



Editorials



Special issue on 'Biomarkers of Oxidative Stress, Aging and Nutrition in Human Studies'

A steadily increasing pool of knowledge and data is available in the field of redox biology. Besides the basic research being performed, for example in animal studies, cell culture, *Drosophila*, and *C. elegans* to elucidate underlying causes, effects, and mechanisms of action of oxidants, studies on the association between redox biomarkers and human health and age are also of special interest. To focus on the human aspect, we invited experts in the field of redox biology to present recent findings on redox biomarkers in human studies.

This special issue on 'Biomarkers of Oxidative Stress, Aging and Nutrition in Human Studies' will bring the readers from biomarker basics in redox biology such as protein oxidation, lipid peroxidation, nucleic acid oxidation, protein glycation and protein glycosylation to the use of redox biomarkers in human studies related to obesity, metabolic syndrome, diabetes, cardiovascular disease or inflammation.

The review by Kehm et al. outlines the most important classes and selected examples of oxidative protein modifications, elucidates the chemistry beyond their formation and discusses available methods for detection and analysis. Furthermore, the relevance and potential of protein modifications as biomarkers in the context of disease and aging is summarized [1]. Altomare et al. discuss the most novel analytical approaches for lipid peroxidation biomarkers and their application for profiling reactive carbonyl species and their enzymatic and non-enzymatic metabolites as an index of lipid peroxidation and oxidative stress including methodological limits and perspectives [2]. The state-of-the-art in biomarkers of nucleic acid oxidation is presented by Chao et al. [3]. In their review, Rabbani and Thornalley describe the clinical diagnostic application of glycation adducts as biomarkers, most commonly used in diabetes, diabetic complications, arthritis, autism and aging [4]. Recent glyco-redox studies and novel therapeutic approaches for the treatment of related diseases are discussed in the review by Khoder-Agha et al. [5]. Erusalimsky focuses on the use of soluble Receptor for Advanced Glycation-End Products (sRAGE) as a biomarker of disease risk and adverse outcomes [6]. His conclusions why sRAGE may reflect chronic inflammation and multimorbidity rather than a healthy state and thus sRAGE is a promising biomarker of disease risk and adverse outcomes are detailed in this review [6].

The reviews mentioned above describe fundamental topics on single biomarkers or whole biomarker groups, their chemical origin and common analytical methods. The next bundle of reviews focuses on the application of biomarkers in human studies, the impact of interventions such as antioxidants or exercise on health and disease [7–11]. Systematic as well as narrative reviews cover the association between diet and redox biomarkers focusing on dietary interventions, dietary habits and supplements [7,8]. Aleksandrova et al. systematically reviewed the results from observational studies and intervention trials published in the

last 5 years focusing on the associations between dietary patterns and biomarkers of oxidative stress and inflammation [7]. Applying the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, they selected 29 studies among which 16 were observational and were 13 intervention studies. Henning and Weber focused more on the nature of applied biomarkers and applied categories of biomarkers (oxidative damage, endogenous, exogenous antioxidants) to 88 articles and found that only seven studies measured biomarkers from the three categories and that many studies rely on controversial assays for total antioxidant capacity [8]. One form of dietary antioxidants, namely (–)-epicatechin (EC) is in the center of the review by Oteiza et al. [9] where they present evidence from both, rodent studies and characterization of mechanisms in cell cultures that mostly support the indirect antioxidant actions of EC and its metabolites in endothelial dysfunction and insulin resistance. For human studies they show beneficial effects of EC but there is limited information on oxidative stress biomarkers and flavonoid consumption for establishing conclusive associations. In their review, Polidori et al. highlight the term "nutritional cognitive neuroscience" defining a research field focusing on the impact of nutrition on cognition and brain health across the life span. In their overview, they summarize the robust evidence on the role of carotenoids as micronutrients with different biological properties in persons with cognitive (pre)frailty [10].

Exercise is interrelated to human health and to oxidative stress. Gomez-Cabrera et al. concentrate on aspects from the relation between exercise and oxidative damage, sources of ROS during exercise to biomarkers in such studies [11].

Other reviews focus more on the disease aspects of redox biomarkers [12–15]. Cardiovascular diseases are highly common and associated with oxidative stress. The *in vivo* footprints of redox biomarkers are discussed in the present review with focus on their clinical relevance, whereas the details of their mechanisms of formation and technical aspects of their detection are only briefly mentioned [12]. Korac et al. discuss diverse redox and metabolic aspects in obesity, metabolic syndrome, and diabetes, aiming to establish a platform for emerging and future redox-metabolic biomarkers research in precision medicine [13]. Lossow et al. took on the task to summarize whether trace element concentrations are suitable biomarkers for the diagnosis of cancer [14]. They tested their hypothesis using case control studies that analyzed trace elements in cancer patients vs. matched controls and discuss these focusing on lung, prostate, breast, and colorectal cancer. Podszun and Frank discuss the recent findings of vitamin E and NAFLD, showing that daily supplementation with at least 200 I.U. α -tocopherol may alleviate oxidative stress in the liver of NAFLD patients [15].

We hope scientists, medical doctors and students equally enjoy this

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special issue and hope, furthermore, that the reding will be helpful for their future research.

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