Dietary dicarbonyls

Scientific and societal impact

Non-communicable inflammatory diseases – primarily cardiovascular diseases, respiratory diseases, cancers and diabetes – pose a major risk to healthy ageing. With an estimated 41 million deaths annually, they account for 71% of all deaths globally[1]. Besides a threat to human health, non-communicable diseases impose a major economic burden on health-care systems, the wider global economy, and on affected individuals, due to medical costs and loss of income[2]. Therefore, prevention of these diseases is imperative to avert these – often premature – deaths and improve quality of life. Diet is an important modifiable risk factor for these diseases, and the availability of nutritious foods and adherence to a healthy diet are key in tackling these diseases. Research aimed at identifying diets and dietary components that play a role in the progression of non-communicable inflammatory diseases, can provide fundamental knowledge which can serve as a basis for guidelines and regulations made by policy makers and governmental bodies, and for industrial techniques applied in food industry.

It is now well-established that elevated concentrations of endogenous dicarbonyls play a role in the development and progression of type 2 diabetes and its complications[3,4]. However, these dicarbonyls are not only formed endogenously, but are also formed during food processing and hence we are exposed to them via the diet[5,6]. This raises the question whether the consumption of these dietary dicarbonyls exerts similar harmful effects on human health as their endogenous counterpart and is therefore a concern to food safety. In this thesis, we have examined this question in more detail. To the best of our knowledge, the studies described in this thesis are the first to investigate the impact of dicarbonyl intake from the diet on health outcomes in humans. Based on our findings, we can conclude that there is no strong evidence for detrimental health effects posed by a higher habitual consumption of dietary dicarbonyls. In contrast, our results showed protective effects regarding low-grade inflammation, insulin sensitivity, and presence of type 2 diabetes. Based on our data we can conclude that there is no need for concern about dietary dicarbonyls for food safety. However, further prospective and intervention studies are definitely needed to confirm this and to study the associations with other outcomes, such as cancer and mental diseases. These outcomes are of particular interest because of the potential role of dicarbonyls in DNA damage by modification and in neurodegenerative mental diseases (as reviewed in[7]).

Although our results are of interest, at this stage, it is too early to make any strong recommendations on the policy maker or consumer levels. When we confirm these results in prospective cohorts and find that dietary dicarbonyls are

associated with higher insulin sensitivity and lower incidence of type 2 diabetes, our research can provide the fundament for prevention strategies for type 2 diabetes and related complications. In that case, the research output can be used to inform multiple stakeholders involved, including inspection bodies, food industry, governments, health-care providers, and consumers. As the World Health Organization mentioned in its global report on diabetes, "a combination of fiscal policies, legislation, changes to the environment and raising awareness of health risks works best for promoting healthier diets and physical activity at the necessary scale"[2]. The current and future research output in this field can be used by inspection bodies (such as Food and Consumer Safety Authorities), to monitor potential food safety concerns for human. Inspection bodies and governmental bodies can draft and implement regulation where necessary. If confirmed in future research, these findings can also provide evidence for dietary recommendations.

The studies describes in this thesis were performed in The Maastricht Study; a population-based observational cohort with individuals from 40-75 years[8]. Therefore these findings are applicable to the general population within this age range, and potentially can be translated beyond this. However, communicating new dietary advice has to be carefully considered in order to provide a clear message for the public, bearing in mind the risk of overwhelming the public and the variety of dietary guidelines already available. In addition, dicarbonyls are present in a broad range of food items, complicating specific dietary recommendations based on dicarbonyls. Given the crucial role of food processing in the formation of dicarbonyls, dicarbonyl content can be altered by food processing, without the need for - often challenging to achieve - dietary changes. The dietary dicarbonyl database presented in this thesis, provides extensive information on the presence of dicarbonyls in a broad variety of food items. It also adds to and confirms existing knowledge about the formation of dicarbonyls during heat treatment, and about processing techniques and ingredients that correlate with high/low dicarbonyl contents in food items. Thus, this database can be informative for food industry when considering processing adaptations in the future.

References

1. WHO. Factsheet noncommunicable diseases 2021 [Available from: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases.
2. WHO. Global report on diabetes. 2016.
3. Hanssen NMJ, Scheijen J, Jorsal A, Parving HH, Tarnow L, Rossing P, Stehouwer CDA, Schalkwijk CG. Higher Plasma Methylglyoxal Levels Are Associated With Incident Cardiovascular Disease in Individuals With Type 1 Diabetes: A 12-Year Follow-up Study. Diabetes. 2017;66(8):2278-83.
4. Hanssen NMJ, Westerink J, Scheijen J, van der Graaf Y, Stehouwer CDA, Schalkwijk CG. Higher Plasma Methylglyoxal Levels Are Associated With Incident Cardiovascular Disease and Mortality in Individuals With Type 2 Diabetes. Diabetes Care. 2018;41(8):1689-95.
5. Degen J, Hellwig M, Henle T. 1,2-dicarbonyl compounds in commonly consumed foods. J Agric Food Chem. 2012;60(28):7071-9.
6. Hellwig M, Gensberger-Reigl S, Henle T, Pischetsrieder M. Food-derived 1,2-dicarbonyl compounds and their role in diseases. Semin Cancer Biol. 2018;49:1-8.
7. Schalkwijk CG, Stehouwer CDA. Methylglyoxal, a Highly Reactive Dicarbonyl Compound, in Diabetes, Its Vascular Complications, and Other Age-Related Diseases. Physiol Rev. 2020;100(1):407-61.
8. Schram MT, Sep SJ, van der Kallen CJ, Dagnelie PC, Koster A, Schaper N, Henry RM, Stehouwer CD. The Maastricht Study: an extensive phenotyping study on determinants of type 2 diabetes, its complications and its comorbidities. Eur J Epidemiol. 2014;29(6):439-51.