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RCST USUE in the new industrialization: innovation potential

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***Abstract*—The article describes the long-term innovative activity of the Research Center of Sensory Technologies of the Ural State University of Economics (RCST USUE). The results of research and development of methods and sensors for the antioxidant activity of biological media are given as examples. The contribution of the obtained new knowledge to the development of monitoring methods of oxidative stress, quality of food, nutrients, cosmetics, etc. are presented. Instruments for monitoring are developed and produced. Trends of future innovation, way from sensor system to smartphone registration, in particular, are mentioned.**

Keywords—innovative potential, antioxidant activity, oxidative stress, health monitoring, instruments trends

I. INTRODUCTION

The Minister of Science and Higher Education of the Russian Federation, M. M. Kotyukov, speaking in his first interview after taking office, about the national project "Science", noted that Russia's strategic goal is to enter the top five developed countries by the number of patents and publications in authoritative international journals. Now, by the number of articles of the kind, Russia is on the 11th place in the world, on patents - on the eighth place [1].

The basis for solving this problem is innovative researches giving a double result: (i) scientific, consisting in obtaining new knowledge, followed by publications in authoritative journals with a high site score, cited by other researchers, and (ii) applied ones, consisting in the development of new technologies, patents and new products.

Long-term studies conducted by Research Center of Sensory Technologies of the Ural State University of Economics (RCST USUE) in the field of monitoring of antioxidant activity (AOA) and oxidative stress (OS) are an example of such innovative activity and contributes to the development of new industrialization.

II. OXIDATIVE STRESS AND HEALTH CONDITIONS

The significance of innovative researches and developments, which are held at the RCST USUE, is due to the fact, that, free radicals-source and reason of OS appearing play dual role in a living organism: (i) they ensure regular metabolism in human body, (ii) in case of oxidant/antioxidant misbalance free radicals lead to oxidation of lipids, membrane destruction and irreversible changes in DNA. Many diseases and cosmetic problems are both causes and consequences of OS.

Modern studies establish a direct or indirect relationship of OS with the pathogenesis of about 200 human diseases [2], including socially significant diseases of the nervous, cardiovascular, reproductive, endocrine organ systems, aging and cancer. Part of that is shown on fig. 1.

OS in the pathogenesis of many diseases is explained by universality and the key role of redox reactions which take place in the cells of the human body along with general pathological processes. As all cells of a living organism are able to generate active molecules or forms of oxygen, OS may be generated in any organ or tissue.

OS is a misbalance between free radical oxidation processes, and antioxidant protection system activity of the organism which neutralizes these processes.

Fig. 2 shows the relationship between the OS resulting from the action of free radicals and other active forms of oxygen and nitrogen, and the activity of the antioxidant system of the body.

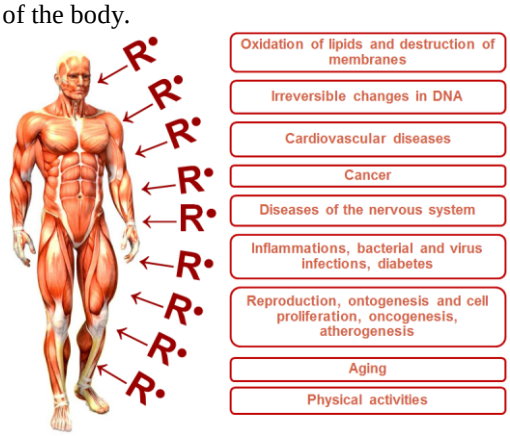

Fig. 1. Role of free radicals in the body.

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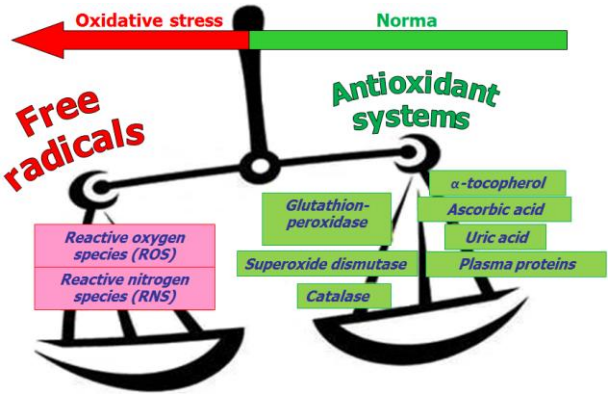

Fig. 2. The ralationship of antioxidant system and oxidative stress.

AOA is regarded as the criterion of OS [3, 4] which characterizes the main human diseases including socially significant ones so as cardiovascular system and malignant neoplasms pathologies. Understanding relationships between typical general pathological processes and OS, monitoring the presence and degree of OS and the state of antioxidant protection system enable to screen large groups of population, detect risk groups, and regulate efficacy of treatment and preventive measures.

Nowadays, the interest in possible clinical uses of methods for measuring OS and AOA is growing as well as the demand for easy-to-use, precise, and reproducible methods of measuring AOA/OA. The development of such a method enables to determine the range of normal values for AOA/OA, criteria for OS. Of particular importance is the study of intensity and dynamics of OS generation and a possibility to identify features of OS in patients with different forms and stages of illness. The method of measuring AOA/OA will enable to screen the presence and degree of OS in large groups of population including during preventive examinations of employees at the enterprises with harmful and arduous working conditions. These activities, together with the data about normal and abnormal values of AOA/OA will allow to select and to form groups of regular medical check-up of the people with a potential risk of developing deceases, in order to diagnose and prevent these diseases at early stage. It is obvious, that AOA studies create applicable in clinical conditions methodology that allow to assess efficacy, safety and tolerability of pharmacotherapy for each patient.

This task is hardly possible to be carried out without solving the fundamental problems: creating a unified approach to measuring concentration of oxidants and antioxidants in biological objects; developing invasive and non-invasive methods of diagnostics of OS and AOA in human skin and blood under normal conditions and pathology (malignant neoplasms, cardiovascular diseases, etc.).

This general approach to understanding OS and its relation to endogenous and exogenous factors that have an impact on human being; monitoring of its existence in terms of antioxidants' and oxidants' activity in biological substrates is developed in RCST USUE. Some approaches are proposed for the first time. These include new hybrid potentiometric method

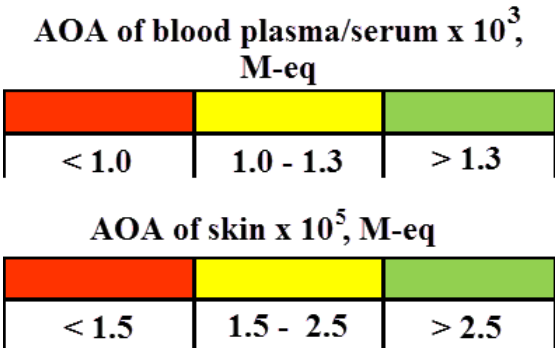

Fig. 3. The ranges of AOA plasma/serum and AOA skin: OS (red), risk zone (yellow) and relatively healthy people (green).

[5] for invasive [6] and non-invasive [7] measurements of AOA of various media in normal and pathological conditions.

III. Hybrid Potentiometric Method for Monitoring of Antioxidant Activity

Employees of RCST USUE made a significant contribution to the understanding and development of os and its monitoring. they proposed a new electrochemical method (hybrid potentiometric method for monitoring of antioxidant activity [5]), in particular for evaluating the AOA of biological fluids [6] and tissues [7], together with the staff of the Zdorovie 365 clinic conducted massive tests and obtained distribution "healthy - ill" (fig. 3).

Currently, the hybrid potentiometric method, proposed and developed in RCST USUE, is successfully used in the determination of the AOA of various objects: beverages and plant extracts [8–10], skin [11–14], blood and its fractions [8, 15, 16], ejaculate and follicular fluid [17], saliva [18].

The solution of the monitoring problem allows to define quantitative and qualitative criteria for occurrence and severity of OS; to offer a standardized method of measuring AOA/OA; to improve diagnostic screening of diseases, and to create the system of early detection, clinic supervision, prevention, as well as estimation of effectiveness and safety of drugs used for treating groups of patients.

IV. Potentiometric Analyzers

In the process of works devices have been developed and manufactured for analyzing solutions (fig. 4) and tissues (fig. 5).

V. Applications

Fields of application of AOA monitoring are: medicine, food, cosmetics, nutrients, pharmaceuticals, etc. Some examples are presented on fig. 3 and figs. 6–9.

VI. Trends and Prospects

Today «humanity is on the threshold of a significant increase in the duration of the biologically active life, and in many ways this will be achieved by means of preventive measures aimed at regulation of radical oxidation processes» [19].

Fig. 4. Potentiometric analyzer ANTIOXIDANT for analysis of solutions (food, biological fluids, cosmetic cream etc.) [6]: 1 – case; 2 – display (touch control panel); 3 – electrode mounting part; 4 – a glass cell; 5 – slot for the cell; 6 – thermal sensor; 7 – connector for the working electrode; 8 – working electrode; 9 – connector for reference electrode; 10 – reference electrode.

Fig. 5. Potentiometric analyzer PA–S for analysis of tissues (skin, fruit surface) [7]: 1 – instrument case; 2 – display (touch control panel).

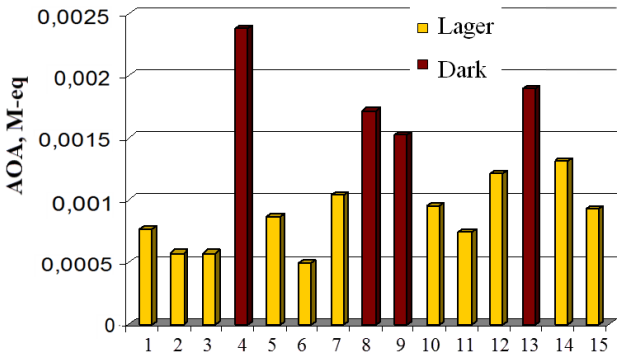

Fig. 6. AOA of lager and dark beer: 1 – Gesser (11 %); 2 – Holsten (11.6 %); 3 – Sibirskay korona (11 %); 4 – Sibirskay korona (16 %); 5 – Sibirskay korona (14 %); 6 – Baltika (12 %); 7 – Baltika № 3 (12 %); 8 – Baltika № 4 (15 %); 9 – Guinnes dark; 10 – Patra knyazhe (14 %); 11 – Zolotaya bochka (12 %); 12 – Zolotaya bochka osoboe (12 %); 13 – Zolotaya bochka (15 %); 14 – Solodov (12 %); 15 – Lowenbrau (12 %).

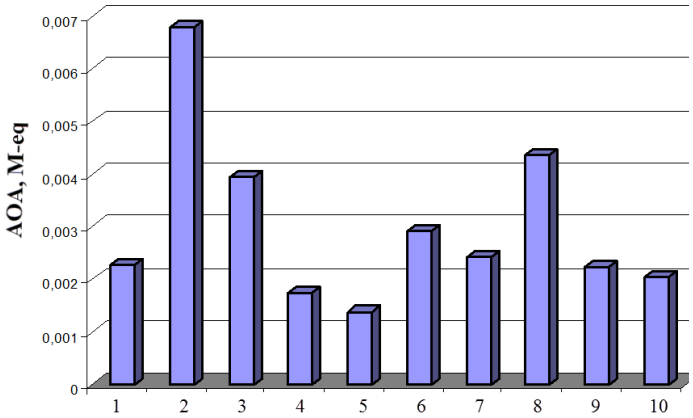

Fig. 7. AOA of alcoholic beverage: 1 – Fetayska (white); 2 – Kaberne (red); 3 – Adelle (pink); 4 – Muscat "Asconi"; 5 – Shampanskoe "Sovetskoe"; 6 – Kagor (Moldova); 7 – Pinot (white); 8 – Kardinal (red); 9 – Aragvi (cognac); 10 – Vinorum (cognac).

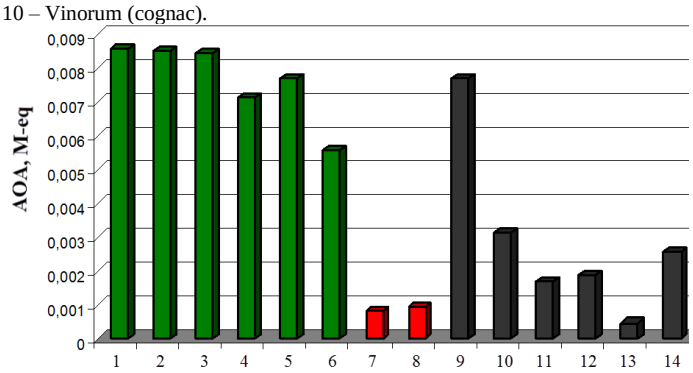

Fig. 8. AOA of tea: 1 – Yava Premium (green); 2 – Yava Best (green); 3 – Imperatorsky (green); 4 – Edvin (green); 5 – Heladiv (green); 6 – Ahmad with jasmine (green); 7 – Karkade (red); 8 – Gibiscus (red); 9 – Korona Rossiyskoi imperii (black); 10 – Russkoe chaepitie (black); 11 – Tee with cowberries (back); 12 – Lipton (black).

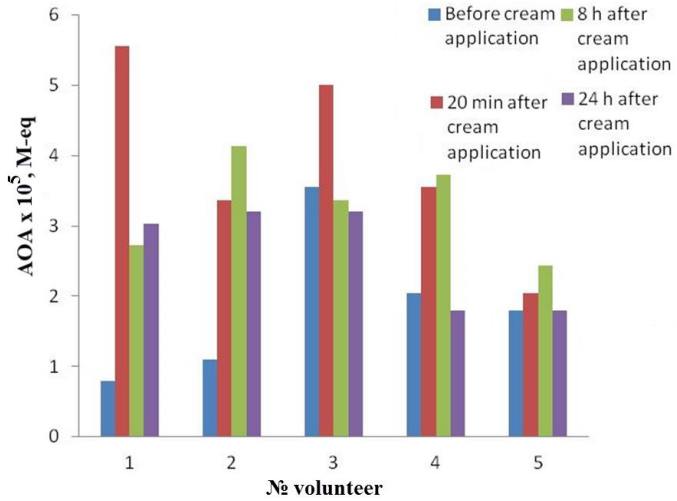

Fig. 9. Skin AOA obtained before and after cream for hand application.

Innovation activity of RCST USUE makes a significant contribution to solving this problem.

A very interesting future lies in the development of new variants of AOA sensors. Scientific and technical basis for that are the non-invasive method of skin research (figs. 4 and 8) described in our papers [11–14] and patent [7], and the recently described in literature wearable sensors [20, 21], that we plan to develop. Since AOA monitoring gives information on OS, i.e. on the state of health, further research in this area and new developments will be very useful for telehealth services, conducting remote consultations for patients using medical devices as mentioned in [22]. Development of "home clinic", skin care is important. It is worth mentioning also the prospects of using non-invasive sensors, in sports medicine. Thus, the avenues for further development of AOA determination method are likely to be the design of *on-site* and *in-situ* options and a wider range of analyzed objects.

A great majority of different sensors, excluding AOA ones, described earlier and used today are based on an application of enzymes as the recognition component. Their advantage is the high selectivity. Their disadvantages are instability, cost, and the need in some cases to use them in combination with a mediator system. There were no attempts to create AOA sensors based on this principle, because other opportunities exist.

As stated in [23] significant role belongs to the development of sensory systems as lab-on-a-chip, printed (written), and wearable sensors.

Continued innovation RCST USUE involves research, including clinical ones, development of new approaches, opening the way from the sensor to the Smartphone, and ways to implement them.

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Addition

The article is published in the author's edition.