network.

In human and animal cells, glycogen molecules comprehend glucose as the primary storage reservoir. Glycogen is easily digested to release glucose when needed. Even if the supply of glucose in blood is unequal, this self-regulating process keeps the amount of glucose in blood at a consistent level. The Cori cycle (Figure 4) revolves around the interplay between glycogen and glucose.

Despite the fact that enough research has been done on the role of hormones like glucagon, adrenaline, and insulin in the control of the glycogen metabolism, it is still a significant issue of research [37–39]. $\alpha(C_1 - C_6)$ glycosidic bonding takes place in glycogen after every 10 glucose residues, forming the branch. The glycogen GL_{μ}^{γ} network is fabricated in $\mu - 1$ ramifications of length

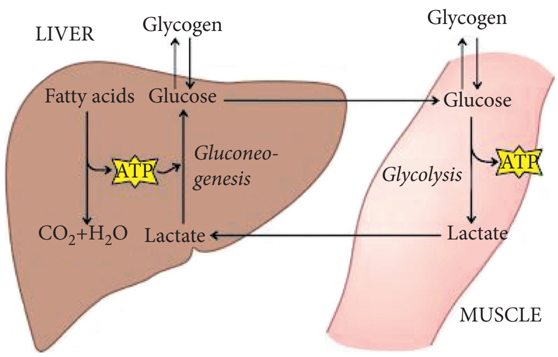


Figure 4: The Cori cycle.

$0 \leq \gamma \leq 1$ and is created from the glycogen molecule, as shown in Figure 5.

Let $V_{GL_\mu^\gamma}$ and $E_{GL_\mu^\gamma}$ represent the vertex set and the edge set of GL_μ^γ, in which there are three types of vertices and four types of edges. The vertices having degrees 1, 2, and 3 and by using fundamental counting rule, $|V^1| = \gamma(\mu-1)+9\mu$, $|V^2| = 2(2\gamma(\mu-1)+21\mu-1)$, and $|V^3| = 3\gamma(\mu-1)+29\mu-2$. The edge partition is grounded on the degrees of terminal vertices of every edge, as given in Table 3. By using the fundamental counting technique, $|E^1| = \gamma(\mu-1)+9\mu$, $|E^2| = \gamma(\mu-1)+12\mu$, $|E^3| = 6\gamma(\mu-1)+60\mu-4$, and $|E^4| = \gamma(\mu-1)+9\mu-1$. After some basic computation, we can see that $|V_{GL_\mu^\gamma}| = 8\gamma(\mu-1)+80\mu-4$ and $|E_{GL_\mu^\gamma}| = 9\gamma(\mu-1)+90\mu-5$. The principle strategy utilized here is the way to deal with edge partitioning and vertices degree calculating. Subsequently, in [40], many degree-based topological indices were calculated. We computed some $\widehat{K}$ Banhatti indices with corresponding $\widehat{K}$ Banhatti entropies. To the best of our knowledge, no such work has ever been done before.

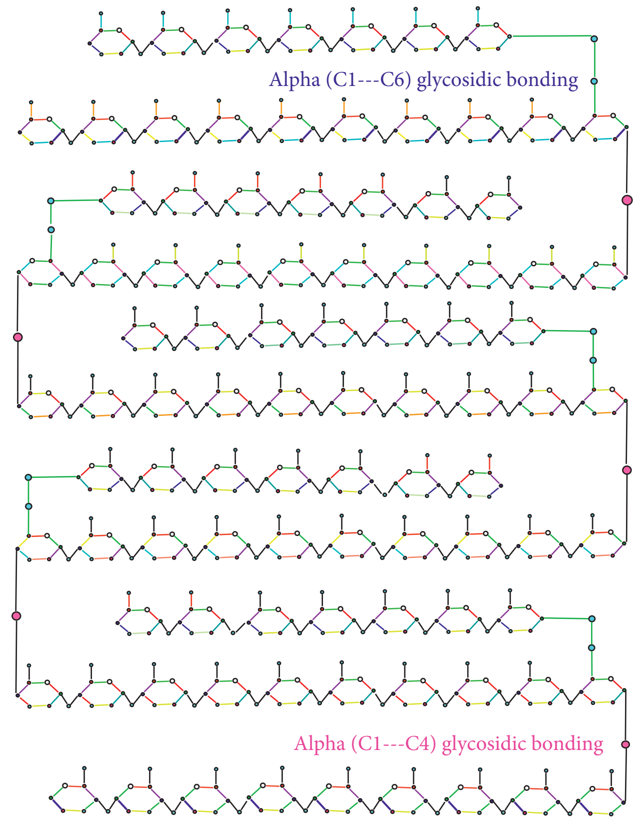


Figure 5: Hydrogen-diminished molecular graph of the glycogen GL_μ^γ network.

Table 3: Edge description of GL_μ^γ.

$(\psi(\gamma), \psi(\mu))$	Frequency	Classes of edges	$\psi(\theta)$
(1, 3)	$\gamma(\mu-1)+9\mu$	E^1	2
(2, 2)	$\gamma(\mu-1)+12\mu$	E^2	2
(2, 3)	$6\gamma(\mu-1)+60\mu-4$	E^3	3
(3, 3)	$\gamma(\mu-1)+9\mu-1$	E^4	4

2.1. Computations of $\widehat{K}$ Banhatti Indices and Entropies for the Glycogen GL_μ^γ Network. Generalized form of the first and second $\widehat{K}$ Banhatti indices is given as

$$\begin{aligned} B_1^\lambda(H_1) &= \sum_{b\theta} (\psi(b)+\psi(\theta))^\lambda = \sum_{bw\in E(H_1)} \left[(\psi(b)+\psi(\theta))^\lambda + (\psi(w)+\psi(\theta))^\lambda\right] \\ &= \left(3^\lambda+5^\lambda\right)[\gamma(\mu-1)+9\mu] + \left(2\times 4^\lambda\right)[\gamma(\mu-1)+12\mu] + \left(5^\lambda+6^\lambda\right)[6\gamma(\mu-1)+60\mu-4] \\ &\quad + \left(2\times 7^\lambda\right)[\gamma(\mu-1)+9\mu-1], \\ B_2^\lambda(H_1) &= \left(2^\lambda+6^\lambda\right)[\gamma(\mu-1)+9\mu] + \left(2\times 4^\lambda\right)[\gamma(\mu-1)+12\mu] + \left(6^\lambda+9^\lambda\right)[6\gamma(\mu-1)+60\mu-4] \\ &\quad + \left(2\times 12^\lambda\right)[\gamma(\mu-1)+9\mu-1]. \end{aligned} \tag{2}$$

The entropy of generalized first $\widehat{K}$ Banhatti indices for the graph of GL_μ^γ structure is computed by using the following equation:

$$E\left(B_i^\lambda(H_1)\right) = \log_2\left(B_i^\lambda\right) - \frac{1}{B_i^\lambda(H_1)} \sum_{i=1}^{4} \sum_{b_i w_i \in GL_\mu^\gamma} \left[(\psi(b_i) + \psi(\theta_i))^\lambda + (\psi(w_i) + \psi(\theta_i))^\lambda \right] \log_2\left[(\psi(b_i) + \psi(\theta_i))^\lambda + (\psi(w_i) + \psi(\theta_i))^\lambda \right]. \quad (3)$$

The entropy of generalized second $\widehat{K}$ Banhatti indices for the graph of AM_μ^γ structure is computed by using the following equation:

$$E\left(B_i^\lambda(H_1)\right) = \log_2\left(B_i^\lambda\right) - \frac{1}{B_i^\lambda(H_1)} \sum_{i=1}^{4} \sum_{b_i w_i \in AM_\mu^\gamma} \left[(\psi(b_i) \times \psi(\theta_i))^\lambda + (\psi(w_i) \times \psi(\theta_i))^\lambda \right] \log_2\left[(\psi(b_i) \times \psi(\theta_i))^\lambda + (\psi(w_i) \times \psi(\theta_i))^\lambda \right], \quad (4)$$

where $B_i^\lambda(H_1)$ are the different $\widehat{K}$ Banhatti indices for the graph of GL_μ^γ. By using (1), we have the following details.

2.1.1. Entropy of the First $\widehat{K}$ Banhatti and Second $\widehat{K}$ Banhatti Indices. When $\lambda = 1$ in (2) and (3), we have

$$\begin{aligned} B_1^1(H_1) &= (3+5)[9\gamma + \mu(\gamma-1)] + (4+2)[12\gamma + \mu(\gamma-1)] + (5+6)[60\gamma + 6\mu(\gamma-1) - 4] + (7+2)[9\gamma + \mu(\gamma-1) - 1] \\ &= 954\mu + 96(\mu-1)\gamma - 58, \\ B_2^1(H_1) &= (2+6)[\gamma(\mu-1) + 9\mu] + (4+4)[\gamma(\mu-1) + 12\mu] \\ &\quad + (6+9)[6\gamma(\mu-1) + 60\mu - 4] + (12+12)[\gamma(\mu-1) + 9\mu - 1] \\ &= 1284\mu + 130(\mu-1)\gamma - 84. \end{aligned} \quad (5)$$

We are interested to compute the first and second $\widehat{K}$ Banhatti entropies as follows:

$$\begin{aligned} E\left(B_1^1(H_1)\right) &= \log_2\left(B_1^1(H_1)\right) - \frac{1}{B_1^1(H_1)} \sum_{i=1}^{4} [(\psi(b_i) + \psi(\theta_i)) + (\psi(w_i) + \psi(\theta_i))] \\ &\quad \log_2[(\psi(b_i) + \psi(\theta_i)) + (\psi(w_i) + \psi(\theta_i))] \\ &= \frac{\ln(954\mu + 96(\mu-1)\gamma - 58)}{\ln(2)} - \frac{(504\mu + 48(\mu-1)\gamma)}{(954\mu + 96(\mu-1)\gamma - 58)} + \frac{11(60\mu + 6(\mu-1)\gamma - 4)\ln(11)}{\ln(2)(954\mu + 96(\mu-1)\gamma - 58)} \\ &\quad + \frac{(14(9\mu + (\mu-1)\gamma - 1)\ln(14)}{\ln(2)(954\mu + 96(\mu-1)\gamma - 58)}, \\ E\left(B_2^1(H_1)\right) &= \log_2\left(B_2^1(H_1)\right) - \frac{1}{B_2^1(H_1)} \sum_{i=1}^{4} [(\psi(b_i) \times \psi(\theta_i)) + (\psi(w_i) \times \psi(\theta_i))] \log_2[(\psi(b_i) \times \psi(\theta_i)) + (\psi(w_i) \times \psi(\theta_i))] \\ &= \frac{\ln(1284\mu + 130(\mu-1)\gamma - 84)}{\ln(2)} - \frac{(504\mu + 48(\mu-1)\gamma)}{(1284\mu + 130(\mu-1)\gamma - 84)} + \frac{(15(60\mu + 6(\mu-1)\gamma - 4))\ln(15)}{\ln(2)(1284\mu + 130(\mu-1)\gamma - 84)} \\ &\quad + \frac{(24(9\mu + (\mu-1)\gamma - 1)\ln(24)}{\ln(2)(1284\mu + 130(\mu-1)\gamma - 84)}. \end{aligned} \quad (6)$$

2.1.2. Entropy of the First and Second $\widehat{K}$-Hyper Banhatti Indices. When $\lambda = 2$ in (2) and (3), we have

$$HB_1^2(H_1) = 5232\mu + 530(\mu-1)\gamma - 342,$$
$$HB_2^2(H_1) = 10356\mu + 1062(\mu-1)\gamma - 756. \quad (7)$$

Entropy of first $\widehat{K}$-hyper Banhatti index is given as

$$E\left(HB_1^2(H_1)\right) = \log_2\left(HB_1^2\right) - \frac{1}{HB_1^2}\sum_{i=1}^{4}\sum_{b_iw_i\in H^1}\left[\left(\psi(b_i)^2+\psi(\theta_i)^2\right)+\left(\psi(w_i)^2+\psi(\theta_i)^2\right)\right]$$
$$\times \log_2\left[\left(\psi(b_i)^2+\psi(\theta_i)^2\right)+\left(\psi(w_i)^2+\psi(\theta_i)^2\right) = \frac{\ln(5232\mu+530(\mu-1)\gamma-342)}{\ln(2)}$$
$$-\frac{(34(9\mu+(\mu-1)\gamma)\ln(34))+}{(\ln(2))(5232\mu+530(\mu-1)\gamma-342)} + \frac{(1920\mu+160(\mu-1)\gamma)}{((5232\mu+530(\mu-1)\gamma-342)}$$
$$+\frac{61(60\mu+6(\mu-1)\gamma-4)\ln(61)}{(\ln(2))(5232\mu+530(\mu-1)\gamma-342)} + \frac{98(9\mu+(\mu-1)\gamma-1)\ln(98)}{(\ln(2))(5232\mu+530(\mu-1)\gamma-342)}. \quad (8)$$

Entropy of second $\widehat{K}$-hyper Banhatti index is given as

$$E\left(HB_2^2(H_1)\right) = \log_2\left(HB_2^2(H_1)\right) - \frac{1}{HB_2^2(H_1)}\sum_{i=1}^{4}\sum_{bw\in H^1}\left[\left(\psi(b_i)^2\times\psi(\theta_i)^2\right)+\left(\psi(w_i)^2\times\psi(\theta_i)^2\right)\right]$$
$$\times \log_2\left[\left(\psi(b_i)^2\times\psi(\theta_i)^2\right)+\left(\psi(w_i)^2\times\psi(\theta_i)^2\right)\right]$$
$$= \frac{\ln(10356\mu+1062(\mu-1)\gamma-756)}{\ln(2)}$$
$$-\frac{40(9\mu+(\mu-1)\gamma)\ln(40)}{\ln(2)(10356\mu+1062(\mu-1)\gamma-756)} - \frac{(1920\mu+160(\mu-1)\gamma)}{(10356\mu+1062(\mu-1)\gamma-756)}$$
$$-\frac{117(60\mu+6(\mu-1)\gamma-4)\ln(117)}{\ln(2)(10356\mu+1062(\mu-1)\gamma-756)} - \frac{288(9\mu+(\mu-1)\gamma-1)\ln(288)}{\ln(2)(10356\mu+1062(\mu-1)\gamma-756)}. \quad (9)$$

2.1.3. Sum Connectivity Banhatti Entropy of GL_μ^γ. When $\lambda = -1/2$ in (2), we have

$$SB_1^{-1/2}(H_1) = \left[12+\frac{9}{\sqrt{3}}+\frac{9}{\sqrt{5}}+\frac{60}{\sqrt{5}}+\frac{60}{\sqrt{6}}+\frac{180}{\sqrt{7}}\right]\gamma + \left[1+\sqrt{6}+\frac{1}{\sqrt{3}}+\frac{1}{\sqrt{5}}+\frac{6}{\sqrt{5}}+\frac{18}{\sqrt{7}}\right]\mu(\gamma-1)$$
$$+\left[\frac{-4}{\sqrt{5}}-\frac{4}{\sqrt{6}}-\frac{10}{\sqrt{7}}\right]. \quad (10)$$

Entropy of sum connectivity Banhatti index is given as

$$E\left(SB_1^{-1/2}(H_1)\right) = \log_2\left(SB_1^{-1/2}(H_1)\right) - \frac{1}{SB_1^{-1/2}(H_1)}\sum_{i=1}^{4}\sum_{bw\in H^1}\left[\frac{1}{\sqrt{\psi(b_i)+\psi(\theta_i)}} + \frac{1}{\sqrt{\psi(w_i)+\psi(\theta_i)}}\right]$$
$$\times \log_2\left[\frac{1}{\sqrt{\psi(b_i)+\psi(\gamma_i)}} + \frac{1}{\sqrt{\psi(w_i)+\psi(\gamma_i)}}\right] \tag{11}$$
$$= \log_2\left(SB_1^{-1/2}(H_1)\right) - \frac{(1/\sqrt{3}+1/\sqrt{5})(\gamma(\mu-1)+9\mu)(\ln(1/\sqrt{3}+1/\sqrt{5}))}{\ln(2)\left(SB_1^{-1/2}\right)}$$
$$- \frac{(1/\sqrt{5}+1/\sqrt{6})(6\gamma(\mu-1)+60\mu-4)\ln(1/\sqrt{5}+1/\sqrt{6})}{\ln(2)\left(SB_1^{-1/2}\right)} + \frac{(2/\sqrt{7})(\gamma(\mu-1)+9\mu-1)\ln(2/\sqrt{7})}{\ln(2)\left(SB_1^{-1/2}\right)}.$$

2.1.4. Modified First and Second $\widehat{K}$ Banhatti Entropies of GL_μ^γ. When $\lambda = -1$ in (2), we have

$$mB_1^{-1}(H_1) = \frac{1238}{35}\mu + \frac{739}{210}\gamma(\mu-1) - \frac{184}{105}. \tag{12}$$

Entropy of the modified first $\widehat{K}$ Banhatti index can be computed as

$$E\left(mB_1^{-1}(H_1)\right) = \log_2\left(mB_1^{-1}(H_1)\right) - \frac{1}{mB_1^{-1}(H_1)}\sum_{i=1}^{4}\sum_{b_iw_i\in H_1}\left[\frac{1}{\psi(b_i)} + \frac{1}{\psi(\theta_i)} + \frac{1}{\psi(w_i)} + \frac{1}{\psi(\theta_i)}\right]$$
$$\times \log_2\left[\frac{1}{\psi(b_i)} + \frac{1}{\psi(\theta_i)} + \frac{1}{\psi(w_i)} + \frac{1}{\psi(\theta_i)}\right]$$
$$= \frac{\ln(1238/35\mu + 739/210\gamma(\mu-1) - 184/105)}{\ln(2)} - \frac{8(\gamma(\mu-1)+9\mu)\ln(8/15)}{15(1238/35\mu + 739/210\gamma(\mu-1) - 184/105)\ln(2)} \tag{13}$$
$$- \frac{(6\mu - 1/2(\mu-1)\gamma)}{(1238/35\mu + 739/210\gamma(\mu-1) - 184/105)} - \frac{11(6\gamma(\mu-1)+60\mu-4)\ln(11/30)}{30(1238/35\mu + 739/210\gamma(\mu-1) - 184/105)\ln(2)}$$
$$- \frac{2(9\mu + (\mu-1)\gamma - 1)\ln(2/7)}{7(1238/35\mu + 739/210\gamma(\mu-1) - 184/105)\ln(2)}.$$

When $\lambda = -1$ in (3), we have

$$mB_2^{-1}(H_1) = \frac{181}{6}\mu + 3(\mu-1)\gamma - \frac{23}{18}. \tag{14}$$

Entropy of the modified second $\widehat{K}$ Banhatti index can be computed as

$$E\left(mB_2^{-1}(H_1)\right) = \log_2\left(mB_2^{-1}(H_1)\right) - \frac{1}{mB_2^{-1}(H_1)}\sum_{i=1}^{4}\sum_{b_iw_i\in E(H_1)}\left[\left(\frac{1}{\psi(b_i)}\times\frac{1}{\psi(\theta_i)}\right)+\left(\frac{1}{\psi(w_i)}\times\frac{1}{\psi(\theta_i)}\right)\right]$$
$$\times\log_2\left[\left(\frac{1}{\psi(b_i)}\times\frac{1}{\psi(\theta_i)}\right)+\left(\frac{1}{\psi(w_i)}\times\frac{1}{\psi(\theta_i)}\right)\right]$$
$$= \frac{\ln(181/6\gamma + 3\mu(\gamma-1) - 23/18)}{\ln(2)} - \frac{2(9\mu + (\mu-1)\gamma)\ln(2/3)}{3(181/6\gamma + 3\mu(\gamma-1) - 23/18)\ln(2)} + \frac{6\mu + 1/2(\mu-1)\gamma}{(181/6\gamma + 3\mu(\gamma-1) - 23/18)}$$
$$- \frac{5(6\gamma(\mu-1) + 60\mu - 4)\ln(5/18)}{18(181/6\gamma + 3\mu(\gamma-1) - 23/18)\ln(2)} + \frac{(\gamma(\mu-1) + 9\mu - 1)\ln(6)}{6(181/6\gamma + 3\mu(\gamma-1) - 23/18)\ln(2)}. \tag{15}$$

2.1.5. Harmonic $\widehat{K}$ Banhatti Index of GL_μ^γ.

$$H_b(H_1) = \sum_{bw\in E(H_1)}\left[\frac{2}{\psi(b)+\psi(\theta)} + \frac{2}{\psi(w)+\psi(\theta)}\right]$$
$$= \left[\frac{2}{3}+\frac{2}{5}\right](\gamma(\mu-1) + 9\mu) + \left[\frac{2}{4}+\frac{2}{4}\right](\gamma(\mu-1) + 12\mu)$$
$$+ \left[\frac{1}{5}+\frac{2}{6}\right](6\gamma(\mu-1) + 60\mu - 4) + \left[\frac{2}{7}+\frac{2}{7}\right](\gamma(\mu-1) + 9\mu - 1)$$
$$= \frac{2476}{35}\mu + \frac{739}{105}(\mu-1)\gamma - \frac{368}{105}. \tag{16}$$

Entropy of harmonic $\widehat{K}$ Banhatti index is

$$E(H_b(H_1)) = \log_2(H_b) - \frac{1}{H_b}\sum_{i=1}^{4}\sum_{b_iw_i\in E(H_1)}\left[\frac{2}{\psi(b_i)+\psi(\theta_i)} + \frac{2}{\psi(w_i)+\psi(\theta_i)}\right]\log_2\left[\frac{2}{\psi(b_i)+\psi(\theta_i)} + \frac{2}{\psi(w_i)+\psi(\theta_i)}\right]$$
$$= \log_2\left(\frac{2476}{35}\mu + \frac{739}{105}(\mu-1)\gamma - \frac{368}{105}\right) - \frac{16(\gamma(\mu-1) + 9\mu)\ln(16/15)}{15(2476/35\gamma + 739/105\mu(\gamma-1) - 368/105)\ln(2)}$$
$$- \frac{(22/5(\mu-1)\gamma + 44\mu - 44/15)\ln(11/15)}{(2476/35\gamma + 739/105\mu(\gamma-1) - 368/105)\ln(2)} - \frac{(4/7(\mu-1)\gamma + 36/7\mu - 4/7)\ln(4/7)}{(2476/35\gamma + 739/105\mu(\gamma-1) - 368/105)\ln(2)}. \tag{17}$$

2.2. Computation of Gourava Indices and Entropy Measure for the Glycogen GL_{μ}^{γ} Network

2.2.1. The First and Second Gourava Entropies of GL_{μ}^{γ}. The first and second Gourava indices by utilizing Table 1 and Table 3 are

$$\begin{aligned}
GV_1(H_1) &= \sum_{bw\in E(H_1)} [\psi(b) + \psi(w) + (\psi(b)\times\psi(w))] \\
&= [1 + 3 + (1\times 3)](\gamma(\mu-1) + 9\mu) + [2 + 2 + (2\times 2)](\gamma(\mu-1) + 12\mu) + [2 + 3 + (2\times 3)](6\gamma(\mu-1) \\
&\quad + 60\mu - 4) + [3 + 3 + (3\times 3)](\gamma(\mu-1) + 9\mu - 1) \\
&= 96\gamma(\mu-1) + 954\mu - 59, \\
GV_2(H_1) &= \sum_{bw\in E(H_1)} [(\psi(b) + \psi(w))\times(\psi(b)\psi(w))] \\
&= [(1+3)\times(1\times 3)](\gamma(\mu-1) + 9\mu) + [(2+2)\times(2\times 2)](\gamma(\mu-1) + 12\mu) \\
&\quad + [(2+3)\times(2\times 3)](6\gamma(\mu-1) + 60\mu - 4) \\
&\quad + [(3+3)\times(3\times 3)](\gamma(\mu-1) + 9\mu - 1) \\
&= 262\gamma(\mu-1) + 2586\mu - 174.
\end{aligned} \tag{18}$$

Entropy of first and second Gourava indices can be computed as

$$\begin{aligned}
E(GV_1(H_1)) &= \log_2(GV_1(H_1)) - \frac{1}{GV_1(H_1)}\sum_{i=1}^{4}\sum_{b_iw_i\in E(H_1)} [\psi(b_i) + \psi(w_i) + (\psi(b_i)\times\psi(w_i))] \\
&\quad \times \log_2[\psi(b_i) + \psi(w_i) + (\psi(b_i)\times\psi(w_i))] \\
&= \frac{\ln(96\gamma(\mu-1) + 954\mu - 59)}{\ln(2)} \\
&\quad - \frac{63(\mu + 7\gamma(\mu-1))\ln(7)}{(96\gamma(\mu-1) + 954\mu - 59)\ln(2)} \\
&\quad - \frac{(288\mu + 24\gamma(\mu-1))}{(96\gamma(\mu-1) + 954\mu - 59)} - \frac{(660\mu + 66\gamma(\mu-1) - 44)\ln(11)}{(96\gamma(\mu-1) + 954\mu - 59)\ln(2)} \\
&\quad - \frac{(135\mu + 15\gamma(\mu-1) - 15)\ln(15)}{(96\gamma(\mu-1) + 954\mu - 59)\ln(2)}, \\
E(GV_2(H_1)) &= \log_2(GV_2) - \frac{1}{GV_2}\sum_{i=1}^{4}\sum_{b_iw_i\in E(H_1)} [\psi(b_i) + \psi(w_i)\times(\psi(b_i)\psi(w_i))]\log_2[\psi(b_i) + \psi(w_i)\times(\psi(b_i)\psi(w_i))] \\
&= \frac{\ln(262\gamma(\mu-1) + 2586\mu - 174)}{\ln(2)} \\
&\quad - \frac{}{(5(60\mu + 6\gamma(\mu-1) - 4)\ln(5)(262\gamma(\mu-1) + 2586\mu - 174)\ln(2)} \\
&\quad - \frac{168\mu + 16\gamma(\mu - 1}{262\gamma(\mu-1) + 2586\mu - 174} - \frac{(6(9\mu + \gamma(\mu-1) - 1))\ln(6)}{(262\gamma(\mu-1) + 2586\mu - 174)\ln(2)} \\
&\quad - \frac{(135\mu + 15\gamma(\mu-1) - 15)\ln(15)}{(262\gamma(\mu-1) + 2586\mu - 174)\ln(2)}.
\end{aligned} \tag{19}$$

2.2.2. Product Connectivity Gourava Entropy of GL_{μ}^{γ}. By utilizing Table 1 and Table 3, we get

$$\begin{aligned} PGV(H_1) &= \sum_{bw\in E(H_1)} \frac{1}{\sqrt{(\psi(b)+\psi(w))\times(\psi(b)\psi(w))}} \\ &= \frac{1}{\sqrt{(1+3)\times(1\times 3)}}(\gamma(\mu-1)+9\mu) + \frac{1}{\sqrt{(2+2)\times(2\times 2)}}(\gamma(\mu-1)+12\mu) \\ &\quad + \frac{1}{\sqrt{(2+3)\times(2\times 3)}}(6\gamma(\mu-1)+60\mu-4) + \frac{1}{\sqrt{(3+3)\times(3\times 3)}}(\gamma(\mu-1)+9\mu-1) \\ &= 17.7769\mu + 1.77017(\mu-1)\gamma - 0.86636. \end{aligned} \tag{20}$$

Entropy is computed as

$$\begin{aligned} E(PGV(H_1)) &= \log_2(PGV(H_1)) - \frac{1}{PGV(H_1)} \sum_{i=1}^{4} \sum_{b_i w_i \in E(H_1)} \left[\frac{1}{\sqrt{(\psi(b_i)+\psi(w_i))\times(\psi(b_i)\psi(w_i))}}\right] \\ &\quad \times \log_2\left(\frac{1}{\sqrt{(\psi(b_i)+\psi(w_i))\times(\psi(b_i)\psi(w_i))}}\right) \\ &= \log_2(17.7769\mu + 1.77017(\mu-1)\gamma - 0.86636) - \frac{1/\sqrt{12}(\gamma(\mu-1)+9\mu)\ln(1/\sqrt{12})}{(17.7769\mu + 1.77017(\mu-1)\gamma - 0.86636)\ln(2)} \\ &\quad - \frac{1/4(\gamma(\mu-1)+12\mu)\ln(1/4)}{(17.7769\mu + 1.77017(\mu-1)\gamma - 0.86636)\ln(2)} - \frac{1/\sqrt{30}(6\gamma(\mu-1)+60\mu-4)\ln(1/\sqrt{30})}{(17.7769\mu + 1.77017(\mu-1)\gamma - 0.86636)\ln(2)} \\ &\quad - \frac{1/\sqrt{54}(\gamma(\mu-1)+9\mu-1)\ln(1/\sqrt{30})}{(17.7769\mu + 1.77017(\mu-1)\gamma - 0.86636)\ln(2)}. \end{aligned} \tag{21}$$

2.2.3. Sum Connectivity Gourava Entropy of GL_{μ}^{γ}. By utilizing Table 1 and Table 3, we obtain

$$\begin{aligned} SGV(H_1) &= \sum_{bw\in E(H_1)} \frac{1}{\sqrt{\psi(b)+\psi(w)+(\psi(b)\times\psi(w))}} \\ &= \frac{1}{\sqrt{(1+3)+(1\times 3)}}(\gamma(\mu-1)+9\mu) + \frac{1}{\sqrt{(2+2)+(2\times 2)}}(\gamma(\mu-1)+12\mu) \\ &\quad + \frac{1}{\sqrt{(2+3)+(2\times 3)}}(6\gamma(\mu-1)+60\mu-4) + \frac{1}{\sqrt{(3+3)+(3\times 3)}}(\gamma(\mu-1)+9\mu-1) \\ &= 28.058610\mu + 2.798766\gamma(\mu-1) - 1.464334, \end{aligned} \tag{22}$$

where entropy is given as

$$E(SGV(H_1)) = \log_2(SGV(H_1)) - \frac{1}{SGV(H_1)} \sum_{i=1}^{4} \sum_{b_i w_i \in E(H_1)} \left(\frac{1}{\sqrt{\psi(b_i) + \psi(w_i) + (\psi(b_i) \times \psi(w_i))}} \right)$$
$$\times \log_2\left(\frac{1}{\sqrt{\psi(b_i) + \psi(w_i) + (\psi(b_i) \times \psi(w_i))}} \right)$$
$$= \log_2(28.058610\mu + 2.798766\gamma(\mu - 1) - 1.464334) - \frac{1}{28.058610\mu + 2.798766\gamma(\mu - 1) - 1.464334} \tag{23}$$
$$\times \left(\frac{1}{\sqrt{12}} (\gamma(\mu - 1) + 9\mu) \log_2\left(\frac{1}{\sqrt{12}} \right) + \frac{1}{\sqrt{8}} (\gamma(\mu - 1) + 12\mu) \log_2\left(\frac{1}{\sqrt{8}} \right) \right.$$
$$\left. + \frac{1}{\sqrt{30}} (6\gamma(\mu - 1) + 60\mu - 4) \log_2\left(\frac{1}{\sqrt{30}} \right) + \frac{1}{\sqrt{54}} (\gamma(\mu - 1) + 9\mu - 1) \log_2\left(\frac{1}{\sqrt{54}} \right) \right).$$

2.2.4. The First and Second Hyper-Gourava Entropies of GL_μ^γ.

The first and second hyper-Gourava indices by utilizing Table 1 and Table 3 are

$$GVh_1(H_1) = \sum_{bw \in E(H_1)} [\psi(b) + \psi(w) + (\psi(b) \times \psi(w))]^2 = [1{+}t3n{+}q(1{\times}t3)]^2 (9\gamma + \gamma\mu - \mu) + [2{+}t2n{+}q(2{\times}t2)]^2$$
$$(12\gamma + \gamma\mu - \mu) + [2{+}t3n{+}qh2{\times}x3]^2 (60\gamma + 6\gamma\mu - 6\gamma - 4) + [3{+}t3n{+}q(3{\times}t3)]^2 (9\gamma + \gamma\mu - \mu - 1) = 1064\gamma(\mu - 1)$$
$$- 10494\mu - 709,$$
$$GVh_2(H_1) = \sum_{bw \in E(H_1)} [(\psi(b) + \psi(w)) \times (\psi(b)\psi(w))]^2 = [(1{+}t3){\times}(1{\times}t3)]^2 (9\gamma + \gamma\mu - \mu) + [(2{+}t2){\times}(2{\times}2)]^2$$
$$(12\gamma + \gamma\mu - \mu) + [(2{+}3){\times}(2{\times}3)]^2 (60\gamma + 6\gamma\mu - 6\gamma - 4) + [(3{+}t3)3{+}3{\times}(3{\times}3)]^2 (9\gamma + \gamma\mu - \mu - 1) = 34200\mu$$
$$+ 3500\gamma(\mu - 1) - 2500,$$
$$E(GVh_1(H_1)) = \log_2(GVh_1(H_1)) - \frac{1}{GVh_1(H_1)} \sum_{i=1}^{4} \sum_{b_i w_i \in E(H_1)} [\psi(b_i) + \psi(w_i) + (\psi(b_i) \times \psi(w_i))]^2$$
$$\times \log_2[\psi(b_i) + \psi(w_i) + (\psi(b_i) \times \psi(w_i))]^2 = \frac{\ln(1064\gamma(\mu - 1) - 10494\mu - 709)}{\ln(2)} - \frac{1}{(1064\gamma(\mu - 1) - 10494\mu - 709)}$$
$$((4608\mu + 384\gamma(\mu - 1)) + \frac{(98(\gamma(\mu - 1) + 9\mu))\ln(7))}{\ln(2)} + \frac{242(60\mu + 6\gamma(\mu - 1) - 4)\ln(11)}{\ln(2)}$$
$$+ \frac{(450(9\mu + \gamma(\mu - 1) - 1))\ln(15)}{\ln(2)} \Bigg),$$
$$E(GVh_2(H_1)) = \log_2(GVh_2(H_1)) - \frac{1}{GVh_2(H_1)} \sum_{i=1}^{4} \sum_{b_i w_i \in E(H_1)} [\psi(b_i) + \psi(w_i) \times (\psi(b_i)\psi(w_i))]^2$$
$$\times \log_2[\psi(b_i) + \psi(w_i) \times (\psi(b_i) t\psi n(w_i))]^2 = \frac{\ln(34200\mu + 3500\gamma(\mu - 1) - 2500)}{\ln(2)} - \frac{1}{(34200\mu + 3500\gamma(\mu - 1) - 2500)}$$
$$\times \left(\frac{\ln((200(\gamma(\mu - 1) + 9\mu))\ln(10))}{\ln(2)} + \frac{(200(\gamma(\mu - 1) + 12\mu))\ln(10)}{\ln(2)} + \frac{(242(6\gamma(\mu - 1) + 60\mu - 4))\ln(20)}{\ln(2)} \right.$$
$$\left. + \frac{(1800(\gamma(\mu - 1) + 9\mu - 1))\ln(30)}{\ln(2)} \right). \tag{24}$$

3. Formation of the Amylopectin AM_{μ}^{γ} Network

In comparison to glycogen, amylopectin has fewer branches and is less compact. These molecules have an open structure due to the helical branching structure; as a result, enzymes may easily access them. As a result, they can be quickly disassembled or reassembled. The branch in amylopectin is formed via $\alpha(C_1-C_6)$ glycosidic bonding, which happens around every 20 glucose residues. The primary distinction between amylopectin and glycogen is that amylopectin is insoluble, whereas glycogen is soluble. Amylopectin is one of two kinds of starch that make up the majority of plant storage polysaccharides. In mammals, glycogen is the primary storage polysaccharide. The linear chain of both amylopectin and glycogen is made up of $\alpha(C_1-C_4)$ glycosidic links, whereas the branches are made up of $\alpha(C_1-C_6)$ glycosidic linkages. Amylopectin is a protein that is utilized in the textile, paper, and laundry industries. It is also utilized in the food business and in the making of paper boards and adhesives for paper in breweries as a raw material. It is used in soaps and a variety of desserts as a thickening and gelling ingredient. The amylopectin molecule is used to build the AM_{μ}^{γ} network, which has $\mu-1$ branches with lengths γ, where $2\leq\gamma\leq 19$. After some basic computation, we can see that $|V_{(AM_{\mu}^{\gamma})}| = 8\gamma(\mu-1)+160\mu-4$ and $|E_{(AM_{\mu}^{\gamma})}| = 9\gamma(\mu-1)+180\mu-5$. The principle strategy utilized here is the way to deal with edge partitioning and vertices degree calculating, as given in Table 4.

3.1. $\widehat{K}$ Banhatti Indices and Entropy Measures for the AM_{μ}^{γ} Network.

Generalized form of the first $\widehat{K}$ Banhatti index by using Table 4 is given as

$$\begin{aligned}B_{\iota}^{\lambda}(H_2) &= \sum_{bw}(\psi(b)+\psi(w))^{\lambda}\\ &=\left(3^{\lambda}+5^{\lambda}\right)[\gamma(\mu-1)+19\mu]+\left(4^{\lambda}+2^{\lambda}\right)[\gamma(\mu-1)+22\mu]\\ &\quad+\left(5^{\lambda}+6^{\lambda}\right)[6\gamma(\mu-1)+120\mu-4]+\left(7^{\lambda}+2^{\lambda}\right)[\gamma(\mu-1)+19\mu-1].\end{aligned}\tag{25}$$

Generalized form of the second $\widehat{K}$ Banhatti index with the help of Table 4 is given as

$$\begin{aligned}B_{\iota}^{\lambda}(H_2) &= \sum_{bw}(\psi(b)+\psi(w))^{\lambda}\\ &=\left(2^{\lambda}+6^{\lambda}\right)[\gamma(\mu-1)+19\mu]+\left(4^{\lambda}+2^{\lambda}\right)[\gamma(\mu-1)+22\mu]\\ &\quad+\left(6^{\lambda}+9^{\lambda}\right)[6\gamma(\mu-1)+120\mu-4]+\left(12^{\lambda}+2^{\lambda}\right)[\gamma(\mu-1)+19\mu-1].\end{aligned}\tag{26}$$

The entropy of generalized first $\widehat{K}$ Banhatti indices for the graph of AM_{μ}^{γ} structure is computed by using the following equation:

$$\begin{aligned}E\left(B_i^{\lambda}(H_2)\right) &= \log_2\left(B_i^{\lambda}\right)-\frac{1}{B_i^{\lambda}(H_2)}\sum_{i=1}^{4}\sum_{b_iw_i\in AM_{\mu}^{\gamma}}\left[(\psi(b_i)+\psi(\theta_i))^{\lambda}+(\psi(w_i)+\psi(\theta_i))^{\lambda}\right]\\ &\quad\log_2\left[(\psi(b_i)+\psi(\theta_i))^{\lambda}+(\psi(w_i)+\psi(\theta_i))^{\lambda}\right].\end{aligned}\tag{27}$$

Table 4: Edge description of AM_{μ}^{γ}.

$(\psi(b), \psi(w))$	Frequency	Classes of edges	$\psi(\theta)$
(1, 3)	$\gamma(\mu-1)+19\mu$	E^1	2
(2, 2)	$\gamma(\mu-1)+22\mu$	E^2	2
(2, 3)	$6\gamma(\mu-1)+120\mu-4$	E^3	3
(3, 3)	$\gamma(\mu-1)+19\mu-1$	E^4	4

The entropy of generalized second $\widehat{K}$ Banhatti indices for the graph of AM_{μ}^{γ} structure is computed by using the following equation:

$$E\left(B_i^{\lambda}(H_2)\right) = \log_2\left(B_i^{\lambda}\right) - \frac{1}{B_i^{\lambda}(H_2)}\sum_{i=1}^{4}\sum_{b_iw_i\in AM_{\mu}^{\gamma}}\left[(\psi(b_i)\times\psi(\theta_i))^{\lambda}+(\psi(w_i)\times\psi(\theta_i))^{\lambda}\right]\log_2\left[(\psi(b_i)\times\psi(\theta_i))^{\lambda} + (\psi(w_i)\times\psi(\theta_i))^{\lambda}\right], \tag{28}$$

where $B_i^{\lambda}(H_2)$ are the different $\widehat{K}$ Banhatti indices for the graph of AM_{μ}^{γ}.

3.1.1. The First and Second $\widehat{K}$ Banhatti Entropies of AM_{μ}^{γ}. In both (25) and (26), for $\lambda = 1$, we have

$$\begin{aligned} B_1^1(H_2) &= 1914\mu + 96(\mu-1)\gamma - 58,\\ B_2^1(H_2) &= 25584\mu + 1062(\mu-1)\gamma - 84. \end{aligned} \tag{29}$$

Corresponding entropies by using (27) and (28) for $\lambda = 1$ are

$$\begin{aligned} E\left(B_2^1(H_2)\right) &= \frac{\ln(1914\mu+96(\mu-1)\gamma-58)}{\ln(2)} - \frac{(984\mu+48(\mu-1)\gamma)}{(1914\mu+96(\mu-1)\gamma-58)}\\ &\quad + \frac{11(120\mu+6(\mu-1)\gamma-4)\ln(11)}{n(2)(1914\mu+96(\mu-1)\gamma-58)} + \frac{(14)(19\mu+(\mu-1)\gamma-1)\ln(14)}{\ln(2)(1914\mu+96(\mu-1)\gamma-58)},\\ E\left(B_2^1(H_2)\right) &= \frac{\ln(2584\mu+130(\mu-1)\gamma-84)}{\ln(2)} - \frac{(984\mu+48(\mu-1)\gamma)}{(2584\mu+130(\mu-1)\gamma-84)}\\ &\quad + \frac{(15(120\mu+6(\mu-1)\gamma-4))\ln(15)}{\ln(2)(2584\mu+130(\mu-1)\gamma-84)} + \frac{(24(19\mu+(\mu-1)\gamma-1)\ln(24)}{\ln(2)(2584\mu+130(\mu-1)\gamma-84)}. \end{aligned} \tag{30}$$

3.1.2. Entropy of the First and Second $\widehat{K}$-Hyper Banhatti Indices. In both (25) and (26), for $\lambda = 2$, we have

$$\begin{aligned} HB_1^2(H_2) &= 10532\mu + 530(\mu-1)\gamma - 342,\\ HB_2^2(H_2) &= 20976\mu + 1062(\mu-1)\gamma - 756. \end{aligned} \tag{31}$$

Entropy of the first and second $\widehat{K}$-hyper Banhatti indices by using both (27) and (28) for $\lambda = 2$ is given as

$$\begin{aligned}
E\left(HB_1^2(H_2)\right) &= \frac{\ln(10532\mu + 530(\mu-1)\gamma - 342)}{\ln(2)} - \frac{(34(19\mu + (\mu-1)\gamma)\ln(34))+}{(\ln(2))(10532\mu + 530(\mu-1)\gamma - 342)} \\
&\quad + \frac{(3520\mu + 160(\mu-1)\gamma)}{(10532\mu + 530(\mu-1)\gamma - 342)} + \frac{61(120\mu + 6(\mu-1)\gamma - 4)\ln(61)}{(\ln(2))(10532\mu + 530(\mu-1)\gamma - 342)} \\
&\quad + \frac{98(19\mu + (\mu-1)\gamma - 1)\ln(98)}{(\ln(2))(10532\mu + 530(\mu-1)\gamma - 342)}, \\
E\left(HB_2^2(H_2)\right) &= \frac{\ln(20976\mu + 1062(\mu-1)\gamma - 756)}{\ln(2)} - \frac{40(19\mu + (\mu-1)\gamma)\ln(40)}{\ln(2)(20976\mu + 1062(\mu-1)\gamma - 756)} \\
&\quad - \frac{(3520\mu + 160(\mu-1)\gamma)}{(20976\mu + 1062(\mu-1)\gamma - 756)} - \frac{117(120\mu + 6(\mu-1)\gamma - 4)\ln(117)}{\ln(2)(20976\mu + 1062(\mu-1)\gamma - 756)} \\
&\quad - \frac{288(19\mu + (\mu-1)\gamma - 1)\ln(288)}{\ln(2)(20976\mu + 1062(\mu-1)\gamma - 756)}.
\end{aligned} \tag{32}$$

3.1.3. Entropy of Sum Connectivity Banhatti Index for AM_μ^γ. When $\lambda = -1/2$ in equation (6), we have

$$\begin{aligned}
SB_1^{-1/2}(H_2) &= \left[\frac{1}{\sqrt{3}} + \frac{1}{\sqrt{5}}\right](\gamma(\mu-1) + 19\mu) + (1)(\gamma(\mu-1) + 22\mu) \\
&\quad + \left[\frac{1}{\sqrt{5}} + \frac{1}{\sqrt{6}}\right](6\gamma(\mu-1) + 120\mu - 4) + \left[\frac{2}{\sqrt{7}}\right](\gamma(\mu-1) + 19\mu - 1) \\
&= 158.4847717\mu + 7.91326318(\mu-1)\gamma - 4.17777642.
\end{aligned} \tag{33}$$

Entropy of sum connectivity Banhatti index by using (27) is given as

$$\begin{aligned}
E\left(SB_1^{-1/2}(H_2)\right) &= \log_2\left(SB_1^{-1/2}(H_1)\right) - \frac{(1/\sqrt{3} + 1/\sqrt{5})(\gamma(\mu-1) + 19\mu)(\ln(1/\sqrt{3} + 1/\sqrt{5}))}{\ln(2)\left(SB_1^{-1/2}\right)} \\
&\quad - \frac{(1/\sqrt{5} + 1/\sqrt{6})(6\gamma(\mu-1) + 120\mu - 4)\ln(1/\sqrt{5} + 1/\sqrt{6})}{\ln(2)\left(SB_1^{-1/2}\right)} - \frac{(2/\sqrt{7})(\gamma(\mu-1) + 19\mu - 1)\ln(2/\sqrt{7})}{\ln(2)\left(SB_1^{-1/2}\right)}.
\end{aligned} \tag{34}$$

3.1.4. Modified First and Second $\widehat{K}$ Banhatti Entropies of AM_μ^γ. In both (25) and (26), for $\lambda = -1$, we have

$$\begin{aligned}
mB_1^{-1}(H_2) &= \left[\frac{1}{3}+\frac{1}{5}\right](\gamma(\mu-1)+19\mu)+(1)(\gamma(\mu-1)+22\mu)\\
&\quad+\left[\frac{1}{5}+\frac{1}{6}\right](6\gamma(\mu-1)+120\mu-4)+\frac{2}{7}(\gamma(\mu-1)+19\mu-1)\\
&= \frac{7409}{105}\mu+\frac{739}{210}\gamma(\mu-1)-\frac{184}{105},\\
mB_1^{-1}(H_2) &= \left[\frac{1}{2}+\frac{1}{6}\right](\gamma(\mu-1)+19\mu)+\left[\frac{1}{4}+\frac{1}{4}\right](\gamma(\mu-1)+22\mu)\\
&\quad+\left[\frac{1}{6}+\frac{1}{9}\right](6\gamma(\mu-1)+120\mu-4)+\left[\frac{1}{12}+\frac{1}{12}\right](\gamma(\mu-1)+19\mu-1)\\
&= \frac{361}{6}\mu+3\gamma(\mu-1)-\frac{23}{18}.
\end{aligned} \tag{35}$$

Entropy of modified first and second $\widehat{K}$ Banhatti indices by using (27) and (28) can be computed as

$$\begin{aligned}
E\left(mB_1^{-1}(H_2)\right) &= \frac{\ln(7409/105\mu+739/210\gamma(\mu-1)-184/105)}{\ln(2)}-\frac{8(\gamma(\mu-1)+19\mu)\ln(8/15)}{15(7409/105\mu+739/210\gamma(\mu-1)-184/105)\ln(2)}\\
&\quad-\frac{(11\mu-1/2(\mu-1)\gamma)}{(7409/105\mu+739/210\gamma(\mu-1)-184/105)}-\frac{11(6\gamma(\mu-1)+120\mu-4)\ln(11/30)}{30(7409/105\mu+739/210\gamma(\mu-1)-184/105)\ln(2)}\\
&\quad-\frac{2(19\mu+(\mu-1)\gamma-1)\ln(2/7)}{7(7409/105\mu+739/210\gamma(\mu-1)-184/105)\ln(2)},\\
E\left(mB_2^{-1}(H_2)\right) &= \frac{\ln(361/6\mu+3\gamma(\mu-1)-23/18)}{\ln(2)}-\frac{2(19\mu+(\mu-1)\gamma)\ln(2/3)}{3(361/6\mu+3\gamma(\mu-1)-23/18)\ln(2)}+\frac{11\mu+1/2(\mu-1)\gamma}{(361/6\mu+3\gamma(\mu-1)-23/18)}\\
&\quad-\frac{5(6\gamma(\mu-1)+120\mu-4)\ln(5/18)}{18(361/6\mu+3\gamma(\mu-1)-23/18)\ln(2)}+\frac{(\gamma(\mu-1)+19\mu-1)\ln(6)}{6(361/6\mu+3\gamma(\mu-1)-23/18)\ln(2)}.
\end{aligned} \tag{36}$$

3.1.5. Harmonic $\widehat{K}$ Banhatti Index of AM_μ^γ.

$$\begin{aligned}
H_b(H_2) &= \sum_{bw\in E(H_2)}\left[\frac{2}{\psi(b)+\psi(\theta)}+\frac{2}{\psi(w)+\psi(\theta)}\right]\\
&= \left[\frac{2}{3}+\frac{2}{5}\right](19\gamma+\mu(\gamma-1))+\left[\frac{2}{4}+\frac{2}{4}\right](22\gamma+\mu(\gamma-1))\\
&\quad+\left[\frac{1}{5}+\frac{2}{6}\right](120\gamma+6\mu(\gamma-1)-4)+\left[\frac{2}{7}+\frac{2}{7}\right](19\gamma+\mu(\gamma-1)-1)\\
&= \frac{1488}{105}\gamma+\frac{739}{105}\mu(\gamma-1)-\frac{368}{105}.
\end{aligned} \tag{37}$$

3.2. Gourava Indices and Entropy Measures for the Amylopectin AM_{ρ}^{λ} Network

3.2.1. First and Second Gourava Entropies of AM_{μ}^{γ}. First and second Gourava indices are calculated by using Table 4:

$$\begin{aligned}GO_1(H_2) &= \sum_{bw\in E(H_2)} [\psi(b)+\psi(w)+(\psi(b)\times\psi(w))] = [1+3+(1\times 3)](\gamma(\mu-1)+19\mu)+[2+2+(2\times 2)]\\&\quad(\gamma(\mu-1)+22\mu) + [2+3+(2\times 3)](6\gamma(\mu-1)+120\mu-4)+[3+3+(3\times 3)](\gamma(\mu-1)+19\mu-1)\\&= 1914\mu+96\gamma(\mu-1)-59,\\GO_2(H_2) &= \sum_{bw\in E(H_2)} [(\psi(b)+\psi(w))\times(\psi(b)\psi(w))] = [(1+3)\times(1\times 3)](\gamma(\mu-1)+19\mu)+[(2+2)\times(2\times 2)]\\&\quad(\gamma(\mu-1)+22\mu) + [(2+3)\times(2\times 3)](6\gamma(\mu-1)+120\mu-4)+[(3+3)\times(3\times 3)](\gamma(\mu-1)+19\mu-1)\\&= 8716\gamma(\mu-1)+84612\mu-6516.\end{aligned} \tag{38}$$

Entropy of first and second Gourava indices by using Table 4 and (1) are

$$\begin{aligned}E(GO_1(H_2)) &= \frac{\ln(1914\mu+96\gamma(\mu-1)-59)}{\ln(2)} - \frac{7(\gamma(\mu-1)+19\mu)\ln(7)}{(1914\mu+96\gamma(\mu-1)-59)\ln(2)}\\&\quad - \frac{8((\gamma(\mu-1)+22\mu))\ln(8)}{(1914\mu+96\gamma(\mu-1)-59)\ln(2)} - \frac{11(6\gamma(\mu-1)+120\mu-4)\ln(11)}{(1914\mu+96\gamma(\mu-1)-59)\ln(2)} - \frac{15(\gamma(\mu-1)+19\mu-1)\ln(15)}{(1914\mu+96\gamma(\mu-1)-59)\ln(2)},\\E(GO_2(H_2)) &= \frac{\ln(8716\gamma(\mu-1)+84612\mu-6516)}{\ln(2)} - \frac{12(\gamma(\mu-1)+19\mu)\ln(12)}{(8716\gamma(\mu-1)+84612\mu-6516)\ln(2)}\\&\quad - \frac{16(\gamma(\mu-1)+22\mu)\ln(16)}{(8716\gamma(\mu-1)+84612\mu-6516)\ln(2)} - \frac{30(6\gamma(\mu-1)+120\mu-4)\ln(30)}{(8716\gamma(\mu-1)+84612\mu-6516)\ln(2)}\\&\quad - \frac{54(\gamma(\mu-1)+19\mu-1)\ln(54)}{(8716\gamma(\mu-1)+84612\mu-6516)\ln(2)}.\end{aligned} \tag{39}$$

3.2.2. Product Connectivity Gourava Entropy of AM_{μ}^{γ}. Product connectivity Gourava index and entropy with the help of Table 4 and (1) can be calculated as

$$\begin{aligned}
PGV(H_1) &= \frac{1}{\sqrt{(1+3)\times(1\times 3)}}(\gamma(\mu-1)+19\mu)+\frac{1}{\sqrt{(2+2)\times(2\times 2)}}(\gamma(\mu-1)+22\mu)\\
&\quad+\frac{1}{\sqrt{(2+3)\times(2\times 3)}}(6\gamma(\mu-1)+120\mu-4)+\frac{1}{\sqrt{(3+3)\times(3\times 3)}}(\gamma(\mu-1)+19\mu-1)\\
&= 35.47865\mu+1.77017\gamma(\mu-1)-0.86636,\\
E(PGV(H_1)) &= \log_2(35.47865\gamma+1.77017\mu(\gamma-1)-0.86636)-\frac{1}{35.47865\gamma+1.77017\mu(\gamma-1)-0.86636}\\
&\quad\times\left(\frac{1}{\sqrt{12}}(\gamma(\mu-1)+19\mu)\log_2\left(\frac{1}{\sqrt{12}}\right)+\frac{1}{4}(\gamma(\mu-1)+22\mu)\log_2\left(\frac{1}{4}\right)\right.\\
&\quad\left.+\frac{1}{\sqrt{30}}(6\gamma(\mu-1)+120\mu-4)\log_2\left(\frac{1}{\sqrt{30}}\right)+\frac{1}{\sqrt{54}}(\gamma(\mu-1)+19\mu-1)\log_2\left(\frac{1}{\sqrt{54}}\right)\right).
\end{aligned}\tag{40}$$

3.2.3. Sum Connectivity Gourava Index and Entropy of AM_{μ}^{γ}.

$$\begin{aligned}
SGV(H_2) &= \sum_{\gamma\mu\in E(H_1)}\frac{1}{\sqrt{\psi(\gamma)+\psi(\mu)+(\psi(\gamma)\times\psi(\mu))}}\\
&= \frac{1}{\sqrt{(1+3)+(1\times 3)}}(\gamma(\mu-1)+19\mu)+\frac{1}{\sqrt{(2+2)+(2\times 2)}}(\gamma(\mu-1)+22\mu)\\
&\quad+\frac{1}{\sqrt{(2+3)+(2\times 3)}}(6\gamma(\mu-1)+120\mu-4)+\frac{1}{\sqrt{(3+3)+(3\times 3)}}(\gamma(\mu-1)+19\mu-1)\\
&= 28.058610\mu+2.798766\gamma(\mu-1)-1.464334,\\
E(SGV(H_2)) &= \log_2(28.058610\gamma+2.798766\mu(\gamma-1)-1.464334)-\frac{1}{28.058610\gamma+2.798766\mu(\gamma-1)-1.464334}\\
&\quad\times\left(\frac{1}{\sqrt{7}}(\gamma(\mu-1)+19\mu)\log_2\frac{1}{\sqrt{7}}+\frac{1}{\sqrt{8}}(\gamma(\mu-1)+22\mu)\log_2\frac{1}{\sqrt{8}}\right.\\
&\quad\left.+\frac{1}{\sqrt{11}}(6\gamma(\mu-1)+120\mu-4)\log_2\frac{1}{\sqrt{11}}+\frac{1}{\sqrt{15}}(\gamma(\mu-1)+19\mu-1)\log_2\frac{1}{\sqrt{15}}\right).
\end{aligned}\tag{41}$$

Table 5: Numerical analysis of $\widehat{K}$ Banhatti indices for GL_{μ}^{γ}.

$[\gamma, \mu]$	B_1^1	B_2^1	HB_2^1	HB_2^2
[2, 2]	2042	2744	11182	22080
[3, 3]	3380	4548	18534	36684
[4, 4]	4910	6612	26946	53412
[5, 5]	6632	8936	36418	72264
[6, 6]	8546	11520	46950	93240
[7, 7]	10652	14364	58542	116340
$[\gamma, \mu]$	mB_1^{-1}	mB_2^{-1}	H_b	$SB_1^{-1/2}$
[2, 2]	76.028 6	65.055 6	152.057 1	170.353 0
[3, 3]	125.476 2	107.222 2	250.952 4	281.358 2
[4, 4]	181.961 9	155.388 9	363.923 8	408.189 9
[5, 5]	245.485 7	209.555 6	490.971 4	550.848 2
[6, 6]	316.047 6	269.722 2	632.095 2	709.333 0
[7, 7]	393.647 0	335.888 89	787.295 2	883.644 3

3.2.4. First and Second Hyper-Gourava Entropies of AM_{μ}^{γ}. First and second hyper-Gourava indices with the help of Table 4 are

$$\begin{aligned}
HGO_1(H_2) &= \sum_{bw\in E(H_2)} [\psi(b)+\psi(w)+(\psi(b)\times\psi(w))]^2 = [1+3+(1\times 3)]^2(\gamma(\mu-1)+19\mu)+[2+2+(2\times 2)]^2 \\
&\quad (\gamma(\mu-1)+22\mu) + [2+3+(2\times 3)]^2(6\gamma(\mu-1)+120\mu-4)+[3+3+(3\times 3)]^2(\gamma(\mu-1)+19\mu-1) \\
&= 10494\mu+1064\gamma(\mu-1)-709, \\
HGO_2(H_2) &= \sum_{bw\in E(H_2)} [(\psi(b)+\psi(w))\times(\psi(b)\psi(w))]^2 = [(1+3)\times(1\times 3)]^2(\gamma(\mu-1)+19\mu)+[(2+2)\times(2\times 2)]^2 \\
&\quad (\gamma(\mu-1)+22\mu) + [(2+3)\times(2\times 3)]^2(6\gamma(\mu-1)+120\mu-4)+[(3+3)\times(3\times 3)]^2(\gamma(\mu-1)+19\mu-1) \\
&= 4340\mu+218\gamma(\mu-1)-136.
\end{aligned} \tag{42}$$

Entropy of first and second hyper-Gourava Indices is computed as

$$\begin{aligned}
E(HGO_1(H_2)) &= \frac{\ln(10494\mu+1064\gamma(\mu-1)-709)}{\ln(2)} - \frac{1}{10494\mu+1064\gamma(\mu-1)-709} \\
&\quad \times(4608\mu+384\gamma(\mu-1)) + \frac{(98(9\mu+\gamma(\mu-1)))\ln(7)}{\ln(2)} \\
&\quad + \frac{(242(60\mu+6\gamma(\mu-1)-4))\ln(11)}{\ln(2)} + \frac{(450(9\mu+\gamma(\mu-1)-1))\ln(15)}{\ln 2}, \\
E(HGO_2(H_2)) &= \frac{\ln(4340\mu+218\gamma(\mu-1)-136)}{\ln(2)} - \frac{1}{4340\mu+218\gamma(\mu-1)-136} \\
&\quad \times(2624\mu+128\gamma(\mu-1)) + \frac{(50(120\mu+6\gamma(\mu-1)-4))\ln(5)}{\ln(2)} \\
&\quad + \frac{(72(19\mu+\gamma(\mu-1)-1))\ln(6)}{\ln(2)}.
\end{aligned} \tag{43}$$

Table 6: Numerical analysis of $\widehat{K}$ Banhatti indices for AM_{μ}^{γ}.

$[\gamma, \mu]$	B_1^1	B_2^1	B_2^1	HB_2^2
[2, 2]	3962	5344	21782	43320
[3, 3]	6260	8448	34434	68544
[4, 4]	8750	11812	48146	95892
[5, 5]	11432	15436	62918	125364
[6, 6]	14306	19320	78750	156960
[7, 7]	17372	23464	95642	190680
$[\gamma, \mu]$	mB_1^{-1}	mB_2^{-1}	H_b	$SB_1^{-1/2}$
[2, 2]	146.409 5	125.055 6	292.819 0	328.618 3
[3, 3]	231.047 6	197.222 2	462.095 2	518.756 2
[4, 4]	322.723 8	275.388 9	645.447 6	724.720 6
[5, 5]	421.438 1	359.555 6	842.876 2	946.511 5
[6, 6]	527.190 5	449.722 2	1054.381 0	1184.128 9
[7, 7]	639.980 9	545.888 9	1279.961 9	437.572 8

Table 7: Numerical analysis of $\widehat{K}$ Banhatti entropies for GL_{μ}^{γ}.

$[\gamma, \mu]$	$E(B_1^1)$	$E(B_2^1)$	$E(HB_2^1)$	$E(HB_2^2)$
[2, 2]	7.573 8	7.524 1	7.524 8	7.364 6
[3, 3]	8.298 8	8.249 3	8.249 9	8.090 3
[4, 4]	8.836 3	8.786 8	8.787 5	8.628 1
[5, 5]	9.269 2	9.219 7	9.220 4	9.061 1
[6, 6]	9.634 3	9.584 9	9.585 6	9.426 4
[7, 7]	9.951 6	9.902 1	9.902 9	9.743 8
$[\gamma, \mu]$	$E(mB_1^{-1})$	$E(mB_2^{-1})$	$E(H_b)$	$E(SB_1^{-1/2})$
[2, 2]	7.569 3	7.479 2	7.569 3	7.587 0
[3, 3]	8.294 2	8.203 9	8.294 2	8.311 9
[4, 4]	8.831 7	8.741 1	8.831 7	8.849 4
[5, 5]	9.264 5	9.173 6	9.264 5	9.282 2
[6, 6]	9.269 6	9.538 5	9.629 6	9.647 4
[7, 7]	9.946 9	9.855 6	9.946 9	9.964 6

Table 8: Numerical analysis of $\widehat{K}$ Banhatti entropies for AM_{μ}^{γ}.

$[\gamma, \mu]$	$E(B_1^1)$	$E(B_2^1)$	$E(HB_2^1)$	$E(HB_2^2)$
[2, 2]	8.524 4	8.474 8	8.475 6	8.316 2
[3, 3]	9.183 5	9.134 0	9.134 9	8.975 6
[4, 4]	9.666 1	9.616 7	9.617 5	9.458 4
[5, 5]	10.051 6	10.002 1	10.002 9	9.843 9
[6, 6]	10.374 8	10.325 4	10.326 2	10.167 3
[7, 7]	10.654 8	10.605 3	10.606 2	10.447 3
$[\gamma, \mu]$	$E(mB_1^{-1})$	$E(mB_2^{-1})$	$E(H_b)$	$E(SB_1^{-1/2})$
[2, 2]	8.519 7	8.427 4	8.394 1	8.537 5
[3, 3]	9.178 8	9.086 5	9.059 4	9.196 6
[4, 4]	9.661 4	9.569 1	9.547 5	9.679 2
[5, 5]	10.046 8	9.954 4	9.937 7	10.064 6
[6, 6]	10.370 0	10.277 6	10.265 4	10.387 9
[7, 7]	10.649 9	10.557 4	10.549 4	10.667 8

Table 9: Numerical analysis of Gourava indices for GL_{μ}^{γ}.

$[\gamma, \mu]$	GO_1	GO_2	SPG
[2, 2]	2041	5522	38.22788
[3, 3]	3379	9156	63.08551
[4, 4]	4909	13314	91.48348
[5, 5]	6631	17996	123.42179
[6, 6]	8545	23202	158.90044
[7, 7]	10651	28932	197.91943

Table 9: Continued.

$[\gamma, \mu]$	HGO_1	HGO_2	SG
[2, 2]	22407	180140	60.2505
[3, 3]	37157	299616	99.5041
[4, 4]	54035	436524	144.3553
[5, 5]	73041	590864	194.8041
[6, 6]	94175	762636	250.8504
[7, 7]	117437	951840	312.4942

Table 10: Numerical analysis of Gourava indices for AM_{μ}^{γ}.

$[\gamma, \mu]$	GO_1	GO_2	SPG
[2, 2]	3961	10762	73.6312
[3, 3]	6259	17016	116.1906
[4, 4]	8749	23794	162.2902
[5, 5]	11431	31096	211.9302
[6, 6]	14305	38922	265.1106
[7, 7]	17371	47272	321.8313
$[\gamma, \mu]$	HGO_1	HGO_2	SG
[2, 2]	43687	165256	116.2480
[3, 3]	69077	561096	183.5005
[4, 4]	96595	785164	256.3505
[5, 5]	126241	1026664	334.7980
[6, 6]	158015	1285596	418.8430
[7, 7]	191917	1561960	508.4856

Table 11: Numerical analysis of Gourava entropies for GL_{μ}^{γ}.

$[\gamma, \mu]$	$E(Go_1)$	$E(Go_2)$	$E(SG)$
[2, 2]	7.5647	7.5827	7.5849
[3, 3]	8.2896	8.3076	8.3098
[4, 4]	8.8271	8.8451	8.8473
[5, 5]	9.2599	9.2780	9.2801
[6, 6]	9.6250	9.6431	9.6452
[7, 7]	9.9422	9.9604	9.9624
$[\gamma, \mu]$	$E(HGo_1)$	$E(HGo_2)$	$E(PG)$
[2, 2]	7.4873	11.5959	8.0322
[3, 3]	8.2123	12.309	8.7589
[4, 4]	8.7497	12.8388	8.8523
[5, 5]	9.1824	13.2655	9.2852
[6, 6]	9.5474	13.6216	9.6503
[7, 7]	9.8646	13.9379	10.4138

Table 12: Numerical analysis of Gourava entropies for AM_{μ}^{γ}

$[\gamma, \mu]$	$E(Go_1)$	$E(Go_2)$	$E(SG)$
[2, 2]	8.5149	8.5337	8.5353
[3, 3]	9.1740	9.1937	9.1944
[4, 4]	9.6566	9.6750	9.6771
[5, 5]	10.0420	10.0604	10.0625
[6, 6]	10.3652	10.3836	10.3836
[7, 7]	10.6451	10.6636	10.6656
$[\gamma, \mu]$	$E(HGo_1)$	$E(HGo_2)$	$E(PG)$
[2, 2]	7.5849	8.5050	8.5405
[3, 3]	8.3098	9.1642	9.1996
[4, 4]	8.8473	9.6468	10.0676
[5, 5]	9.2801		10.0676
[6, 6]	9.6452	10.3560	10.3857
[7, 7]			10.6708

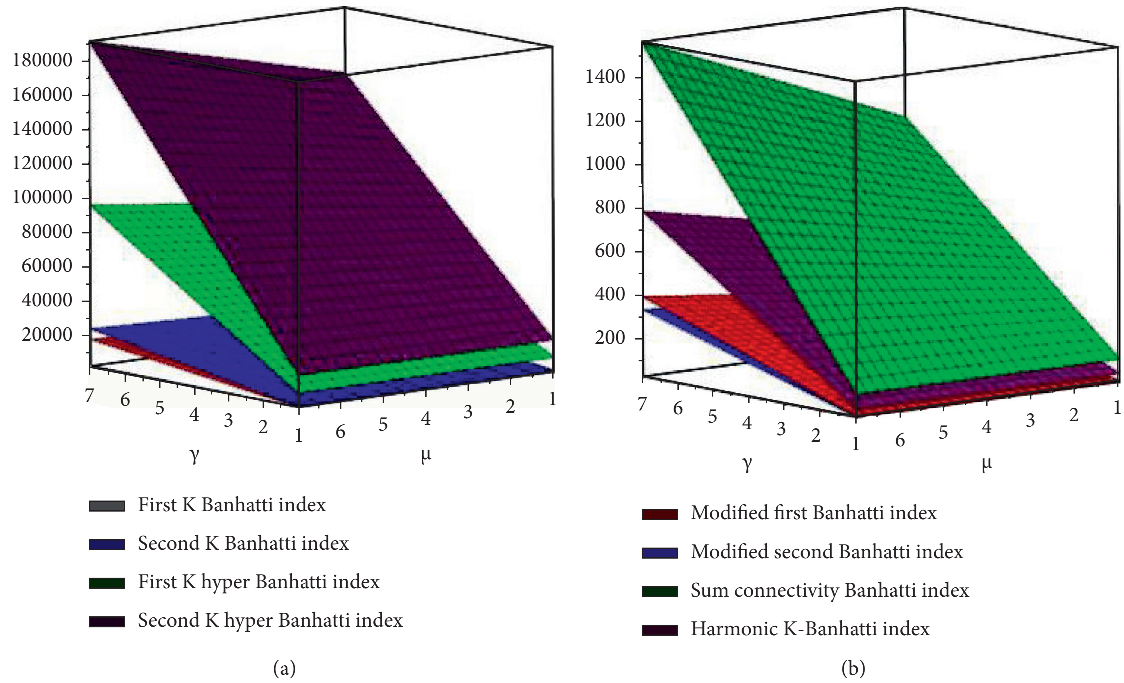


FIGURE 6: Graphical illustration of $\widehat{K}$ Banhatti indices for GL_{μ}^{γ}. (a) The first and the second $\widehat{K}$ Banhatti indices as well as $\widehat{K}$-hyper Banhatti indices. (b) The sum connectivity Banhatti index, harmonic $\widehat{K}$ Banhatti index, and modified first and second Banhatti indices.

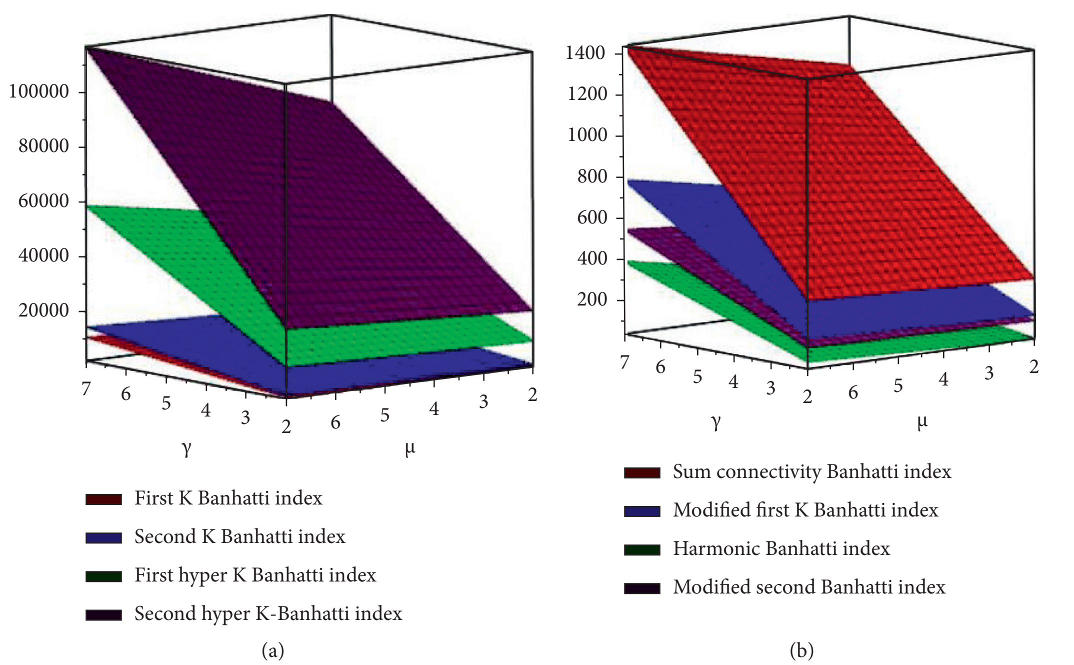
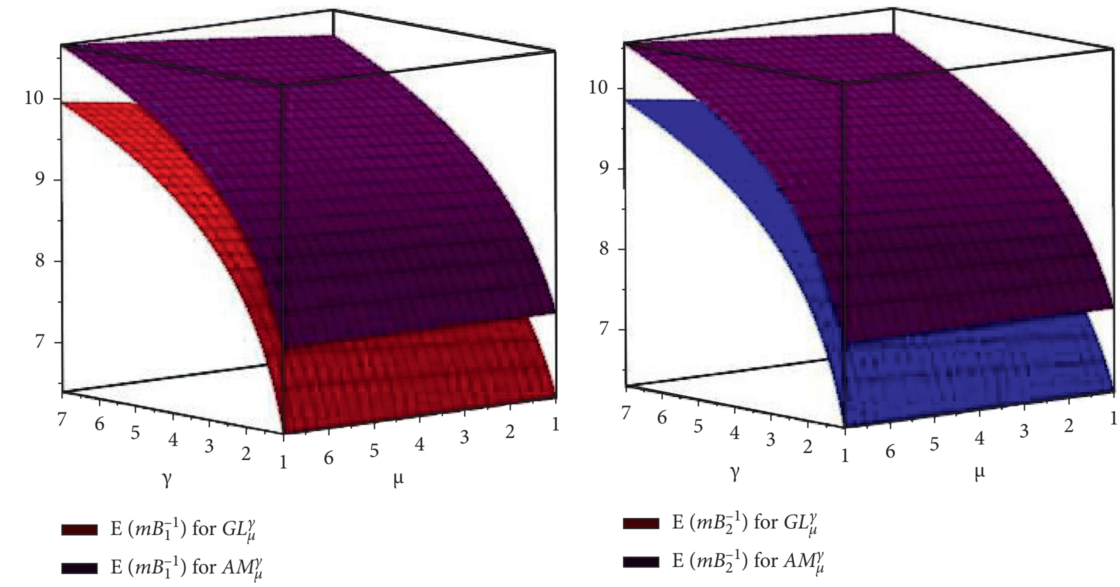


FIGURE 7: Graphical illustration of $\widehat{K}$ Banhatti indices for AM_{μ}^{γ}. (a) The first and the second $\widehat{K}$ Banhatti indices as well as $\widehat{K}$-hyper Banhatti indices. (b) The sum connectivity Banhatti index, harmonic $\widehat{K}$ Banhatti index, and modified first and second Banhatti indices.

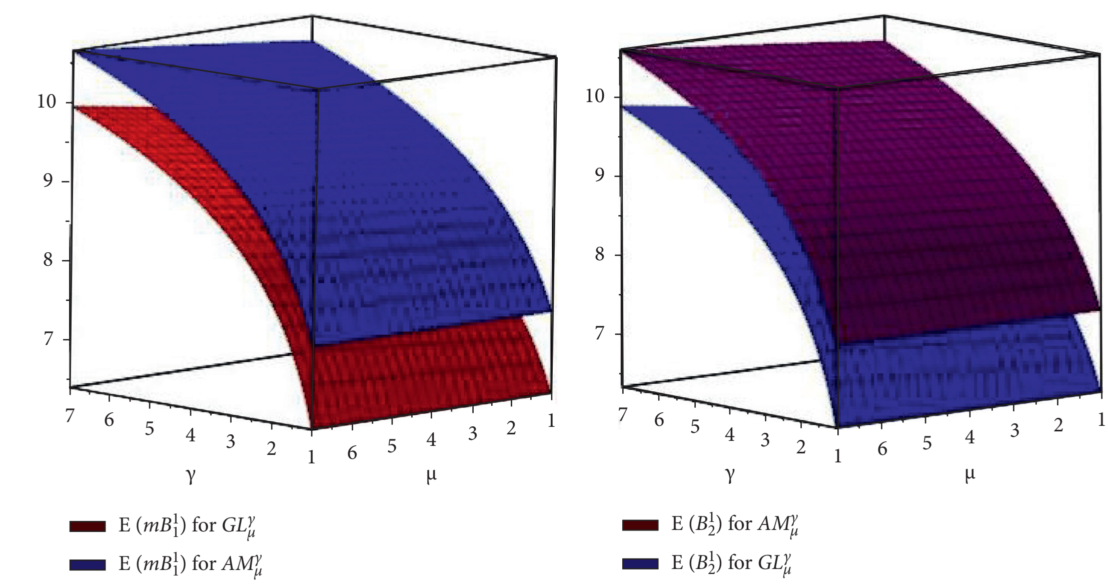
4. Applications and Discussion of Computed Results

We calculated information entropy for two natural polymer networks, namely, the glycogen GL_{μ}^{γ} network and amylopectin AM_{μ}^{γ} network. The information entropies that are measured in this research are $\widehat{K}$ Banhatti and Gourava entropies. These entropies are calculated corresponding to different $\widehat{K}$ Banhatti and Gourava indices, namely, first and second $\widehat{K}$ Banhatti indices, first and second $\widehat{K}$-hyper Banhatti indices, harmonic Banhatti index, sum connectivity Banhatti index, first and second Gourava indices, sum and



(a) (b)

Figure 8: Graphical comparison between (a) modified first Banhatti entropies for GL_μ^γ and AM_μ^γ and (b) modified second Banhatti entropies for GL_μ^γ and AM_μ^γ



(a) (b)

Figure 9: Graphical comparison between (a) first $\widehat{K}$ Banhatti entropies for GL_μ^γ and AM_μ^γ and (b) second $\widehat{K}$ Banhatti entropies for GL_μ^γ and AM_μ^γ.

product connectivity Gourava indices, and first and secon hyper Gourava indices. Analytical results are obtained for these entropies. We analysed the analytical data for various parameters μ and γ, and this analysis is given in Tables 5–12. Graphical comparison is shown in Figures 6–16. Numerical analysis is performed by using MATLAB software, while Maple software is used for 3D graphical comparisons.

We can observe from Tables 5, 6, 9, and 10 that when the number of monomers is the same, $\Gamma_{GL_\mu^\gamma} \leq \Gamma_{AM_\mu^\gamma}$, where $\Gamma_{GL_\mu^\gamma}$ and $\Gamma_{AM_\mu^\gamma}$ represent the aforementioned topological indices for the glycogen GL_μ^γ network and amylopectin AM_μ^γ network, respectively. Furthermore, all of the graphical illustrations for glycogen and amylopectin are adjacent, which could be owing to the presence of monomer α-glucose, digestibility, solubility, and their utilization as energy storage

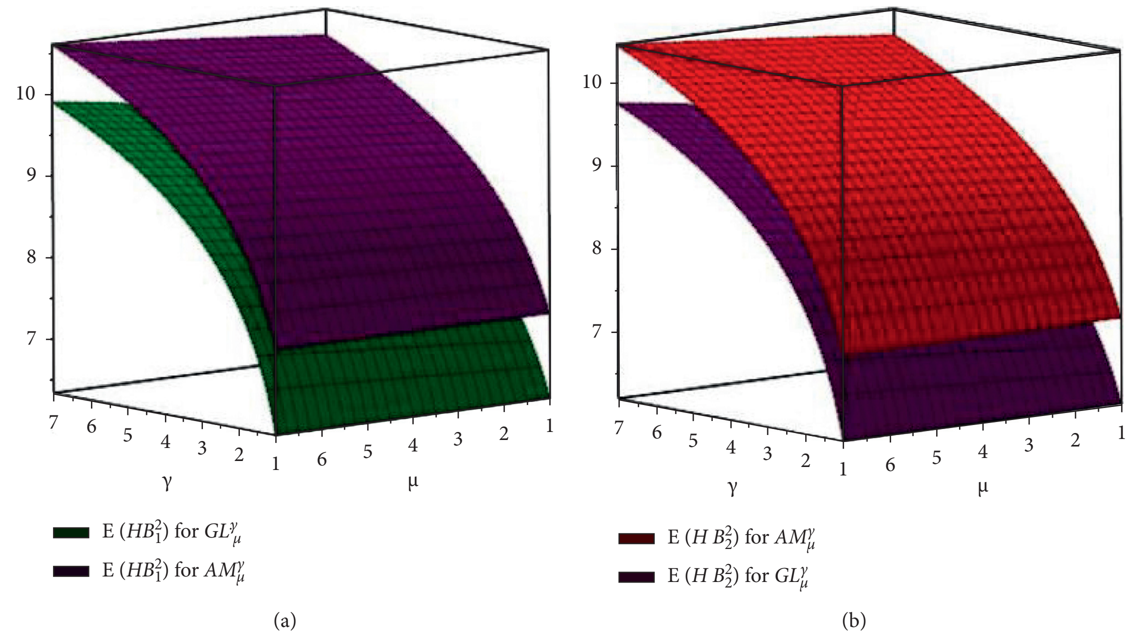


Figure 10: Graphical comparison between (a) first $\widehat{K}$-hyper Banhatti entropies for GL_μ^γ and AM_μ^γ and (b) second $\widehat{K}$-hyper Banhatti entropies for GL_μ^γ and AM_μ^γ.

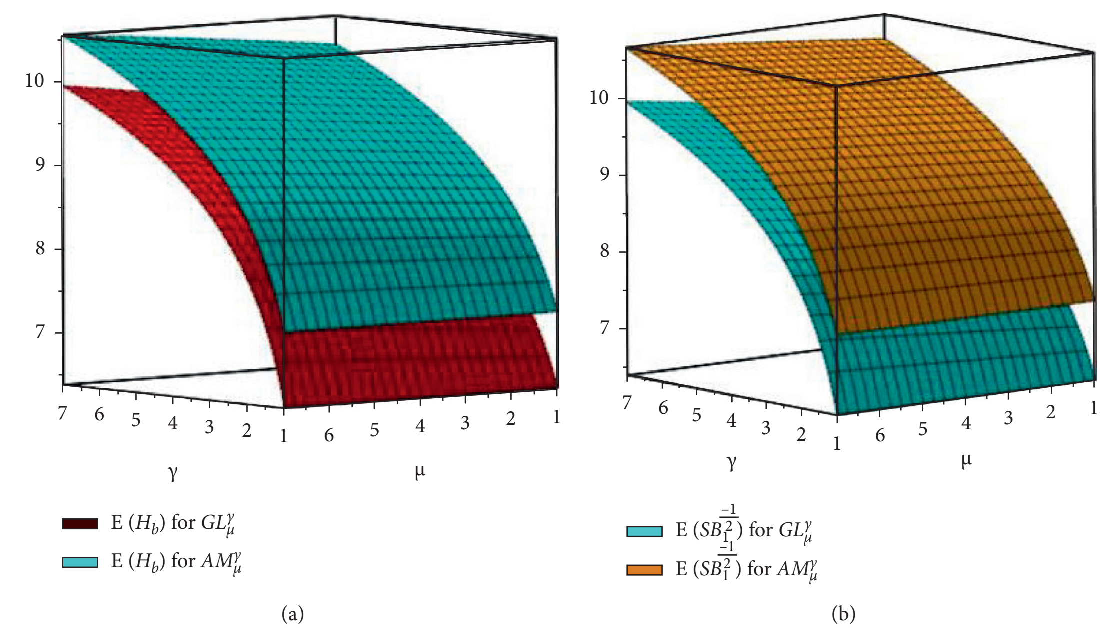


Figure 11: Graphical comparison between (a) harmonic $\widehat{K}$ Banhatti entropies for GL_μ^γ and AM_μ^γ and (b) sum connectivity Banhatti entropies for GL_μ^γ and AM_μ^γ.

in animal organs and plants, correspondingly. In addition, the findings in this section could be used in QSPR/QSAR research to predict the biological features of the natural polymers under consideration.

It can be observed from Tables 7, 8, 11, and 12 that when the number of monomers is the same, $E(\Gamma_{GL_\mu^\gamma}) \le E(\Gamma_{AM_\mu^\gamma})$, where $E(\Gamma_{GL_\mu^\gamma})$ and $E(\Gamma_{AM_\mu^\gamma})$ represent the aforementioned information entropies corresponding to $\widehat{K}$ Banhatti and Gourava indices for the glycogen GL_μ^γ network and amylopectin AM_μ^γ network, respectively. For both the structures, the sum connectivity Banhatti entropy is expanding faster than other entropies, while second $\widehat{K}$-hyper Banhatti entropy is growing slower than other entropies. The graphical illustration shows that the entropies for glycogen and amylopectin go along the side.

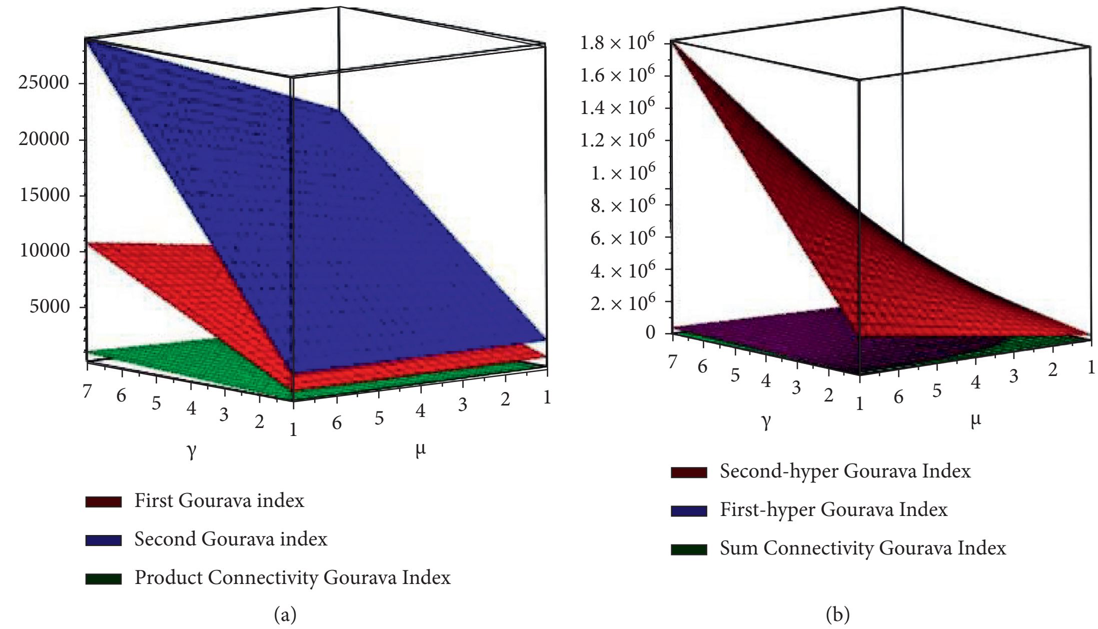


Figure 12: Graphical illustration of Gourava indices for GL_{μ}^{γ}. (a) The first and the second Gourava indices and Gourava hyper-indices. (b) The sum and the product Gourava connectivity indices.

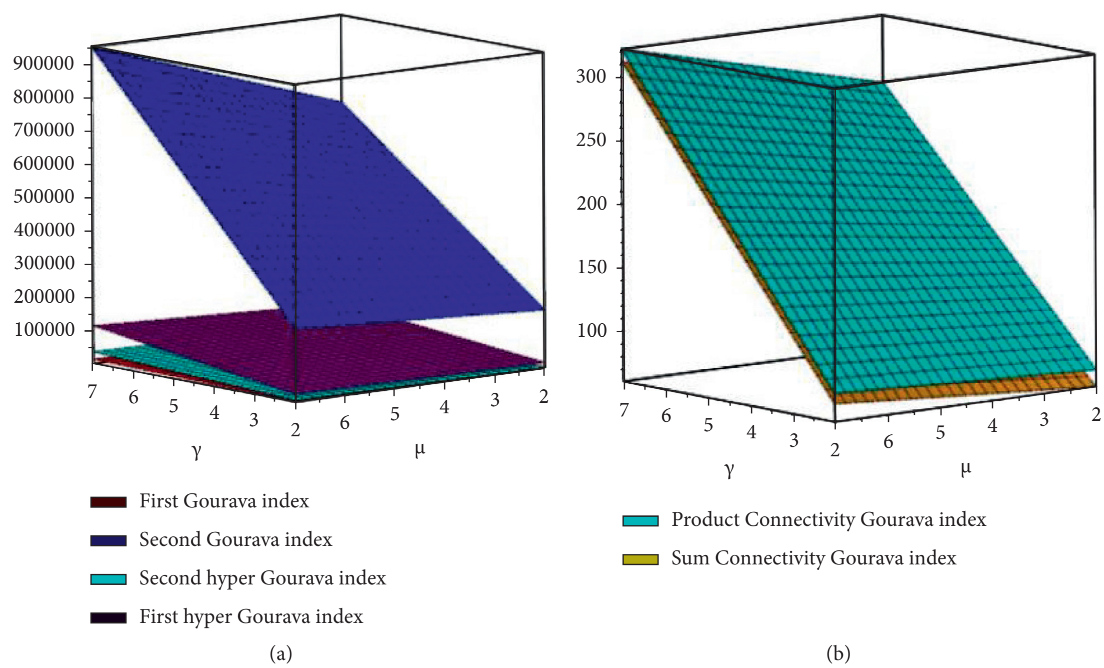


Figure 13: Graphical illustration of Gourava indices for AM_{μ}^{γ}. (a) The first and the second Gourava indices and Gourava hyper-indices. (b) The sum and the product Gourava connectivity indices.

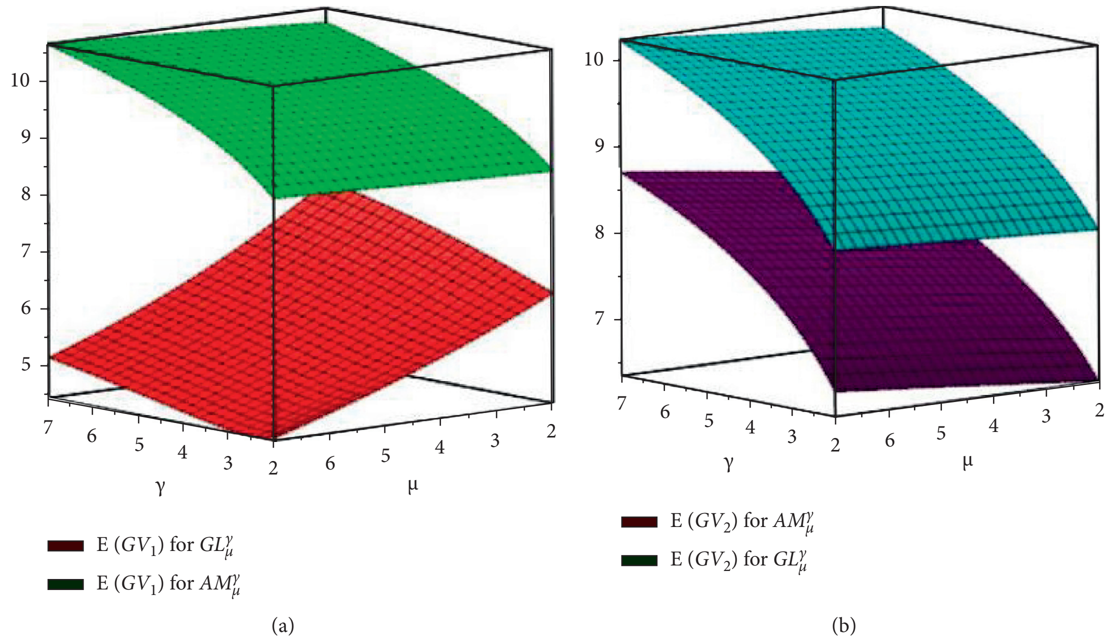


Figure 14: Graphical comparison between (a) the first Gourava entropies for GL_μ^γ and AM_μ^γ and (b) the second Gourava entropies for GL_μ^γ and AM_μ^γ.

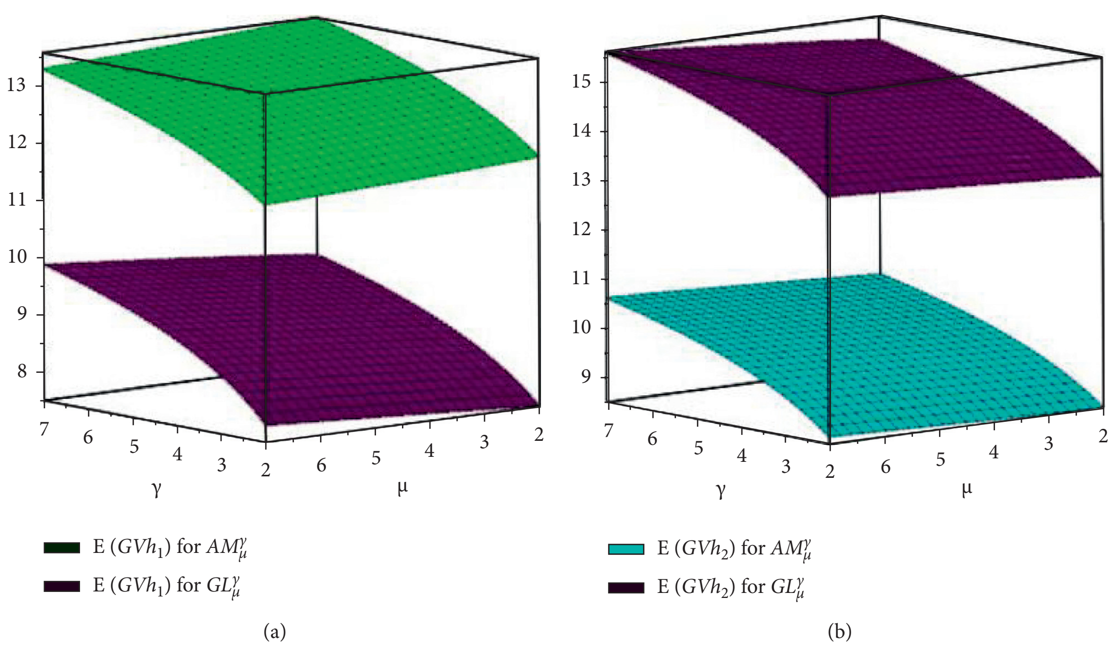
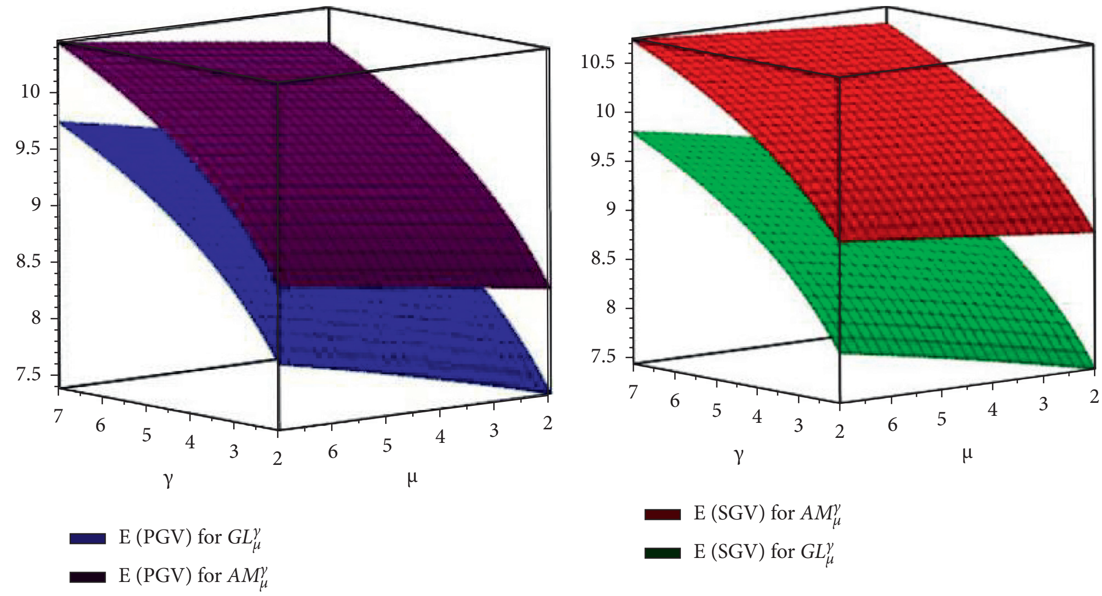


Figure 15: Graphical comparison between (a) the first hyper-Gourava entropies for GL_μ^γ and AM_μ^γ and (b) the second hyper Gourava entropies for GL_μ^γ and AM_μ^γ.



(a) (b)

Figure 16: Graphical comparison between (a) the product connectivity Gourava entropies for GL_{μ}^{γ} and AM_{μ}^{γ} and (b) the sum connectivity Gourava entropies for GL_{μ}^{γ} and AM_{μ}^{γ}.

5. Conclusion

In this study, we looked into natural polymers of polysaccharides (glycogen and amylopectin) with fascinating pharmacological applications and unique molecular structures. Nutritional activities, including energy storage for metabolism, are the principal biological functions of these polysaccharides (amylopectin and glycogen). We computed $\widehat{K}$ Banhatti and Gourava indices and their corresponding entropies. These indices, together with entropies, are quantitatively and graphically compared. The findings of this article could be used in QSPR/QSAR analysis to predict the biological properties of the natural polymers being studied. Polysaccharide research can be expanded to include molecular graphs of other natural polymers (proteins and nucleotides) in the future.

Data Availability

The data used to support the findings of this study are cited at relevant places within the text as references.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

This work was equally contributed by all authors.

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