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Modern analytical methods for the analysis of synthetic dyes in food

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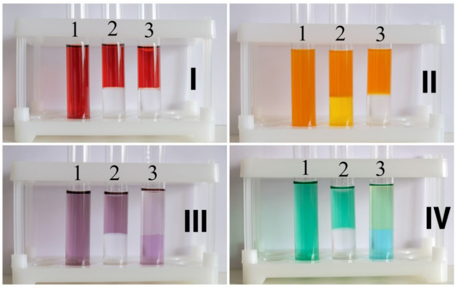
Abstract

Currently, synthetic dyes are widely used in the food industry to give foodstuffs an attractive appearance and compensate for the loss of natural colours in food that are destroyed during processing and storage. The use of these additives is rigorously regulated worldwide. Some synthetic dyes are prohibited from use; for others, the maximum permitted levels in food have been established. However, there are no universal approaches to assessing the safety of synthetic dyes. As a result, some dyes are permitted for use in one country but banned in another For instance, Codex Alimentarius (CA) permits 13 synthetic dyes (FAOSTAT, 1995). The European Union (EU) allows 14 dyes (Directive, 1994; EU, 2007), and the USA permits 9 dyes ("Electronic Code of Federal Regulations e-CFR"; Lehto et al., 2017). In accordance with Sanitary and Hygienic requirements in the Republic of Belarus (RB) and in the countries of the Eurasian Economic Union (EAEU), 13 synthetic dyes are allowed for use in the production of foodstuffs (TR CU 029, 2012). Their amount should not exceed 50–500 mg kg-1, depending on the nature of the dye and the type of food. It is strictly forbidden to use synthetic dyes in the production of baby food, wines, and juices. However, there are cases of noncompliance with norms and requirements, as well as the use of dyes to adulterate food for colouring, which are not included in the listed ingredients or technology. In addition, the differences in the rules regulating the use of dyes from country to country make the monitoring of their presence and amount in food an important and urgent task.

Two methods for the determination of synthetic dyes in food were developed and validated. The visual qualitative expression method was applicable for testing food that must not contain synthetic dyes (wines, juices, etc.) in a very short time (5-10 min). The visual qualitative expression method was based on the extraction of synthetic dyes using a liquid anion exchanger (0.01 M solution of trioctylmethylammonium chloride (TOMAC) in chloroform). Using this reagent, an optimal transition of 15 anionic synthetic dyes from the aqueous to the organic phase was achieved ($R > 99.8\%$) (Pliashak et al., 2020; Pliashak et al., 2020b). As examples, the results of quality determination of synthetic dyes in red wine (I), a beverage containing orange juice and natural dye carotenoids, according to the information on the package (II), a violet-flavoured cocktail syrup (III), and a mint-flavoured cocktail syrup (IV) are shown in Fig. 1. Test tube 1 - original sample of liquid food, test tube 2 - preliminary extraction of natural dyes from the sample by chloroform (phase ratio 1:1 v/v), test tube 3 - extraction of synthetic dyes from the obtained sample (upper layer in tube 2) by $1\cdot10^{-2}$ M solution of TOMAC in chloroform (phase ratio 1:1 v/v). Colouration of the lower layer in test tube 2 indicates the presence of natural dyes in the analysed sample (Fig. 1 (I)). Colouration of the lower layer in test tube 3 (Fig. 1 (III, IV)) indicates the presence of synthetic dye in the analysed sample. If the lower layer in test tube 3 did not stain, it indicates the absence of synthetic dye (Fig. 1 (I, II)) In the case of colouration of the lower chloroform layer in test tube 3, identification and quantification of synthetic dye in the indicated sample should be performed using the HPLC-DAD. The violet-flavoured cocktail syrup (Fig. 1 (III)) contained synthetic dye E 129 (12.5 mg kg− 1) and E 133 (3.5 mg kg− 1), and the mint-flavoured cocktail syrup (Fig. 1 (IV)) contained synthetic dye E 133 (4.5 mg kg− 1).



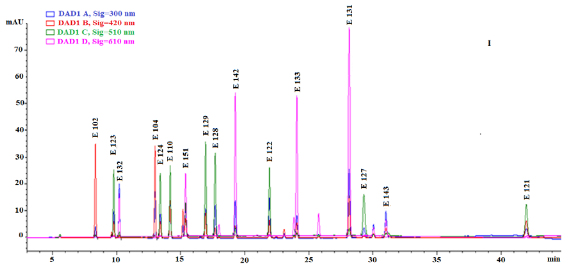


Fig. 1. Quality determination of synthetic dyes in a red wine (I), a beverage containing orange juice and natural dye carotenoids, according to the information on the package (II), a violet-flavoured cocktail syrup (III), and a mint-flavoured cocktail syrup (IV).

Fig. 2. Chromatogram of a mixture of 16 synthetic dyes at a concentration of 5μg mL− 1

Developed HPLC-DAD method allows the simultaneous determination of 16 synthetic dyes from all types of food (Palianskikh et al., 2019; Palianskikh et al., 2022). Chromatogram of a mixture of 16 synthetic dyes at a concentration of 5 μg mL− 1 (I) are in Fig. 2

These methods makes it possible to promptly identify hazardous and adulterated synthetically dyed food and thereby reduce the risk of the adverse effects of synthetic dyes on human health.

Importance of Research: Two methods were developed for the determination of synthetic dyes in food. A rapid, simple quantitative HPLC-DAD method for the simultaneous determination of 16 synthetic dyes in different types of food (milk, meat and fsh products, confections, wines, juices, beverages, etc.) is based on the extraction of synthetic dyes from food with an aqueousmethanol solution of ammonia followed by purifcation. The absence of the need to use expensive reagents and additional cleaning of the sample on solid-phase extraction cartridges makes this method relatively cheap and fast. The lower limit of the range of determined concentrations for each synthetic dye varies from 1 to 5 mg kg− 1 depending on the type of food, and is 10 or more times lower than the maximum level established by the EU and EAEU regulations. The qualitative expression method is based on the extraction of synthetic dyes by a liquid anion exchanger (solution of trioctylmethylammonium chloride in chloroform). Using this reagent, at pH 4–8, an optimal transition of 15 anionic synthetic dyes from the aqueous to the organic phase is achieved. It is applicable for testing foods prohibited from containing synthetic dyes (wines, juices, etc.) and other liquid food in a very short time by an operator who does not have a special chemical education and in the absence of expensive equipment (HPLC). In the case of colouring of the organic phase, identifcation and quantifcation should be carried out using the developed HPLC-DAD method.

Biography

Alena Palianskikh has completed her PhD (chemistry) from Belarusian State University. She is a Leading Researcher at the Laboratory of Food Chemistry, Republican Unitary Enterprise "Scientific Practical Centre of Hygiene". The sphere of her interests is analytical chemistry, extraction of organic compounds, chromatographic methods of analysis. He has published more than 90 papers in reputed journals.

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