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STUDY OF THE CHEMICAL-QUANTUM INTERACTIONS OF CYANIDIN AND THE AMINO ACIDS OF PROTEINS TO VERIFY THEIR POTENTIAL IN THE TREATMENT OF DEGENERATIVE DISEASES

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ABSTRACT

Cyanidin 3-glucoside (C3G), the most abundant anthocyanin in the diet, may represent a new approach and a highly effective strategy to reduce carcinogenesis. As a central part of this research, we decided to study the quantum-chemical interactions of cyanidin (CND) and protein amino acids to verify its potential in treating degenerative diseases. CND was characterized using hyperchem software. In this characterization, the PM3 semi-empirical method (SE-PME) was used. The calculated parameters were HOMO, LUMO, BANDGAP (BG), E-, E+ Electrostatic Potential (EP). CND occupies the bottom of the quantum well. This lower value indicates the higher chemical stability of the cyanidin relative to amino acids (AAs). It can be said that CND has a very high probability of remaining in the body for a long time. We observe that CND oxidizes 18 amino acids and reduces two amino acids before the mean, exceeding the first quartile. The oxidation-reduction pattern is conserved in the 441 interactions of any protein sequencing. The probability that CND is an alternative for treating degenerative diseases is high.

KEYWORD: Cyanidin, Chemical-quantum interaction, amino acid, proteins, degenerative diseases.

INTRODUCTION

Cyanidin 3-glucoside (C3G), the most abundant anthocyanin in the diet, may represent a new approach and a highly effective strategy to reduce carcinogenesis. C3G can be considered a new therapeutic agent with anti-proliferative and pro-differentiating properties.[1, 2]

Studies it was shown that cranberry extract, rich in CND, promoted the cardioprotection of H9c2 cells in an in vitro model of oxidative damage induced by norepinephrine (NE); these studies suggest a cardioprotective role for BBE in response to NE exposure.[3] Nevertheless, other researchers elucidated the mechanism of BBE to reduce neuronal damage by promoting neuronal autophagy and showed that protocatechuic acid (PCA) might be the significant bioactive metabolite of BBE for neuroprotective effects.[4, 5]

In other investigations, a methanolic extract of Tulbaghia violacea was evaluated. In vitro studies showed antitumor activity against ovarian tumor cells mediated by the induction of cell death not dependent on caspase and by the activation of reactive oxygen species. As a second investigation, the effect of this extract against the characteristics of Alzheimer's disease was tested in vivo in Caenorhabditis elegans. Tulbaghia extract led to a reduction in amyloid-beta 1-42 peptide formation and prevented oxidative stress. These results suggested that Tulbaghia violacea could be a new source of phenolic compounds for the development of nutraceuticals and functional foods.[6]

In studies of raspberry, acylated anthocyanins effectively prevent the release of ROS. The researchers showed that cyanidin-3-O-glucoside (C3G) was the main anthocyanin in raspberry, and the acylation binding site was on the C-6 glucoside, and the product was cyanidin-3-(6- salicyloyl) glucoside (C3-6(S)G). After acylation, its stability in light, heat, and oxidation environments could be significantly improved.[7]

As for cardioprotection. The dietary intake of anthocyanins produces a cardioprotective effect. These findings established that the effect of dietary intake of C3G on the gut microbiota determines long-lasting cardioprotection.[8] Pretreatment with cyanidin-3-O-glucoside can positively influence cardiac ischemia and dysfunction. Cyanidin-3-O-glucoside pretreatment improves cardiac function tests, enzymes, and myocytes. In conclusion, cyanidin-3-O-glucoside shows promise for protecting the heart against injury after ischemia-reperfusion in the rat examination.[9] Pretreatment with cyanidin-3-O-glucoside can positively influence cardiac ischemia and dysfunction. Cyanidin-3-O-glucoside pretreatment improves

cardiac function tests, enzymes, and myocytes. In conclusion, cyanidin-3-O-glucoside shows promise for protecting the heart against injury after ischemia-reperfusion in the rat examination.[10]

Other studies show the hypouricemic effect of black rice anthocyanins in vivo and their possible interaction mechanism with xanthine oxidase (XO). This study suggests that black rice anthocyanins have potential applications as an effective bioactive substance against hyperuricemia.[11] On the other hand, researchers conclude that berries rich in phenolic compounds may promote health benefits. This study demonstrates a potential use of RR in treating inflammation and possibly also IR in patients with type 2 diabetes.[12]

Regarding liver diseases, a 4-week supplementation of mice with a CND and delphinidin-rich extract (CDRE) could mitigate or reverse HFD-induced hepatic steatosis and inflammation (60% calories from butterfat). Short-term consumption of CND and delphinidin could help mitigate the adverse consequences, i.e., metabolic endotoxemia and associated liver inflammation triggered by regular consumption of high-fat diets.[13]

Due to the low stability of anthocyanins, scientific studies showed that the storage, temperature, and pH analysis results showed that +4 °C was the best stability temperature. In addition, the total content of monomeric anthocyanins in the samples decreased with increasing storage time. Based on the findings, an ecological, high-efficiency methodological alternative was offered to extract anthocyanins from food matrices.[14, 15]

Another alternative for preserving anthocyanins, including CND, is bioactive encapsulation using cold processing techniques such as ionic gelation, emulsification, complex coacervation, and adsorption to expand production and application in the food sector.[16]

As a central part of this research, we decided to study the quantum-chemical interactions of CND and protein amino acids to verify its potential in treating degenerative diseases.

CND and anthocyanin derivatives are being studied for the same purpose.

METHODOLOGY

CND was characterized using hyperchem software. In this characterization, the PM3 semi-empirical method (SE-PME) was used. The calculated parameters were HOMO, LUMO,

BANDGAP (BG), E-, E+ Electrostatic Potential (EP). After these basic calculations, the electron transfer coefficient (ETC) was determined.

$$BG = |HOMO - LUMO| \quad \textit{Equation 1}$$

$$EP = |E_{-} - E_{+}| \quad \textit{Equation 2}$$

$$ETC = \frac{BG}{EP} \quad \textit{Equation 3}$$

Similar calculations were made for the 20 amino acids that make up human proteins. These calculations were grouped into several tables that resembled the level of a quantum well. The quantum levels determine the affinity of each substance. These molecules were taken in two. The first table tells us the ETC of each pure substance. The second table shows us the possible oxidation-reduction interactions, and the third table is a rotary combination. All tables include CND. This inclusion of CND in the tables shows the level of affinity in each of the quantum wells.

The designated parameters for each calculation are shown in the following two tables.[17-27]

Table 1: Parameters used for quantum computing molecular orbitals HUMO and LUMO. Parameter.	**Value**	**Parameter**	**Value**
Total charge	0	Polarizability	Not
Spin Multiplicity	1	Geometry Optimization algorithm	Polak-Ribiere (Conjugate Gradient)
Spin Pairing	RHF	Termination condition RMS gradient of	0.1 Kcal/Amol
State Lowest Convergent Limit	0.01	Termination condition or	1000 maximum cycles
Interaction Limit	50	Termination condition or	In vacuo
Accelerate Convergence	Yes	Screen refresh period	1 cycle

Table 2: Parameters used for visualizing the map of the electrostatic potential of the molecules.			
Parameter	**Value**	**Parameter**	**Value**
Molecular Property	Property Electrostatic Potential	Contour Grid increment	0.05
Representation	3D Mapped Isosurface	Mapped Function Options	Default
Isosurface Grid: Grid Mesh	Coarse	Transparency level	A criteria

Size			
Isosurface Grid: Grid Layout	Default	Isosurface Rendering: Total charge density contour value	0.015
Contour Grid: Starting Value	Default		Rendering Wire Mesh

RESULTS

The characterization of the CND molecule was made. The figure below shows the results.

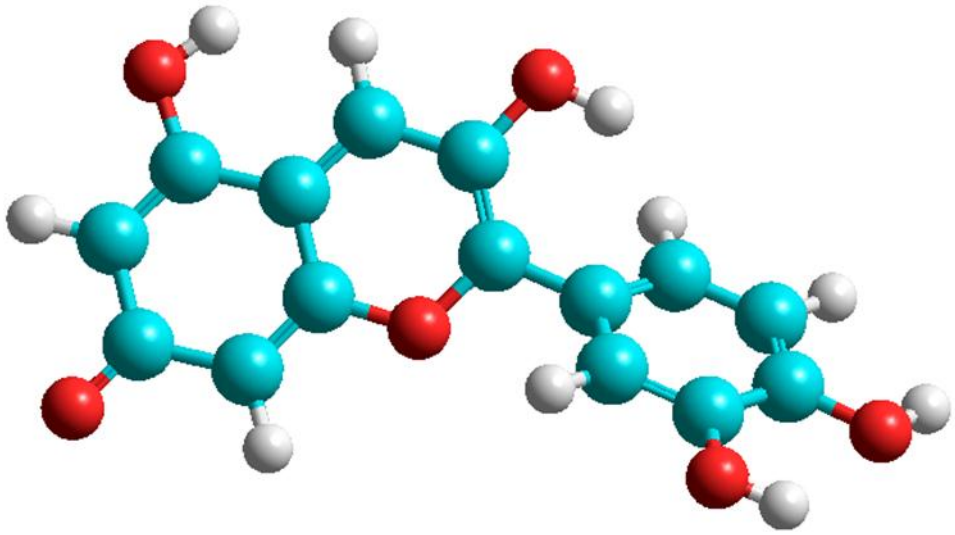

Figure 1. CND. 3 D, Hyperchem model.

Figure 1 shows the molecule to scale. This characterization was done with the SE-PM3 method.

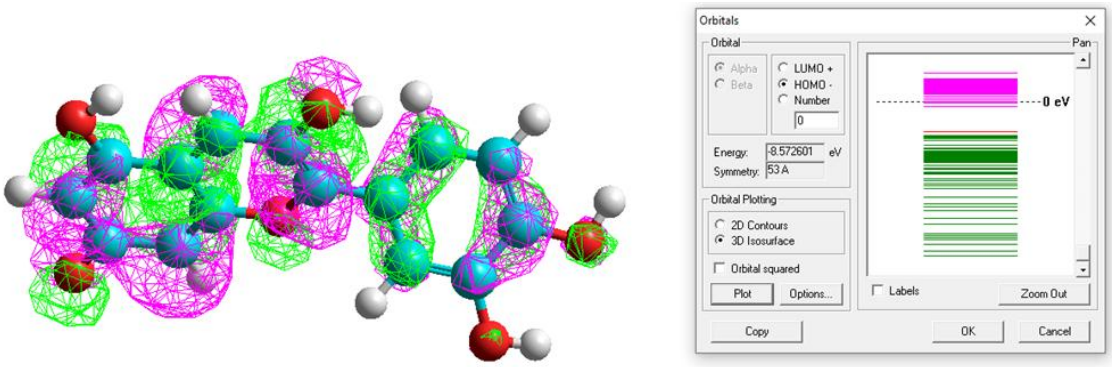

Figure 2. CND, HOMO.

Figures 2 and 3 show the calculation of the valence molecular orbital HOMO and LUMO.

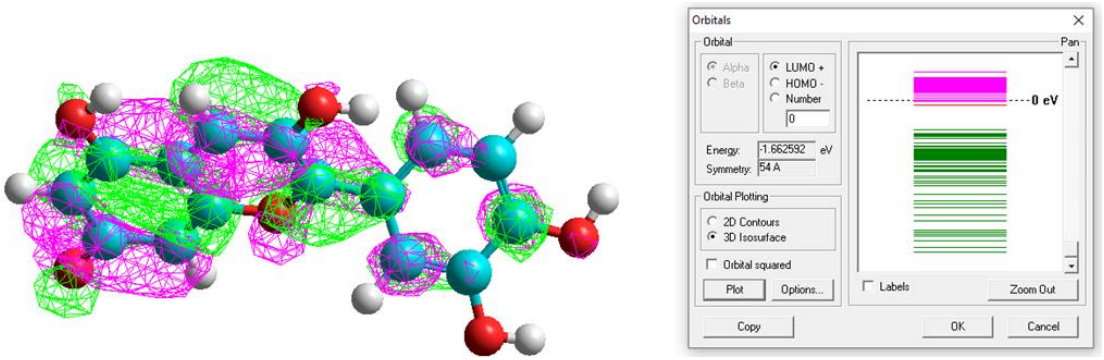

Figure 3. CND. LUMO.

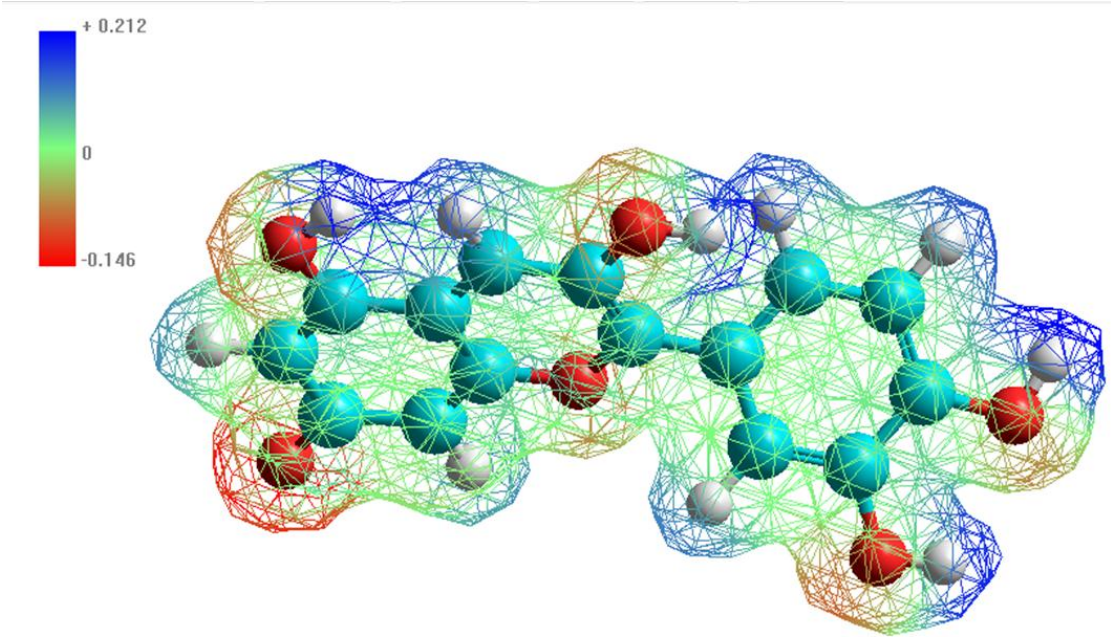

Figure 4. CND. Electrostatic Potential.

Figure 4 shows us the map of the electrostatic potential calculations. 3D mapped isosurface.

The quantum calculation of ETC was done with the previous results.

Quantum calculations Cyannidin's ETC:
BG = |HOMO – LUMO| = |- 8.572601 + 1.662592| = 6.910009 eV
EP = |- 0.146 - 0.212| = 0.358 a.u.
ETC = BG/EP = 6.910009/0.358 = 19.301701117318 eV/a.u.

In Table 3, the ETCs of the 20 amino acids and CND results are shown. If the table is viewed as levels of the quantum well, then these levels indicate the stability of each pure substance.

Table 3: Ordered amino acids and substance. QUANTUM WELL.									
N	**Reducing agent**	**Oxidizing agent**	**HOMO**	**LUMO**	**BG**	**E-**	**E+**	**EP**	**ETC**
21	Val	Val	-9.914	0.931	10.845	-0.131	0.109	0.240	45.188
20	Ala	Ala	-9.879	0.749	10.628	-0.124	0.132	0.256	41.515
19	Leu	Leu	-9.645	0.922	10.567	-0.126	0.130	0.256	41.279
18	Phe	Phe	-9.553	0.283	9.836	-0.126	0.127	0.253	38.879
17	Gly	Gly	-9.902	0.902	10.804	-0.137	0.159	0.296	36.500
16	Ser	Ser	-10.156	0.565	10.721	-0.108	0.198	0.306	35.037
15	Cys	Cys	-9.639	-0.236	9.403	-0.129	0.140	0.269	34.956
14	Glu	Glu	-10.374	0.438	10.812	-0.111	0.201	0.312	34.655
13	Ile	Ile	-9.872	0.972	10.844	-0.128	0.188	0.316	34.316
12	Thr	Thr	-9.896	0.832	10.728	-0.123	0.191	0.314	34.167
11	Gln	Gln	-10.023	0.755	10.778	-0.124	0.192	0.316	34.108
10	Asp	Asp	-10.370	0.420	10.790	-0.118	0.204	0.322	33.509
9	Asn	Asn	-9.929	0.644	10.573	-0.125	0.193	0.318	33.249
8	Lys	Lys	-9.521	0.943	10.463	-0.127	0.195	0.322	32.495
7	Pro	Pro	-9.447	0.792	10.238	-0.128	0.191	0.319	32.095
6	Trp	Trp	-8.299	0.133	8.431	-0.112	0.155	0.267	31.577
5	Tyr	Tyr	-9.056	0.293	9.349	-0.123	0.193	0.316	29.584
4	His	His	-9.307	0.503	9.811	-0.169	0.171	0.340	28.855
3	Met	Met	-9.062	0.145	9.207	-0.134	0.192	0.326	28.243
2	Arg	Arg	-9.176	0.558	9.734	-0.165	0.199	0.364	26.742
1	CND	CND	-8.573	-1.663	6.910	-0.146	0.212	0.358	19.302

In this table 3, CND occupies the bottom of the quantum well. This lower value indicates more excellent chemical stability of CND concerning amino acids. As a corollary, it can be said that CND has a very high probability of remaining in the body for a long time.

Table 4. ETCs of the oxidation-reduction interactions of amino acids and CND.									
N	**Reducing agent**	**Oxidizing agent**	**HOMO**	**LUMO**	**BG**	**E-**	**E+**	**EP**	**ETC**
61	Val	Val	-9.914	0.931	10.845	-0.131	0.109	0.240	45.188
Interactions (20-60) omitted due to lack of space.									
21	CND	Glu	-8.573	0.438	9.011	-0.146	0.201	0.347	25.968
20	CND	Met	-8.573	0.145	8.718	-0.146	0.192	0.338	25.792
19	CND	Asp	-8.573	0.420	8.993	-0.146	0.204	0.350	25.693
18	Gln	CND	-10.023	-1.663	8.361	-0.124	0.212	0.336	24.882
17	Thr	CND	-9.896	-1.663	8.234	-0.123	0.212	0.335	24.579
16	Asn	CND	-9.929	-1.663	8.266	-0.125	0.212	0.337	24.530
15	Ala	CND	-9.879	-1.663	8.216	-0.124	0.212	0.336	24.453
14	Ile	CND	-9.872	-1.663	8.209	-0.128	0.212	0.340	24.146
13	Val	CND	-9.914	-1.663	8.251	-0.131	0.212	0.343	24.056
12	Leu	CND	-9.645	-1.663	7.983	-0.126	0.212	0.338	23.617
11	Gly	CND	-9.902	-1.663	8.240	-0.137	0.212	0.349	23.610
10	Cys	CND	-9.639	-1.663	7.976	-0.129	0.212	0.341	23.391
9	Phe	CND	-9.553	-1.663	7.890	-0.126	0.212	0.338	23.344

8	Lys	CND	-9.521	-1.663	7.858	-0.127	0.212	0.339	23.180
7	Pro	CND	-9.447	-1.663	7.784	-0.128	0.212	0.340	22.894
6	Tyr	CND	-9.056	-1.663	7.393	-0.123	0.212	0.335	22.070
5	Met	CND	-9.062	-1.663	7.399	-0.134	0.212	0.346	21.385
4	Trp	CND	-8.299	-1.663	6.636	-0.112	0.212	0.324	20.481
3	His	CND	-9.307	-1.663	7.645	-0.169	0.212	0.381	20.065
2	Arg	CND	-9.176	-1.663	7.514	-0.165	0.212	0.377	19.930
1	CND	CND	-8.573	-1.663	6.910	-0.146	0.212	0.358	19.302
							Average		**28.783**
							First quartile		**24.530**

Oxidation-reduction interactions are shown in table 4. In it, we can observe that CND oxidizes amino acids (1-18) and reduces these amino acids (19-21) before the mean, exceeding the first quartile.

The same pattern is preserved (Table 4) when all against all are combined. The round-robin combination simulates amino acids linked in a protein.

DISCUSSIONS

The authors can only say that CND has a high probability of causing effects on amino acids that are the primary or specialized structure of tissues.

Because of these solid and probable interactions, CND does have antiproliferative and differentiating effects, among others.

In general, we reaffirm the colleagues' research that we cited in the introduction to this article.

CONCLUSIONS

We did the following:

- We characterize the cyanide molecule with the hyperchem simulator.
- We calculate all the quantum parameters of both CND and the amino acids that make up proteins.
- We rank these calculations of ETCs in the form of a quantum well.

We found the following:

- CND is more stable than any of the 20 amino acids. Table 3.
- CND has a prolonged effect on the human body.
- CND oxidizes 15 amino acids and reduces five amino acids.

- Both oxidations and reductions take place in the first quartile. Table 4.
- The oxidation-reduction pattern is conserved in the 441 interactions of any protein sequencing.
- The probability that CND is an alternative for treating degenerative diseases is high.

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