THE ANNALS OF "DUNĂREA DE JOS" UNIVERSITY OF GALAȚI
FASCICLE XIV MECHANICAL ENGINEERING, ISSN 1224-5615
2019

THE NEED FOR FOOD ADDITIVES AND THEIR TOXICITY

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ABSTRACT

The paper presents an ecotoxicological study upon some food additives used worldwide. A brief assessment of the use of food additives, the advantages and disadvantages of their introduction into technological processes and their biological effects has been carried out. Chemical analyzes were realized in some food sauces for representatives of the group of food dyes and the group of antioxidants, namely tartrazine and the sodium salt of ethylene diamino-tetra acetic acid (EDTA). The results showed the presence of the two additives in the studied products from the Romanian market, whether declared or not. Finally, the results obtained were discussed both from the perspective of the need and the toxicity of the studied food additives.

KEYWORDS: food additives, tartrazine, EDTA, toxicity of additives, need of additives

1. Introduction

Ecotoxicology is the science that studies the effects that toxic substances have on organisms. Ecotoxicology is the frontier science between ecology and toxicology and studies the effect of toxic substances on ecological systems. Toxicology generally deals with the analysis of the negative effects of chemicals that have reached the living organism, with the clarification of the cause-effect laws and with the avoidance of the negative effects of harmful processes [19]. Human toxicology analyzes the effects on the human body, while environmental toxicology focuses on plants, animals and ecological systems [11]. According to the new points of view, man can be seen as an element of ecological systems and not isolated from them, because there are organic relationships between man and his living environment [5]. In this paper, the need and the toxicity of food additives is discussed and an ecotoxicological study is performed on some food chemicals.

The continuous progress of human society has led to an ubiquitous presence of technology in all areas. Today, food products are also obtained with the help of modern technologies and processes, and the growing demand that is being recorded leads to an overproduction and a varied offer from food producers. Thus, everything possible is done for food to be successful, to be preserved for as long as possible, to be as attractive as possible, or to be as rich in vitamins as possible, even if they are obtained artificially [7]. The use of additives enables the range of products to be constantly diversified and new products to be created within the food industry.

This is one of the main causes of the continued growth and development of the food industry in recent years. In parallel with this diversification, there are growing debates on food safety in general and the use of additives in particular [3].

According to the procedural manual of the Codex Alimentarius Commission, the food additive means 'any substance, even of a microbiological nature, not consumed as a food, which is not normally used as a typical ingredient of the food, whether or not it has nutritional value, the addition to the food is linked to a technological purpose in the manufacture, packaging or storage of foodstuffs, with a certain or expected convenient effect on their properties' [12]. The term does not include contaminants or substances added to food to maintain or to improve nutritional qualities.

As regards the classification of additives, there is no consensus so far, but most classifications are based on the effects of additives. Additives may be classified into 5 categories [13] as set out in Table 1.

***Tabel 1**. Classification of food additives [5]*

Category I	Preservatives	antimicrobials, antifungals, salting agents, anti-aging agents, enzymes
Category II	Texture and consistensy modifiers	emulsifiers, stabilizers and thickeners; gelling agents; dispersing agents; raising agents; antifoaming agents; enzymes.
Category III	Sonsorial character modifiers	dyes; substances that influence taste, smell or appearance (salting substances, natural sweeteners, acidulants, flavor enhancers, bleaching agents, color-fixing agents, enzymes)
Category IV	Substances for the improvement of the nutritional value	vitamins and provitamins; amino acids and peptides; mineral salts; trace elements.
Category V	Technological agents	clarifiers; coagulants and anticoagulants; humectants; water retaining, softening, plasticizing, agglomerating, acidifying and neutralizing substances; fluidizing substances; homogenizers; enzymes; bleachers; solvents

The following aspects must be taken into account in the use of additives in the food industry [13,14]:

- the replacement and absence of danger following possible accumulation of doses or effects over time, conditions to be experimentally demonstrated on at least two animal species;
- their use is accepted as necessary and justified on scientific and/or technical considerations. FAO/OMS recommends in this direction the predominant use of natural substances instead of synthetic substances;
- the amount added to the food is as low as possible but sufficient to obtain the effect for which the food additive is indicated;
- the introduction of a substance from the group of food additives does not result in the substitution of any normal constituents of the foodstuff;
- the purity of the food additive, by testing its physico-chemical qualities, is regulated by law;
- the introduction of food additives must be preceded by the establishment of sensitive, simple methods of qualitative identification and quantitative dosage;
- the addition of additives to foodstuffs must be clearly indicated on the packaging in accordance with the legal provisions.

The use of additives must be based on a firm principle, i.e. however economically their use may be, they must be used in industrial practice only on condition that they are not harmful to the health of consumers.

The non-harmfulness (the innocuity) of the additives means not only the lack of toxicity and carcinogenic potential of the additive, but also the lack of delayed, mutagenic, teratogenic, embryotoxic consequences and other consequences which may affect future generations.

Food additives play an important role in the modern food industry by improving organoleptic properties: color, smell and taste of food and also the processing and preservation conditions [8,22].

While the use of additives during food processing has become natural worldwide, consumer concerns about their potential risks have increased greatly [4,6].

In recent years, with the continuous improvement in consumer quality of life and information opportunities, demand for natural food without additives has increased. Therefore, a number of synthetic food additives have been included in the list of possible food safety hazards and many consumers consider their use to be unnecessary or unjustified [24,25,28].

Some additives have been used since the earliest times, lithe preserving food with vinegar, salting meat and meat derivatives, fruits preservation with sugar or the use of sulfur dioxide for combating diseases of the wine. With the appearance of processed foods, in the second half of the last century, many more additives were introduced, either of natural origin or synthetic origin.

Studies show that only 20 food additives, out of the approximately 315 existing, are safe, E 160, E 162, E 300, E 100 being only a few of the food additives considered safe or harmless [26]. These are natural substances extracted from fruit or vegetables and found in foods in the form of vitamins, colorants, lecithin [26].

The preservation of foodstuffs by refrigeration and freezing does not confer an excessive period of validity, therefore researchers have always sought new long-term preservation methods and chemical preservatives for food have become the ideal solution [27] until it has been found that their cumulative effect can be dangerous to human health [17].

Artificial colors and synthetic sweeteners are also added to commercial products to make them more attractive, tasty, although some additions are beneficial for health and others are dangerous [2].

2. The purpose and objectives of the work

In this work a study was carried out on some food sauces, namely mustard and mayonnaise, marketed by two different producers. For the two types of sauces, the presence of the following food additives was analyzed: Tartrazine (E102) in a mustard produced and marketed in Romania and the preservative EDTA (Complexon III) in both the mustard and an internationally branded mayonise. The motivation for choosing these food additives for study is due both to the degree of spread they know and to the multiple harmful effects described below.

According to Mencinicopschi [21], E 102 (tartrazine) is a synthetic chemical product of the azo dyes class. This yellow dye is found in sweets (puddings, ice cream, drops), drinks, mustard, instant soups, jams, cereals, snacks. It has carcinogenic action (thyroid tumors), can cause chromosomal mutations, causes deficiencies in vitamin B6 and zinc, causes asthma attacks, hives and hyperactivity in children [20]. It is prohibited in Norway, Austria, Sweden, Switzerland, Great Britain and the Netherlands [21]. In Romania, the authorities are requested to prohibit the use of this compound, at least for products frequently consumed by children, as high doses of tartrazine have been found to result in irreversible histological changes of the liver [22]. Since this compound is frequently used in soft drinks during the summer, the problems caused by tartrazine can become extremely serious. The maximum permitted intake levels are 0 – 7,5 mg/kg body weight and in foodstuffs 70 mg/kg body weight [1]. In other words, if a manufacturer introduces into soft drinks the maximum amount of dye, about 70 mg / kg (liter equivalent), then a 30 kg person who drinks two liters of juice will ingest 140 mg of dye, while the maximum allowed dose for a 30 kg person it is of 22.5 mg [21].

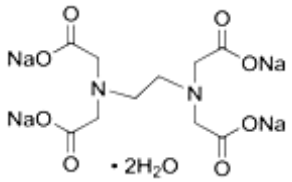
EDTA (ethylenediaminetetraacetic acid), also called Complexon III, is a food additive with antioxidant, emulsifier, listener and preservative function [23]. It is found in alcoholic and non-alcoholic beverages, in products of vegetables, fruit, fish, meat, eggs, emulsified and non-emulsified fats, in preserved products by fermentation, freezing or drying, in sauces, spices, drink concentrates prepared by automatic dosing devices, jams, jellies, creams, glazings and fillings for pastry products, dried fruit, cereal-based desserts or starch, etc. [9]. It is not permitted in foods intended for infants and young children. EDTA is not metabolized and is excreted via urine. Has a wide variety of industrial uses, due to its property of forming fixed compounds with metallic ions, such as calcium, magnesium, manganese, copper, lead, iron, mercury, etc. The same action is also carried out at the level of the human organism, being used in medicine for the treatment of hypercalemia, mercury or lead poisoning, of the thalassemia (excess iron). The acceptable daily intake for human consumption is up to 2,5 mg/kg body weight, which can be easily exceeded by cumulative consumption, especially by children. The intake dose in food shall be of 800 mg/kg. For healthy people EDTA is a toxic cell-level agent that can splolate the organism by important elements such as calcium, magnesium and iron, and also has an anticoagulant effect [23]. On the other hand, the use of EDTA in food is so widespread that its presence in blood samples even raised questions as to its source, i.e. whether it originated from food or from blood samples taken previously (since EDTA is also used as blood anticoagulant when performing laboratory analyzes) [18].

It should be noted, however, that microbial hazards and the oxidation of food have gained substantial economic, ethical and legal importance in the food industry. The administration of a variety of food additives together with strict preservation processes are applied to suppress the development of pathogenic micro-organisms and oxidation reactions and to prolong the shelf-life of the food. Thus, the need for food additives is a certainty, but the current task of food producers is to strike the balance between the use of synthetic chemical preservatives and the adoption of natural alternatives [10].

3. Materials and working methods

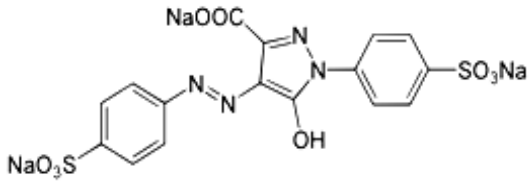
The food additives whose presence has been studied in food products on the Romanian market, are: the yellow dye tartrazine (from mustard) and the antioxidant EDTA (from mayonnaise and mustard). The chemical and structural formulae of the two food additives are shown in fig. 1 and fig. 2.

The selection of the foodstuffs to be analyzed was made after prior study of the labels indicating the presence of the two food additives: The presence of the tartrazine in mustard, and the presence of EDTA in mayonnaise (fig. 3). The daily intake rates for the two food additives are shown in Table 2.



$[CH_2N(CH_2CO_2Na)\text{-}CH_2CO_2H]_2$

Fig. 1 Chemical and structural formula of EDTA (Sodium Salt of Ethylenediaminetetraacetic Acid)



$C_{16}H_9N_4Na_3O_9S_2$

Fig. 2 Chemical and structural formula of Tartrazine (E 102 or FD&C Yellow 5)

Fig. 3 Labels of the food products taken into study

Table 2. Daily intake for the studied food additives

Studied food additive	Acceptable daily dose
EDTA	2.5 mg/kg body weight
Tartrazine	7.5 mg/kg body weight

Tartrazine was determined qualitatively by the method described in [14] using two solutions of sulfuric acid: a concentrated solution and a dilute solution. According to the method, 2-3 drops of H_2SO_4 from the two concentrations are added on two distinct mustard samples and depending on the resulting staining, the presence of tartrazine is confirmed or denied.

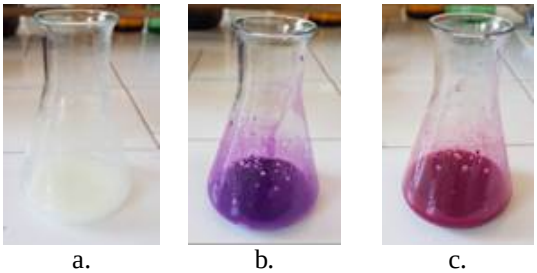
To perform the EDTA determination analysis, the mayonnaise was diluted 1:5 in four distinct solvents, namely: distilled water (fig. 4a), ethyl ether (fig. 4b), acetone (fig. 4c) and ethyl alcohol (fig. 4d). The analyzes were performed for all types of solvents, because the fat content is high, and in order not to remain a non-extracted chelating agent with distilled water, the EDTA content was determined as the arithmetic mean of the values obtained for each extraction.

a. b. c. d.

Fig. 4 Mayonnaise extracts

Fig. 5 Mustard extract

The presence of the food additive EDTA has also been analyzed in the mustard sample. Due to complete extraction, dilution was only carried out with distiled water in this case (fig 5). In the case of both alimentary products the working methodology was the same.



a. b. c.

Fig. 6 Steps for determining the EDTA content

The sequestering compound EDTA was determined quantitatively by the complexono-metric volumetric method, in the presence of NaOH (fig. 6a), with murexid as indicator (fig. 6b), and titration with CaCl2, obtaining the color change from purple to pink (fig. 6c).

4. Results and discussions

After carrying out the qualitative analysis, it has been observed that tartrazine is present in the mustard sample. Figure 7a shows the mustard samples before analysis and fig. 7b, the mustard samples analyzed with H_2SO_4: the orange-reddish color of the solution resulting by the sample treated with concentrated H_2SO_4, and the light-yellow color of the solution resulting to the sample treated by diluted H_2SO_4, according to the method [14].

Tartrazine is a food additive allowed in Romania and used for the last decades. Consumption of this dye should be done in moderate amounts so as not to produce the negative effects presented above. Mustard is a food product that cannot be consumed in large quantities at a meal and even more so, it is not a product that is consumed daily. At the same time, according to the manufacturer's instructions, this product has, due to the mustard seed content, an intake of vitamins and minerals such as A, C, K, E, B1, B2 and B3, manganese, calcium, potassium, magnesium, iron, potassium [15]. However, many local producers have aligned themselves with the indications of international norms, and most of the time synthetic food additives with coloring effect used in recent years, have been replaced with dyes of natural origin: i.e. beta-carotene, betanin, chlorophyll.

Mayonnaise has a content of EDTA of 15,3 mg/100 g of mayonnaise, from which a total content of 64,26 mg EDTA can be deducted in the 420 g of the product (which represents 15% EDTA in the product).

a. b.

Fig. 7 Qualitative determination of tartrazine in mustard

As regards the EDTA content of mustard, the analysis determined it to be of 8,87 mg/100 g of mustard and 24,84 mg of the total contents of the container of the product respectively 280 g (which represents 8.87% EDTA in the product).

If the maximum acceptable daily intake for this food additive is of 2,5 mg EDTA/kg body weight (as shown in Table 2), for an adult with a body weight of 60 kg, the maximum dose would be of 150 mg EDTA/day.

This calculation assumes that the person in the taken example can consume approximately 1000 g of mayonnaise/day without exceeding the allowable limit dose, i.e. at least two tubes of the product. Similarly, for the taken example of body weight, approximately 1700 g mustard/day can be consumed, which represents 6 jars of the weight taken in the study without exceeding the permissible limit dose.

According to this calculation, it is impossible to exceed the maximum allowable proportion of EDTA per day by consuming these products, which, moreover, cannot be consumed in large quantities, or on a daily basis. The diagram in Figure 8 shows the EDTA content, in mg, of the mayonnaise tube and the mustard jar studied, in relation to the maximum daily dose allowed.

However, it should be noted that, although the consumption of a single product cannot exceed the maximum permitted dose, the cumulative effect per day of all processed and industrialized products containing food additives such as preservatives, dyes, thickeners, antioxidants, etc., and an unbalanced diet can cause unwanted biological effects, both in the short and long term.

On the other hand, the use of EDTA as a food additive with an antioxidant or preservative role also reveals a number of advantages [13], such as:

- prolonging the storage period and preventing rancidity;
- maintaining the aroma and color of the products;
- inhibition of the self-oxidation of essential oils;
- removal of metallic catalysts from hydrogenated fats and oils;
- improving the oxidation stability of fats and oils.

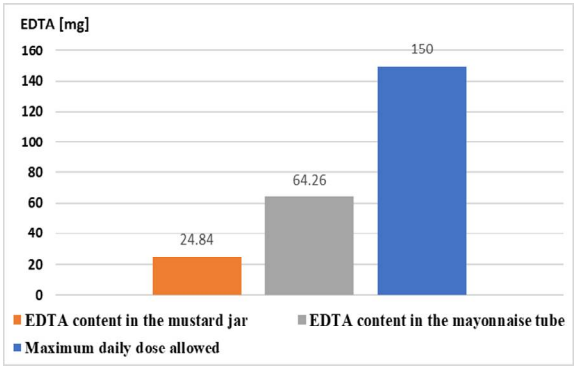


Fig. 8 EDTA content (mg) of the products under study, in relation to the maximum permissible daily dose, for a person of 60 kg

Also, due to its antioxidant properties, EDTA has many uses in other industries, such as the pharmaceutical industry and the cosmetics industry [18].

5. Conclusions

1. In this paper, the presence of some food additives in certain sauces sold in Romania, such as mayonnaise and mustard was studied. The presence of the dye tartrazine (E102) and of the antioxidant agent EDTA were determined qualitatively or quantitatively.
2. The study draws a parallel between the harmful effect of food additives due to high consumption, such as information on their toxicity, the biological effects they produce, on the one hand, and the qualities of some food additives and the need to use them in the contemporary food industry, on the other hand, as they can prolong the shelf life, maintain the aroma and color of the products or help remove metal catalysts.
3. The results of the laboratory analyzes confirmed the presence of EDTA and tartrazine in the studied products. In the case of EDTA preservative, the resulting concentration is within the maximum allowed limit, and the calculations showed that the daily dose is impossible to be exceeded even by an overconsumption of 1000 g mayonnaise/day, respectively 1700 g mustard/day, in the case of an adult. However, the cumulative effect of all processed and industrialized products containing food additives, as well as an unbalanced diet, can cause undesirable effects on health.
4. Alternatively, synthetic additives should be replaced in the food industry with biopreservatives that can contribute to microbial safety and antioxidant activity and that can bring other organoleptic, technological, nutritional and health benefits. These agents can provide additional advantages over the preservatives and the cultures currently used in food manufacturing and can create the possibility to improve and optimize food production processes, which will lead to safer and healthier products [10].

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