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Chemical-Quantum Analysis Of The Anticancer Potential Of Rhodionin Present In The Plant Rhodiola Rosea Vs. Amino Acids Of The Human Body

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ABSTRACT

Rhodiola rosea (*R. rosea*) extract has molecular contrast mechanisms, which have normal physiological functions. Extracts of R. rosea have anticancer potentials. Rhodiodin (RDN) is a flavonoid compound found in Rhodiola plants. The aim was to analyze the anticancer potential of rodionin present in the *R. rosea* plant by quantum chemistry. Hyperchem software was used as a quantum chemistry simulator. The fundamental basis of quantum calculations was the electron transfer coefficient (ETC) theory. We can see the ETCs ordered according to the quantum well. The substance lies at the bottom of the quantum well. This situation indicates that the probability of oxidative interactions occurring is very high. We found that the RDN is a potent oxidant of AAs in the human body; for this reason, it has potential as an anticancer chemotherapeutic agent.

***Keywords*:** Chemical-Quantum; Anticancer potential; Rhodionin; *Rhodiola Rosea.*

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Análisis Químico-Cuántico del Potencial Anticancerígeno de la Rodionina Presente en la Planta Rhodiola Rosea Vs Aminoácidos del Cuerpo Humano

RESUMEN

Los extractos de Rhodiola rosea (R. rosea) tiene mecanismos de contraste molecular, que tienen funciones fisiológicas normales. Los extractos de R. rosea tienen potencial anticancerígeno. La rodiodina (RDN) es un compuesto flavonoide que se encuentra en las plantas de Rhodiola. El objetivo fue analizar el potencial anticancerígeno de la rodionina presente en la planta R. rosea mediante química cuántica. El software Hyperchem se utilizó como simulador de química cuántica. La base fundamental de los cálculos cuánticos fue la teoría del coeficiente de transferencia de electrones (ETC). Podemos ver las ETC ordenadas según el pozo cuántico. La sustancia se encuentra en el fondo del pozo cuántico. Esta situación indica que la probabilidad de que se produzcan interacciones oxidativas es muy alta. Encontramos que el RDN es un potente oxidante de AA en el cuerpo humano; por esta razón, tiene potencial como agente quimioterapéutico contra el cáncer.

Palabras clave: *Química-Cuántica; Potencial anticancerígeno; Rodionina; Rhodiola Rosea; aminoácidos del cuerpo humano.*

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INTRODUCTION

Natural compounds extracted from herbs are used to prevent or treat different diseases. Cancer is included in these diseases. In addition, these natural compounds are an alternative to drug consumption. The researchers conducted studies on plant compounds. They aimed to find substances with selective cytotoxicity in abnormal cells. Phenolic compounds are important secondary metabolites of plants. (Teodor et al., 2020); (Kwon, 2018); (Alamgir, 2018)

The plant of the genus R. (Crassulaceae) comprises approximately 96 species. R. rosea is a popular plant in traditional medical systems in the Nordic countries, Eastern Europe, and Asia. This plant has medicinal properties such as stimulating the nervous system, reducing depression, improving work performance, eliminating fatigue, and preventing altitude sickness. (T. Li & Zhang, 2008); (Petsalo et al 2006); (Khanum et al 2005a); (Panossian et al 2010b)

The researchers conducted a study on the content and location of the phenolic compounds of R. rosea. The study focused on phenylpropanoid compounds. The plant material used in the introduction experiment was obtained by the in vitro method. The researchers used the HPLC method to identify the phenolic compounds. The compounds identified were: gallic acid, rosavin, rosin, cinnamon alcohol, rhodopsin, RDN, and kaempferol. RDN is a flavonoid compound found in R. rosea plants. (Erst et al. 2021); (Kurkin, 2013b); (ALtAntsetseG, K et al 2007)

Researchers have studied the molecular mechanisms of action of R. rosea extracts. R. rosea extracts have molecular contrast mechanisms, and these have normal physiological functions. Extracts of R. rosea have anticancer potentials. These inhibit the mTOR pathway and further reduce angiogenesis by downregulating HIF-1α/HIF-2α expression. (Y. Li et al. 2017b); (Liu et al. 2011)

Cancer is one of the leading causes of death in the world. Cancer has a prevalence of >10 million deaths annually. Current cancer treatments include surgery, radiation, and chemotherapy drugs, often killing healthy cells and producing toxicity in patients. (Zaimy et al. 2017) (Hausman, 2019); (Torre et al 2016); (Gilbertson, 2011)

MATERIAL AND METHODS

Hyperchem software was used as a quantum chemistry simulator. The fundamental basis of quantum calculations was the theory of the ETC. In tables 1-2. The parameters used in this simulation are specified.

The Plot Molecular Graph method in three dimensions was used to calculate the electrostatic potential (EP).

Finally, the ETC was calculated by dividing the band gap by the EP.

As there are too many calculations, only the tables, whisker, and box diagrams are presented in this article. If you would like more information, please contact Dr. Manuel González Pérez.

Table 1. Parameters used for quantum computing molecular orbitals-HOMO 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 gradeint 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 Size	Coarse	Transparency level	A criteria
Isosurface Grid: Grid Layout	Default	Isosurface Rendering: Total charge density contour value.	0.015
Contour Grid: Starting Value	Default	Rendering Wire Mesh	

Interpretation of the quantum well.

Figure 1 presents the quantum well of the interactions through its ETC. On the left side, the antioxidant or reducing interactions are shown, on the right side, the oxidant interactions. This well is divided into four quadrants, ordered from lowest to highest, from bottom to top. The deeper interactions in the well have greater chemical affinity and probability of occurring.

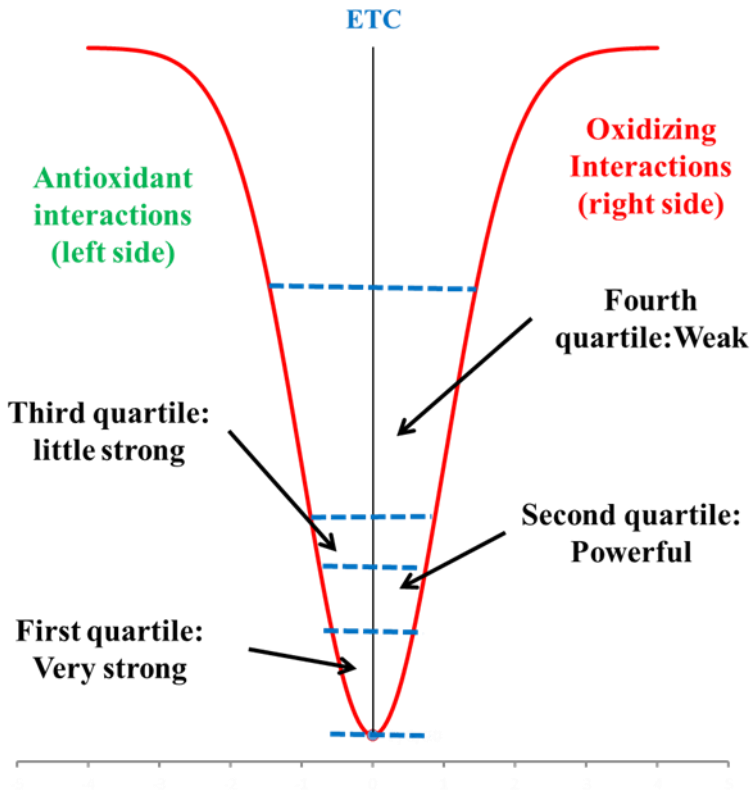
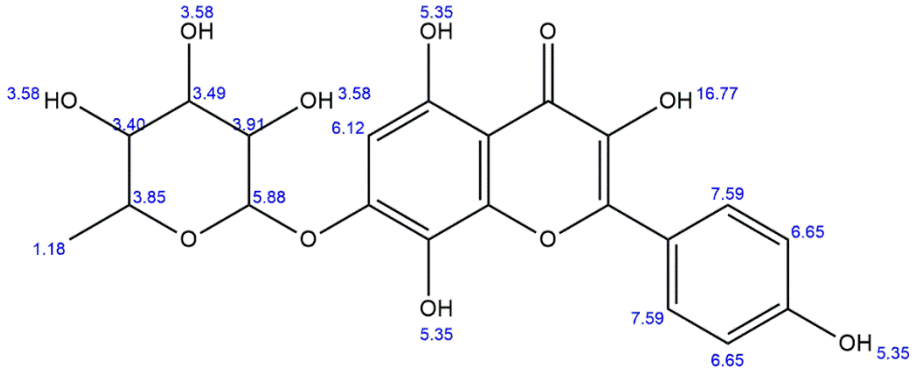


Figure 1. Quantum well. Interpretation of the interactions in the four statistical quadrants.

RESULTS AND DISCUSSION

Classic characterization

Figure 2 shows the results of the simulated characterization of H Nuclear Magnetic Resonance and the scientific name according to the UIPAC of RDN.



3,5,8-trihydroxy-2-(4-hydroxyphenyl)-7-((3,4,5-trihydroxy-6-methyltetrahydro-2H-pyran 2-yl)oxy)-4H-chromen-4-one

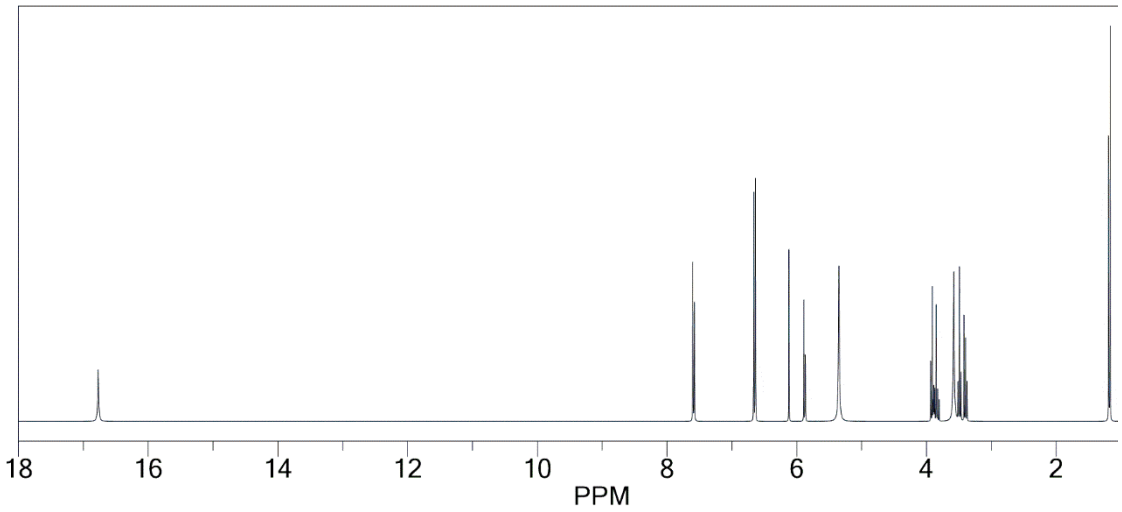
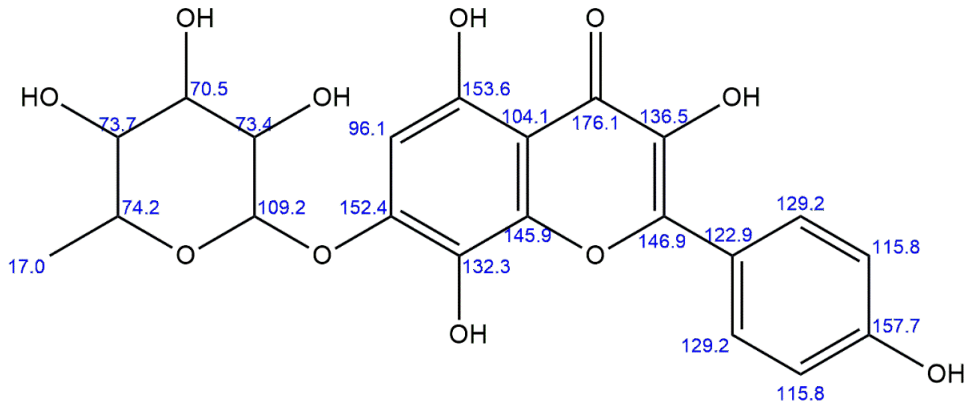


Figure 2. Scientific name UIPAC and Nuclear Magnetic Resonance of H. Above the molecule with its quantified protons. Below is the multiplicity diagram of protons.

Figure 3 shows the results of the simulated characterization of C13 Nuclear Magnetic Resonance.



3,5,8-trihydroxy-2-(4-hydroxyphenyl)-7-((3,4,5-trihydroxy-6-methyltetrahydro-2H-pyran 2-yl)oxy)-4H-chromen-4-one

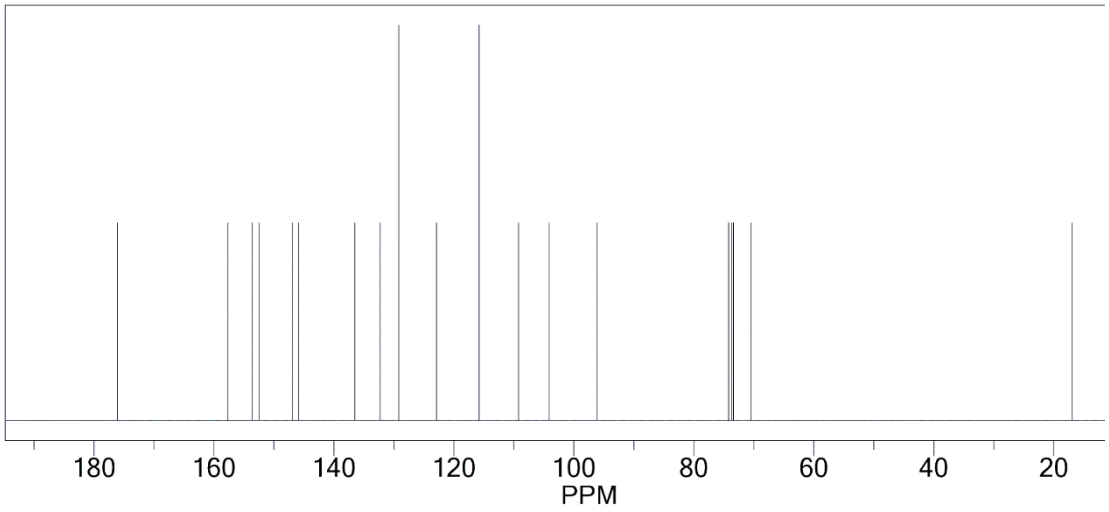
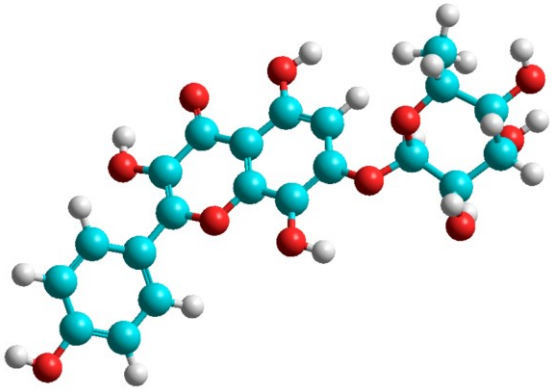


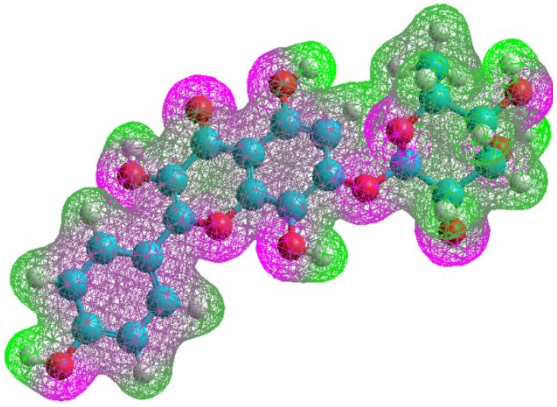
Figure 3. C13 nuclear magnetic resonance. At the top the molecule is shown with its quantified carbons and at the bottom is the diagram in ppm.

Quantum characterization.

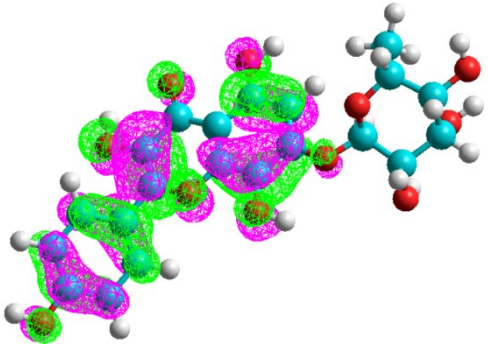
Figure 4 shows us the RDN molecule characterized by its different quantum concepts. This molecule presents a quantum superposition of HOMO and LUMO. This quantum property infers that it has spheres or micelles.



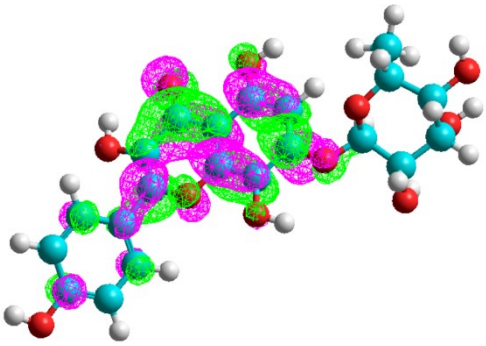
A) RDN. Hyperchem.



B) RDN. Electrostatic potential. -d = -0.105 eV/a°; +d = 0.212 eV/a°.



C) RDN. HOMO. -8.509754 eV.



D) RDN.LUMO. -0.625973 eV.

Figure 4. Quantum characterization. A) Cyan = C; White = H; Red = O; B) Electrostatic potential; C) HOMO; D) LUMO

Quantum calculations.

BG = |HOMO-LUMO| Eq. 1.

EP = |(-d) - (+d) | Eq. 2.

ETC = BG/EP Eq. 3.

Where:

BG = band gap. Column 6 of table 1.

EP = electrostatic potential. Column 9 of table 1.

ETC = Electron Transfer Coefficient. Column 10 of table 1.

To show a summary of 61 interactions between the RDN and the 20 AAs of the human body, we used whisker and box diagrams.

In Table 1, we can see the ETCs ordered according to the quantum well. It is observed that the RDN is at the bottom of the well. This location leads us to infer that RDN is a long-acting substance so this substance cannot be eliminated by the biological organism without complications. (González-Pérez, 2017a) (González-Pérez, 2015) (González *et al* 2017) (Ahuactzin *et al* 2018) (González-Pérez, 2017b) (González *et al* 2018) (Pérez *et al* 2019) (Olmos *et al* 2018) (Pacheco *et al* 2017)

Table 1. ETCs of pure substances AAs and RDN.

No.	Reducing agent	Oxidizig agent	HOMO	LUMO	BG	d-	d+	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	RDN	RDN	-8.510	-0.626	7.884	-0.105	0.212	0.317	24.870

Figure 5 shows the information in diagrams of whiskers and boxes. The upper left graph shows the reducing or antioxidant interactions, and the lower exemplary chart shows the oxidative interactions. The substance lies at the bottom of the quantum well. This action indicates that the probability of oxidative interactions occurring is very high.

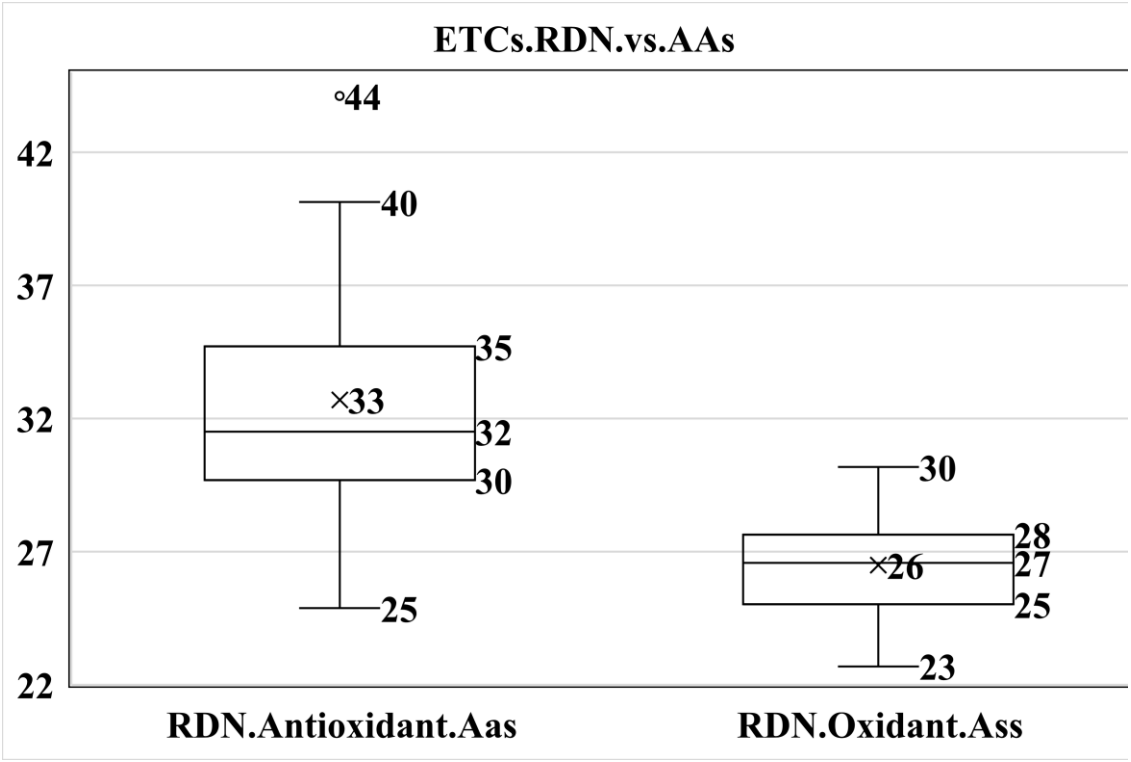


Figure 5. Whisker diagrams of the CTEs of chemical-quantum interactions. The lower right diagram indicates that the interactions are highly oxidizing in nature.

CONCLUSIONS

Aim. To analyze the anticancer potential of RDN present in the *R. rosea* plant by quantum chemistry.

Thesis. The diagrams (Figure 5) show that the probability of oxidative interactions occurring is very high. This leads us to infer that RDN is a potent oxidant of AAs in the human body, for this reason it has a potential as an anticancer chemotherapeutic agent.

Corollary. We found outside our target that the RDN is at the bottom of the well. This location leads us to infer that RDN is a long-acting substance so this substance cannot be eliminated by the biological organism without complications.

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