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ON THE INCLUSION OF SODIUM BENZOATE (E 211) AS ANTISEPTIC FOOD ADDITIVE IN SOFT DRINKS AND FISH PRODUCTS

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Abstract

Six products belonging in two food categories (carbonated soft drinks and fish products) have been investigated in laboratory via spectrophotocolorimetry to identify and quantify the usage of sodium benzoate as food additive with antiseptic-preservative purpose. The inclusion level of E-211 in the first group (carbonated soda) was 55-49% less than the maximum admitted inclusion level (AIL) (20 mg additive/100 g product, while the calculated daily intake through drinking a portion (500 ml) reached 32.7-34% out of the maximal admitted daily intake (MADI) for children and 11.25-17% of the MADI for adults. The concentration detected in the marinated fish was 25.1-35.1% lower than the AIL for this food category (200 mg/100 g). Calculus of the daily intake for a serving portion of marinated fish (env. 75 g) reached 64.9-74.6% of the MADI for children and 24.34-37.30% for adult consumers. Although the inclusion rates were below the maximal admitted limits, if we cumulate the potential intake of the sodium benzoate from these two food sources with other food preferred by children (sweet treats), the daily intake dose for this additive present becomes alarming and could endanger the health of young age consumers.

Key words*: daily intake, inclusion level, marinated fish, soda, sodium benzoate.*

INTRODUCTION

The most numerous group among additives that slow down food spoilage is represented by the antiseptic ones, commonly known as preservatives. These are either natural or synthetic chemical compounds added to food to restrict as much as possible the biological processes that take place in the product, e.g. the development of microflora and pathogenic microbes, and the effects of enzymes that affect food freshness and quality (Banu, 2010). In food products, preservatives change the permeability of cytoplasmic membranes or cell walls, damage the genetic system, and deactivate some enzymes (Pundir et al., 2011). Food is preserved using antiseptics or antibiotics (Luck & Jager, 1995). The former ones are synthetically produced simple compounds that often have natural correlates, and they make up no more than 0.2% of the product. Antibiotics, or substances produced by microorganisms, were also used in very small, yet effective, doses but they were eventually cancelled, due to antibioresistance installation in both foodborne pathogens and in consumers (Cebrián et al., 2026; Liao et al., 2020; Wales et al., 2015). The effectiveness of preservatives depends primarily on their effect on a specific type of microorganism, which is why it is vital to select the appropriate preservative based on the microbes found in the product (bacteria, mold, or yeast) (Ricke et al., 2005). Other factors that determine the effectiveness of preservatives include the pH value (a low pH is desirable), temperature, the addition of other substances, and the chemical composition of the product. Preservatives constitute an alternative to physical and biological product freshness stabilization methods, such as drying, pickling, sterilizing, freezing, cooling, and thickening. Consumer objections concerning the widespread use of chemical preservatives and their effects on human health have motivated producers to develop new food preservation procedures. These include irradiation, packaging, and storing products in a modified atmosphere, using aseptic technology (Yousef et al., 2012), along with newer biotechnological methods, as the usage of beneficial bacteria (Gao et al., 2019) or bacteriophage viruses capable to selectively

destroy the foodborne pathogens only (Bai et al., 2016). Products that are most commonly preserved include ready-made dishes and sauces, meat and fish products, fizzy drinks, and ready-made deserts (Millstone et al., 2003; Monneuse et al., 1997).
Other substances used as preservatives are acids and acidity regulators. These substances lower the pH level and slow down the growth of enzymes and yeasts, which hampers the development of fermentations and unwanted microbiota species (Stratford et al., 2013). They are used mainly in the production of marinades. Specific mixtures of acetic acid, salt and sugar are used to preserve and equally provide flavor to pickled vegetables (Komitopoulou et al., 2011). However, for a specific acid or acidity regulator to fulfil its role as a preservative, it needs to be added in highly concentrated form, but acetic acid, for instance, can irritate mucous membranes when its concentration exceeds 3% (A.O.A.C., 1990). Acids and acidity regulators are also used to enhance flavor (usually in fruit or vegetable products, or beverages, to bring out their sour taste) or to facilitate gelatinization and frothing during food processing (Multon, 1992; Wibertmann, 2000).
A Report of European Food Safety Authority from 2015 (EFSA, 2015) says that the most commonly used preservatives and antioxidants are sorbic acid and its salts (E200-203), benzoic acid and its salts (E210-213), sulfur dioxide (E220), sodium nitrite (E250), lactic acid (E270), citric acid (E330) and tocopherols (E306).
Other studies (Ratusz et al., 2013) demonstrate that mayonnaises and mustards are the fourth most often preserved product group, with ready-made concentrates ranking seventh.
The food products investigated within this study belonged to two groups in whose composition the benzoic acid and its salts can be included. The additives in this group, coded by the E numbers E210-E213 in the Codex Alimentarius catalogue (FAO, 2011), are known for inducing some adverse effects in consumers' health. The oral and/or dermal exposure to benzoic acid (Clemmensen et al., 1982) and to sodium benzoate could produce rush, asthma, rhinitis (Kumari et al., 2019; Scheman et al., 2012) or even allergic reactions leading to sudden anaphylactic shock in certain highly sensitive consumers (Aerts et al., 2020; del Olmo et al., 2017).
Experimental data, issued from laboratory analysis on the investigated products, served to estimate the daily ingested intake for sodium benzoate, in relation with the food category, with the consumer type (age, gender, body weight). All the data was interpreted in relation with the on-force regulations on the usage of sodium benzoate as antiseptic (preservative) food additive (EFSA, 2016; FAO, 2011).

MATERIALS AND METHODS

There have been studied two groups of food, in whose composition the usage of sodium benzoate as antiseptic additive is allowed at certain legal levels: "Carbonated soda" (maximum inclusion level of 20 mg/100 g edible portion) and "Marinated fish" (maximum inclusion level 200 mg per 100 g edible portion). Out of the first category (sauses), three brands of soda, have been investigated (coded Carbo Soda A, Carbo Soda B, Carbo Soda C). Out of the second category, three commercial products of "Marinated fish" type have been investigated (coded Marinade A, Marinade B, Marinade C).
The analytical method was derived from the A.O.A.C. 960.38 and 980.17 methods [1, 2] and has as principle the Beer's laws.
Equipment: UV-VIS VWR UV-6300PC (double beam, reading wavelength spectrum: 190-1100 ± 0.3 nm); quartz cuvettes; laboratory glassware (flasks of 150 ml, 100 ml balloons, 0.5, 1 and 10 ml pipettes).
Reagents: sodium benzoate 0.2% solution; bi-distilled and ultra-purified water.
Calibration curves: 6 successive diluted solutions of sodium benzoate are prepared (1; 2; 3; 4; 5; 6 ml sodium benzoate 0.2% solution added in 100 ml bi-distilled and ultra-purified water). Out of each dilution, there were taken 5 ml and were added to the measuring cuvettes. The blank sample cuvette is filled with 5 ml bi-distilled and ultra-purified water only. The successively diluted solutions, as well as the blank sample, were read in spectrophotometer between 200-300 nm wavelengths. The values read at 225 nm (wavelength at which the sodium benzoate exerts absorbance of the

photonic beam) were subtracted from the value read for the blank sample, resulting the quantitative values corresponding to 0.1-0.6 mg sodium benzoate.

Working procedure: 20 g (mashed) or 20 ml for each food product have been sampled and introduced into a 100 ml balloon. There were added 80ml bi-distilled and ultra-purified water to reach the whole balloon capacity. The balloons were steered then quantitatively filtered in 150 ml flasks. From the filtrate, 5 ml have been taken and pipetted into the measuring cuvettes. Those were scanned at 200-300 nm wavelengths, observing the peak readings for 225 nm. The readings were expressed as deviations from blank sample reading. Hence every cuvette contains a dilution equivalent of 1 g or 1 ml sample, each point of 0.1 mg on the calibration curve represents 0.01% sodium benzoate. Ten reading replicates have been run for each analyzed product.

The acquired data have been statistically interpreted, computing the main statistical descriptors (mean, standard mean error and variation coefficient). The means have been compared with the maximum tolerated limits of sodium benzoate inclusion in food and relative differences were also calculated. Starting from the average obtained values, the ADI (average daily intake) of E-211 were calculated, in relation with the legal allowance and with the type of consumer (child - 30 kg body weight, adult woman - 60 kg body weight, adult man - 80 kg body weight). When ADI was calculated, the size of consumed portions was considered in accordance with every product specificity and consumption habits: 500 ml for carbonated soda, 75 g of marinate fish.

RESULTS AND DISCUSSIONS

The data on the occurrence and concentration of sodium benzoate in the analyzed soda carbonate are presented in Table 1. In the situation of CarboSoda A samples, the analytical values varied within the 6 - 12 mg sodium benzoate /100 ml, resulting a mean of 9 mg/100 l, which represented 45% of the maximal inclusion level (20 mg E-211/100 ml product). In the other analyzed products, there were identified levels of 8-12 mg/100 l CarboSoda B, resulting an average content of 9.8 mg sodium benzoate/100 l, respectively values of 8-12 mg/100 l CarboSoda C, with an average of 10.2 mg sodium benzoate /100 l.

Table 1. Average values of the sodium benzoate contents in the three food products in the "soft drinks" category

Product	Analytical values			MAIL*	%
	$\bar{X}$	$\pm s_{\bar{x}}$	CV%	(mg/100 ml)	of MAIL
CarboSoda A	9	0.45	15.71	20	45
CarboSoda B	9.8	0.53	17.07	20	49
CarboSoda C	10.2	0.28	8.77	20	51

* MAIL = maximal allowed inclusion level (mg/100 ml product)

In order to estimate the daily intake of sodium benzoate, the carbonated soda portion was considered of 500 ml. The results are presented in Table 2. It resulted that compared with the maximal allowed intake level (5 mg E-211/kg body weight), a child drinking such a carbonated soda portion will ingest a daily dose of 1.5 mg/kg BW - 1.7 mg/kg BW, which means 30-34% of the maximal allowed daily intake. If such a product would be eaten by adults, we estimated a daily intake of 0.75 mg/kg BW - 0.85 mg/BW in women, respectively of 0.563-0.638 mg/kg BW in men, resulting proportions of 15-17% of the maximal allowed daily intake in women and 11.25-12.75% in men (Table 2)

Table 2. Calculation of daily ingested dose sodium benzoate (E-211) through the three food products from the category carbonated soda

Daily ingested dose, related to consumer type	Product		
	CarboSoda A	CarboSoda B	CarboSoda C
MADI (mg E211/kg body weight)	5	5	5
Child, 30 kg body weight (mg E211/kg body weight)	1.500	1.633	1.700
% of MADI	30.0	32.7	34.0
Adult, woman, 60 kg body weight (mg E211/kg body weight)	0.750	0.817	0.850
% of MADI	15.00	16.33	17.00
Adult, man, 80 kg body weight (mg E211/kg body weight)	0.563	0.613	0.638
% of MADI	11.25	12.25	12.75

MADI - Maximal allowed daily intake

Results of the analytical trials related to the marinated fish are presented in Table 3.

Compared to the legal limit of E-211 inclusion for the food category "Fish products, salted/marinated/dry" (200 mg/100 g), the analytical values oscillated between 128-142 mg/100 g in Marinade A samples, between 112-140 mg/100 g in Marinade B and between 138-160 mg/100 g in Marinade C samples. Detection of such concentrations led to various proportions of remanence in the three products, respectively of 67.5%, 64.9% and 74.6%, compared with the maximal admitted level (200 mg/100 g) (Table 3).

Table 3. Average values of sodium benzoate (E-211) content in the three products analysed from the group fish products, salted/marinated/dry

Product	Analytical values			MAIL* (mg/ 100 mg)	% of MAIL
	$\bar{X}$	$\pm s_{\bar{x}}$	CV%		
Marinade A	135.0	2.07	4.85	200	67.50
Marinade B	129.8	2.88	7.01	200	64.90
Marinade C	149.2	1.64	3.47	200	74.60

*MAIL = maximal allowed inclusion level (mg/100 g product)

Starting from these values and considering the size of an eaten portions of marinated fish of 75 g per day, the daily intake of sodium benzoate has been calculated (Table 4).

If such products would be consumed by children weighing 30 kg, the daily intake would reach 3.245-3.730 mg sodium benzoate per kg body weight (64.9-74.6% of the maximal allowed daily intake dosage, i.e. 5 mg preservative E-211/kg body weight). In adult consumers, the daily intake varied between 1.623-1.865 mg sodium benzoate/kg body weight in women (60 kg) or between 1.217-1.399 mg sodium benzoate/kg body weight in men (80 kg), resulting levels of 32.45-37.30% and 25.31-27.98% of the maximal allowed daily intake level in both analyzed genders (Table 4).

Table 4. Calculation of daily ingested dose of sodium benzoate (E-211) through the three products from the category fish products, salted/marinated/dry

Daily ingested dose, related to consumer type	Product		
	Marinade A	Marinade B	Marinade C
MADI (mg E211/kg body weight)	5	5	5
Child, 30 kg body weight (mg E211/kg body weight)	3.375	3.245	3.730
% of MADI	67.5	64.9	74.6
Adult, woman, 60 kg body weight (mg E211/kg body weight)	1.688	1.623	1.865
% of MADI	33.75	32.45	37.30
Adult, man, 80 kg body weight (mg E211/kg body weight)	1.266	1.217	1.399
% of MADI	25.31	24.34	27.98

MADI - Maximal allowed daily intake

Although in the investigated foods, the intake proportions, compared to the maximal allowed daily intake were lower, if one child would consume a portion from both products in the same day, the real daily intake would reach 5.3-6.2%. In adult consumer, the daily cumulative intake of sodium benzoate from the two food categories would reach 2-4% of the daily maximal admitted intake level.

In both consumption scenarios, there must be proceeded with caution when children nutritional habits are considered, due to the cumulative intake of such food additives and, in particular, of sodium benzoate, from many other food categories (Kim et al., 2017). It is known that E-211 is also used in sweet treats and fizzy drinks, frequently consumed by toddlers, school pupils and teenagers (Trasande et al., 2018). It is known that there are common food consumption patterns and preferences in children of such ages for products rich in antiseptic-preserving additives (fast-food products, sweets, snacks and sodas) (Bemrah et al., 2008; Berentzen et al., 2015; Mischek et al. 2012).

CONCLUSIONS

The inclusion level of E-211 in the first group (carbonated soda) was 55-49% less than the maximum admitted inclusion level (AIL) (20 mg additive/100g product, while the calculated daily intake through drinking a portion (500ml) reached 32.7-34% out of the maximal admitted daily intake (MADI) for children and 11.25-17% of the MADI for adults.

The concentration detected in the marinated fish was 25.1-35.1% lower than the AIL for this food category (200 mg/100 g). Calculus of the daily intake for a serving portion of marinated fish (env. 75 g) reached 64.9-74.6% of the MADI for children and 24.34-37.30% for adult consumers.

Although the inclusion rates were below the maximal admitted limits, if we cumulate the potential intake of the sodium benzoate from these two food sources with other food preferred by children (sweet treats), the daily intake dose for this additive present becomes alarming and could endanger the health of young age consumers.

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