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Biotechnological approach to modeling the processes of hydrogen production in the human intestine

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Abstract

The biotechnological approach to the diagnosis of pathological conditions of the gastrointestinal tract caused by microbiome imbalance consists of studying the kinetics of biochemical interaction within the microbiocenosis in relation to the nature and degree of pathology. Considering the diversity of intestinal microorganisms in healthy and ill people, it is advisable not to identify individual microbes, but to evaluate the functional capacity of the gut microbiota in general.

In this case, the use of load method is effective. It implies provoking the distinctive enzymatic reactions by specific substrates, which leads to an increase in the production of individual metabolites and changes in the intestinal metabolome.

The gaseous products of microbial intestinal metabolism, primarily hydrogen and methane, enter the lungs through the bloodstream and are then exhaled. Analysis of breath metabolites makes it possible to judge the presence and nature of intestinal pathology, as well as to determine the current state of the microbiota of the entire digestive system.

The ways the intestinal gas appears, its transformation and excretion are described. An expression for the total composition of the intestinal gas, determined by its individual components, is presented.

The mechanism of the process of hydrogen production in the lower parts of the gastrointestinal tract is studied. A mathematical model of the dynamics of changes in the concentration of intestinal hydrogen in the small and large intestine in the presence of functional disorders in the small intestine, depending on the initial substrate and enzyme level, is performed.

The model is useful both in the diagnosis of disturbances of the normal functioning of the lower intestines and in monitoring and evaluating the effectiveness of the

therapeutic use of exogenous or endogenous molecular hydrogen, for example, as a reducing agent in the inactivation of the oxidative stress.

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References

[1] M. Wilson. Bacteriology of Humans An ecological perspective. *London: Blackwell Publishing*. **2008**. 351p.

[2] Human Physiology: Textbook. Ed. by V.M. Pokrovsky, G.F. Korot'ko. *Moscow: JSC "Publishing House" Medicine "*. **2007**. 656p. (Russian)

[3] K. Kalantar-Zadeh, K.J. Berean, Ha, N. et al. A human pilot trial of ingestible electronic capsules capable of sensing different gases in the gut. *Nat Electron.* **2018**. Vol.1. P.79-87. https://doi.org/10.1038/s41928-017-0004-x

[4] M. Monalto, M.D. Levitt. Intestinal gas. In: Sleisenger and Fordtran's Gastrointestinal and Liver Diseases: Pathophysiology/Diagnosis/ Management. M.H. Sleisenger and J.S. Fordtran, eds. – 5th edn. *Philadelphia: WB Sanders Co.* **1993**. P.1035-1042.

[5] F.R. Steggenia. Gastrointestinal gas following food consumption. *Ann. NY Acad. Sci*. **1968**. Vol.150. P.57-66.

[6] M. Monalto, M. Di Stefano, A. Gasbarini et al. Introductory remarks to intestinal gas metabolism. *Aliment. Pharmacol. Ther.* **2009**. Vol.29 (Suppl.1). P.1-49.

[7] M.D. Levitt, P. Hirsh, C.A. Fetzer et.al. H_2 excretion after ingestion of complex carbohydrates. *Gastroenterology.* **1987**. Vol.92. P.383-389.

[8] D.H. Calloway, D.J. Colasito, R.D. Mathews. Gases produced by human intestinal microflora. *Nature (Lond.).* **1966**. Vol.212. P.1238-1239.

[9] V.A. Kozlov. Intestinal gas metabolism and its role in the development of gastrointestinal syndromes. *Ukr. Med. Chasopis.* **2011**. Vol.2. No.82. P.116-118.

[10] Paulette M. Vignais, Bernard Billoud. Occurrence, Classification and Biological Function of Hydrogenases: An Overview. *Chem. Rev.* **2007**. Vol.107. P.4206-4272.

[11] A. Strocchi, J.K. Furne, C.J. Ellis et al. Competition for hydrogen by human faecal bacteria: evidence for the predominance of methane producing bacteria. *Gut.* **1991**. Vol.32. P.1498-1501.

[12] A. Strocchi, J.K. Furne, Ellis C.J. et al. Methanogens outcompete sulphate reducing bacteria for H2 in the human colon. *Gut.* **1994**. Vol.35. P.1098-1101.

[13] F. Azpiroz, J.R. Malagelada. Abdominal bloating. *Gastroenterology.* **2005**. Vol.129. P.1060-1078.

[14] M.D. Levitt. Production and excretion of hydrogen gas in man. *New Engl. J. Med.* **1969**. Vol.281. P.122-127.

[15] F. Azpiroz. Intestinal gas dynamics: mechanisms and clinical relevance. *Gut.* **2005**. Vol.54. P.893-895.

[16] M.D. Levitt, F.J. Ingelfinger. Hydrogen and methane production in man. *Ann. N.Y. Acad. Sci.* **1968**. Vol.150. P.75-81.

[17] A. Newman. Breath-analysis tests in gastroenterology. *Gut.* **1974**. Vol.15. P.308-323.

[18] E.N. Maximova, V.F. Markov, A.E. Bezdetnova, Yu.G. Shashmurin, L.N. Maskaeva, and V.F. Dyakov. Using of chemical sensors for rapid diagnostic tests of exhaled air. *Butlerov Communications.* **2019**. Vol.60. No.12. P.25-36. DOI: 10.37952/ROI-jbc-01/19-60-12-25 (Russian)

[19] P.G. Wolf, A. Biswas, S.E. Morales, C. Greening, H.R. Gaskins. H2 Metabolism Is Widespread and Diverse Among Human Colonic Microbes. *Gut Microbes.* **2016**. Vol.7(3). P.235-45. doi: 10.1080/19490976.2016.1182288.

[20] P.M. Vignais, A. Colbeau. Molecular Biology of Microbial Hydrogenases. *Curr Issues Mol Biol.* **2004**. Vol.6(2). P.159-88.
[21] V.V. Stepanov. Differential Equations Course: *Textbook. Moscow: LKI.* **2016**. 512p. (Russian)
[22] Y. Zhang, S. Tan, J. Xu, T. Wang. Hydrogen Therapy in Cardiovascular and Metabolic Diseases: From Bench to Bedside. *Cell Physiol Biochem.* **2018**. Vol.47(1). P.1-10. doi: 10.1159/000489737
[23] R.J. Neale. Dietary fibre and health: the role of hydrogen production. *Med. Hypotheses.* **1988**. Vol.27. P.85-87.
[24] Hydrogen Molecular Biology and Medicine. Ed. by Xuejun Sun, Shigeo Ohta, Atsunori Nakao, transl. from Engl. *Moscow: Publishing House "Enhel Press".* **2016**. 160p. (Russian)
[25] I. Ohsawa, M. Ishikawa, K. Takahashi et.al. Hydrogen acts as a therapeutic antioxidant by selective reducing cytotoxic oxygen radicals. *Nat. Med.* **2007**. Vol.13. P.688-694.
[26] A. Shimouchi, K. Nose, M. Yamaguchi et al. Breath Hydrogen Produced by Ingestion of Commercial Hydrogen Water and Milk. *Biomarker Insights.* **2009**. Vol.4. P.27-32.
[27] T.W. LeBaron, B. Kura, B. Kalocayova, N. Tribulova, J. Slezak. A New Approach for the Prevention and Treatment of Cardiovascular Disorders. Molecular Hydrogen Significantly Reduces the Effects of Oxidative Stress. *Molecules.* **2019**. Vol.24(11). P.2076. doi:10.3390/molecules24112076.
[28] W.J. Guan, C.H. Wei, A.L. Chen, X.C. Sun, G.Y. Guo, X. Zou, J.D. Shi, P.Z. Lai, Z.G. Zheng, N.S. Zhong. Hydrogen/oxygen mixed gas inhalation improves disease severity and dyspnea in patients with Coronavirus disease 2019 in a recent multicenter, open-label clinical trial. *J. Thorac. Dis.* **2020**. Vol.12(6). P.3448-3452. doi: 10.21037/jtd-2020-057.
[29] K. Lucas, M. Rosch, P. Langguth. Molecular hydrogen (H_2) as a potential treatment for acute and chronic fatigue. *Arch Pharm (Weinheim).* **2020** (Dec 23). e2000378. doi: 10.1002/ardp.202000378
[30] Marina A. Dmitrienko, Sergey E. Bykov. Biotechnological approach to modeling the processes of hydrogen production in the human intestine. *Butlerov Communications.* **2021**. Vol.65. No.2. P.116-124. DOI: 10.37952/ROI-jbc-01/21-65-2-116 (Russian)