

Non-targeted screening for the identification of potentially toxic chemicals present in food packaging and their detection in biological samples

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Background

The exposome is defined by Gary W. Miller as the cumulative measure of environmental influences and associated biological responses throughout the lifespan, including exposures from the environment, diet, behaviour, and endogenous processes [1]. The Toxic Substances Control Act (TSCA) and EC HA lists more than 86,000 and 23,376 chemicals, respectively [2] [3]. Some of these substances, in particular plasticizers as phthalates and bisphenols, are used in the production of food packaging material.

In addition to intentionally used chemicals, food packaging can contain non-intentionally added substances (NIAS) as a result of the interactions between different ingredients in the packaging materials, from degradation processes and mainly from the impurities present in the raw materials used for their production. All these chemicals can be transferred from food contact materials and articles into food and, consequently, are taken up by humans [4].

All migrating substances have inherent toxicity properties that can cause different effects at different doses and are related to the length of exposure, mode of action, and other aspects [4]; however, it is not always possible to predict or test a compound's toxicity due to the lack of reference materials and the high costs and low sensitivity of in-vitro bioassays.

For migrated compounds without hazard data, generic concentration thresholds are commonly used in their risk assessment. In Europe, unauthorized chemicals may be used in food contact plastics if their migration into food is below the detection limit of 10 ppb (10 µg/kg food), and if they are not genotoxic, mutagenic, and toxic to reproduction [5].

Considering that it is not possible to predict which types of pollutants may migrate from food contact materials into food and that could become a source of exposure to humans, to identify the greatest possible number of possible pollutants, the use of high sensitive advanced analytical techniques and non-targeted screening approaches is required. Therefore, high resolution accurate mass spectrometry (HRMS) has become a very powerful technology for food packaging material applications [6] [7].

Aim

The purpose of this study is to investigate the presence and source of substances potentially dangerous for human health in food contact materials and verify if these substances can be found in urine from human samples.

Bibliography

1. Gary W. Miller, Dean P. Jones, The Nature of Nurture: Refining the Definition of the Exposome, Toxicological Sciences, Volume 137, Issue 1, (2014).
2. <https://www.epa.gov/tsca-inventory/about-tsca-chemical-substance-inventory#whatistheinventory>
3. <https://echa.europa.eu/it/information-on-chemicals/registered-substances>
4. Muncke, J., Andersson, AM., Backhaus, T. et al. Impacts of food contact chemicals on human health: a consensus statement. Environ Health 19, 25 (2020).
5. Commission Regulation (EU) No 10/2011 of 14 January 2011 on plastic materials and articles intended to come into contact with food, (2011).
6. Nerin C, Alfaro P, Aznar M, Domeño C. The challenge of identifying non-intentionally added substances from food packaging materials: a review. Anal Chim Acta. (2013).
7. Martínez-Bueno, M. J., Gómez Ramos, M. J., Bauer, A., & Fernández-Alba, A. R. An overview of non-targeted screening strategies based on high resolution accurate mass spectrometry for the identification of migrants coming from plastic food packaging materials. TrAC Trends in Analytical Chemistry, 110, 191–203 (2019).
8. Mengozzi A, Carli F, Biancalana E, Della Latta V, Seghieri M, Gastaldelli A, Solini A. Phthalates Exposure as Determinant of Albuminuria in Subjects With Type 2 Diabetes: A Cross-Sectional Study. J Clin Endocrinol Metab. (2019).
9. La Rocca C, Maranghi F, Tait S, Tassinari R, Baldi F, Bottaro G, Buzzigoli E, Carli F, Cianfarani S, Conte R, Deodati A, Gastaldelli A, Pala AP, Raffaelli A, Saponaro C, Scirè G, Spadoni GL, Busani L; LIFE PERSUADED Project Group. The LIFE PERSUADED project approach on phthalates and bisphenol A biomonitoring in Italian mother-child pairs linking exposure and juvenile diseases. Environ Sci Pollut Res Int. (2018).

Material and Methods

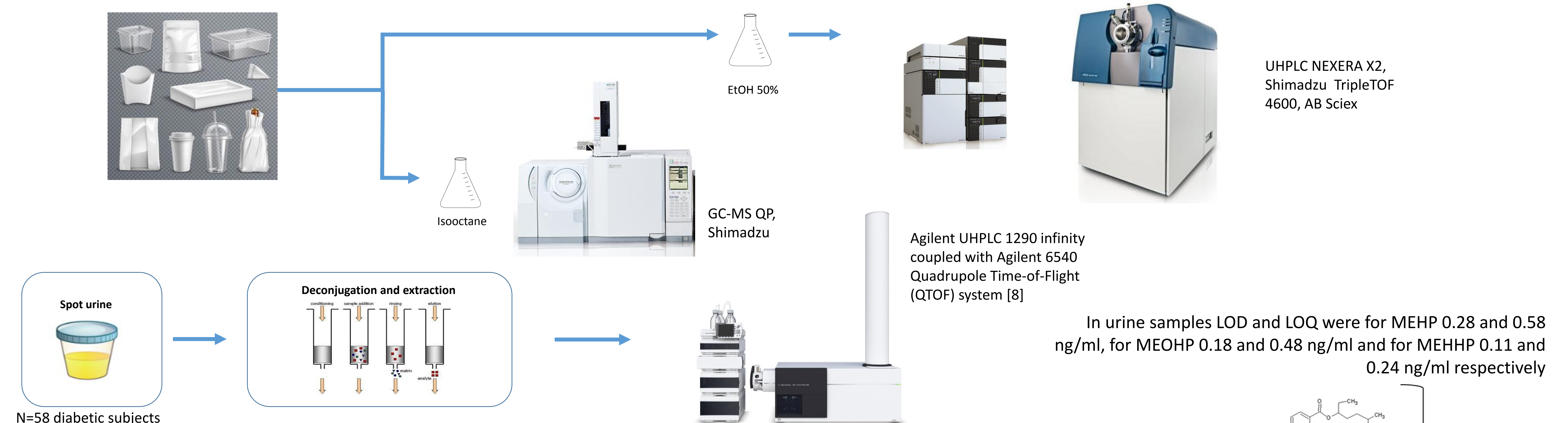
Virgin Paper and Recycled Paper and Board were tested for the presence of phthalates and bisphenols. Other matrices like plastic, wood, rubber, and aluminium + epoxy coated were tested.

For non-volatile and polar compounds, liquid chromatography acquisition of all food contact samples was made with UHPLC-TOF-MS (ultra-high-performance liquid chromatography time-of-flight mass spectrometry), using reversed-phase chromatography and electrospray ionization in positive and negative. Data evaluation was performed by the software Analyst from AB Sciex. For the analysis of volatile and semi-volatile compounds, gas chromatography acquisition of all food contact samples was made with GC-MS from Shimadzu.

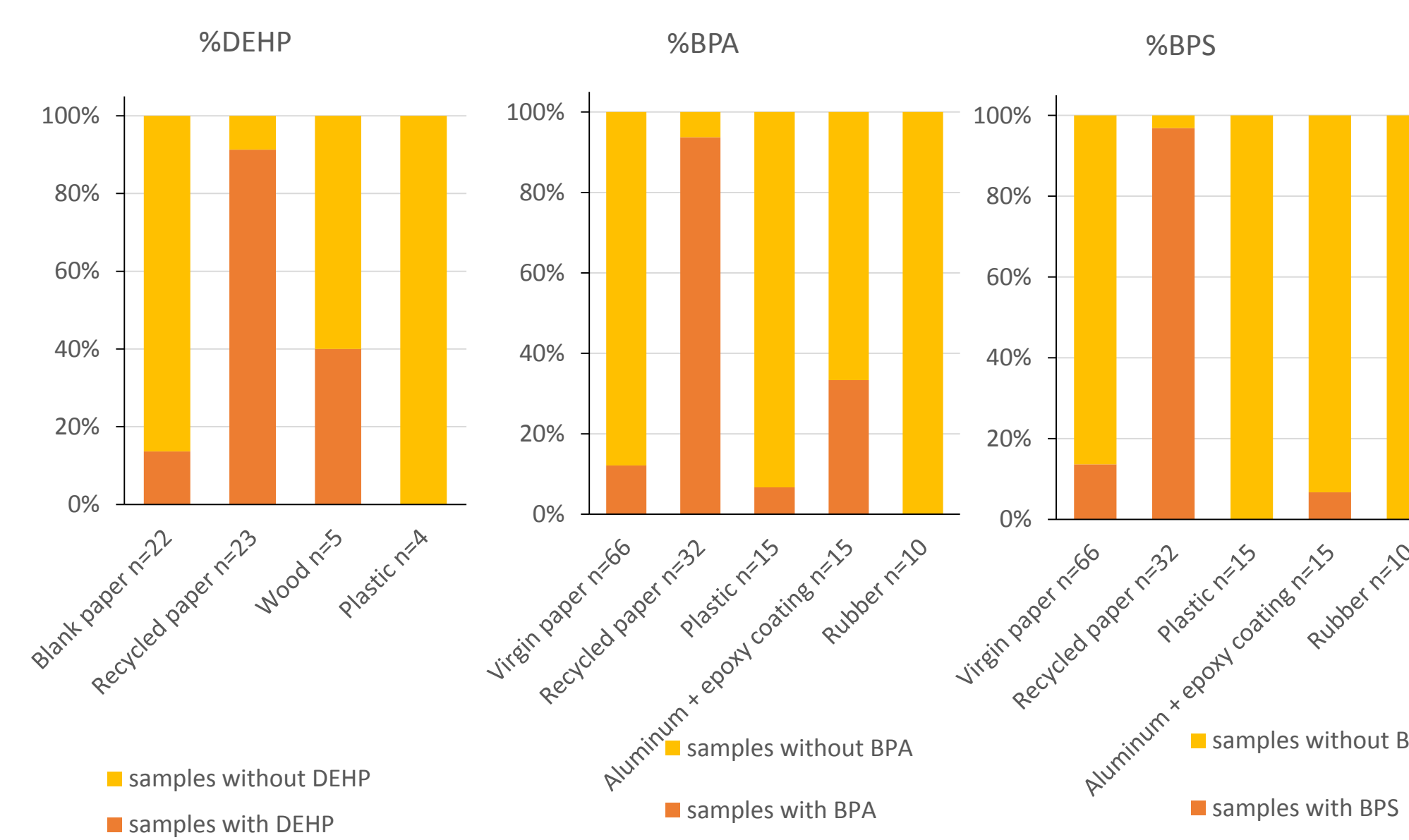
The migrant solution was obtained using ethanol 50% for liquid chromatography and with isooctane for gas chromatography acquisition.

For all biological samples, 500 µL of urine samples were treated with enzymatic deconjugation to hydrolyse the glucuronide form, then the samples were purified with C18 SPE and analysed with Agilent UHPLC-TOF-MS. Data evaluation was performed by the software Profinder from Agilent.

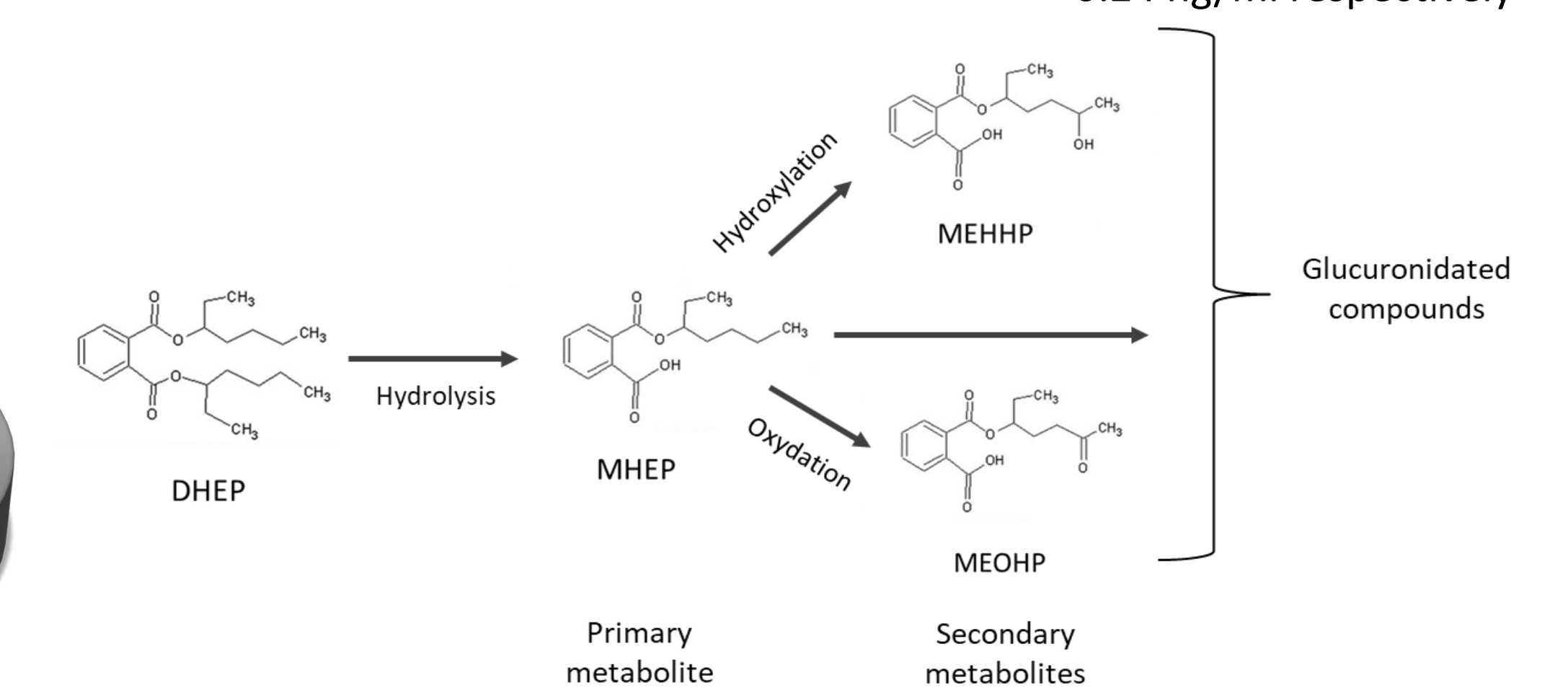
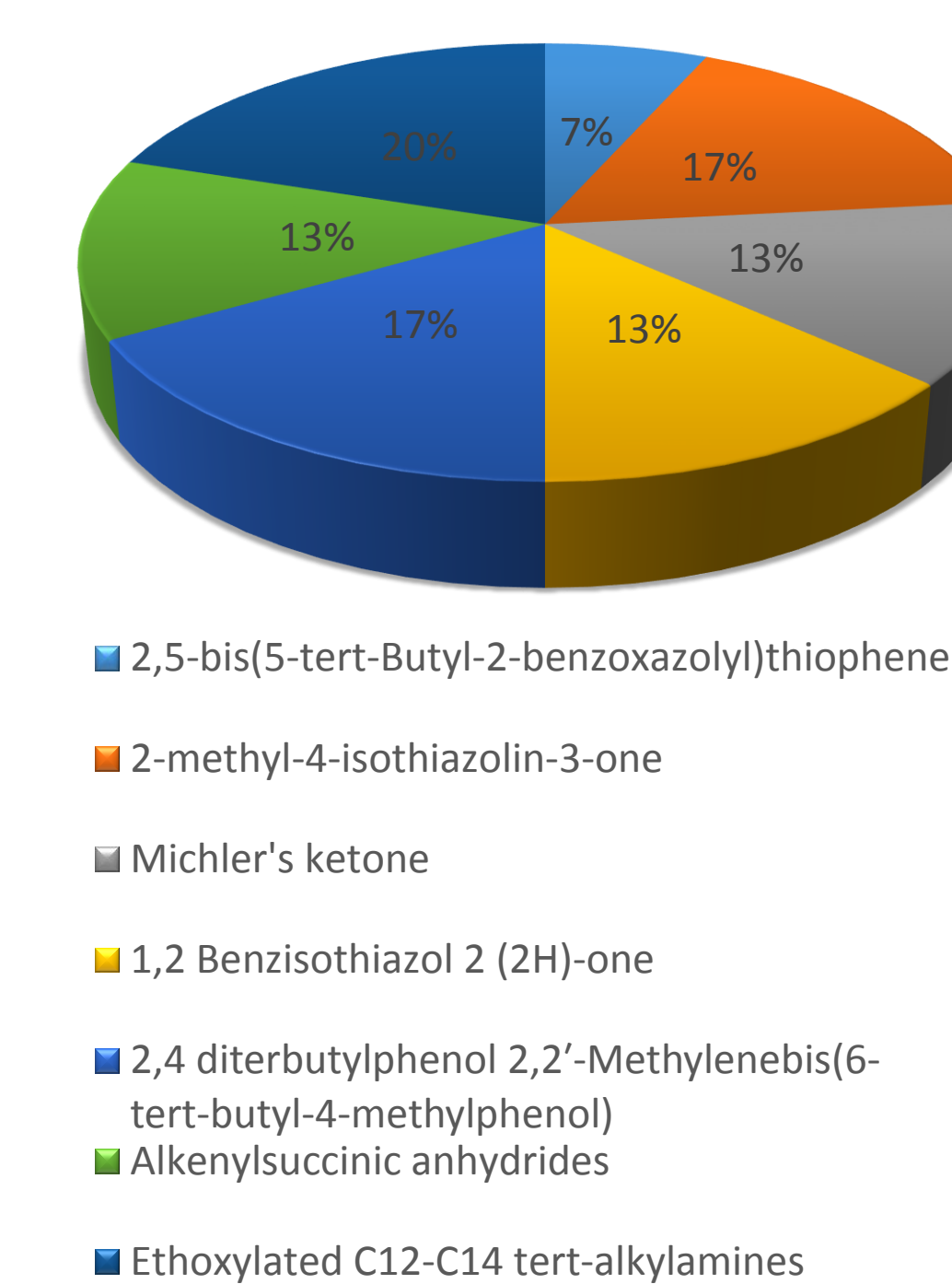
Urine samples from 58 diabetic subjects were analyzed to check the presence of some substances identified in food contact materials.



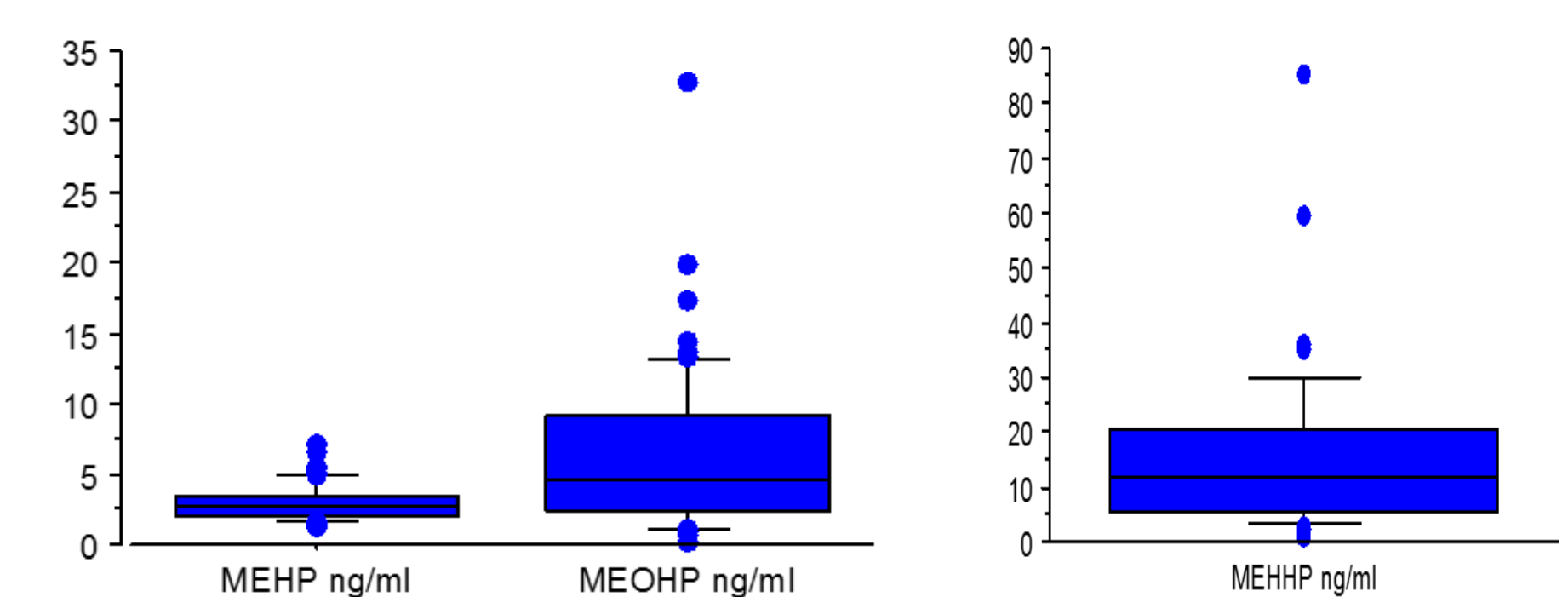
Results



Other Nias in Recycled Paper



DEHP metabolites were detectable in all urine samples. MEHHP showed the highest concentration in urine samples [9].



Conclusions

The materials used for food packaging contain many substances that can migrate into food becoming potential health hazards. Some of these compounds, such as bisphenol A and phthalates, are recognized endocrine disruptors; for other compounds, toxicological information is lacking and they are often not well monitored. Furthermore, considering the complexity and variety of materials used in food packaging, it is not easy to predict the presence of these types of compounds and therefore it is important through untargeted screening techniques to try to identify such compounds in the packaging before they enter the human diet.