



## **92nd JECFA - Chemical and Technical Assessment (CTA), 2021**

### **Benzoic acid and its salts**

#### **Chemical and Technical Assessment (CTA)**

**Prepared by N. Sugimoto, Ph.D., reviewed by Jim Smith, Ph.D.**

#### **1. Summary**

This Chemical and Technical Assessment (CTA) summarizes the information on benzoic acid (INS No. 210) and its salts such as sodium benzoate (INS No. 211), potassium benzoate (INS No. 212) and calcium benzoate (INS No. 213) that are synthetic antimicrobial preservatives. They are allowed as food additives in the EU, Japan, USA, and other regions. The specifications for benzoic acid and its salts were prepared at the 17<sup>th</sup> JECFA (1973) and metals and arsenic specifications were revised at the 63<sup>rd</sup> JECFA (2004). A group ADI 0-5 mg/kg bw for benzoic acid and its salts was established at the 27<sup>th</sup> JECFA (1983). The ADI was withdrawn and re-established to 0-20 mg/kg for benzoic acid, its salts (calcium, potassium and sodium), benzaldehyde, benzyl acetate, benzyl alcohol and benzyl benzoate, expressed as benzoic acid equivalents bw at the 92<sup>nd</sup> JECFA (2021). At the 92<sup>nd</sup> JECFA (2021), the Committee, while reviewing the specifications of benzoic acid and its salts for food additives, considered it relevant to editorially update them.

#### **2. Description**

Benzoic acid and its salts are used as microbial preservatives for wide varieties of processed foods and beverages all over the world. Although the free acid form has antimicrobial effect, the salts of benzoic acid are often used as the actual food additives because the water-soluble property of the salts is much more advantageous for the food processing than that of the free acid, benzoic acid. By the availability of benzoic acid and its salts, the qualities of food additive grade materials have been well-controlled by the regulations of all countries, and the JECFA specifications of benzoic acid and its salts such as sodium benzoate, potassium benzoate and calcium benzoate were prepared and now maintained.

#### **3. Manufacturing process**

Benzoic acid is naturally present in plants and organic tissues and can be generated in fermented products. Since it has been reported that benzoic acid had the antibacterial and antifungal activities, the applications to food processing had been attracted and then the efficient synthesis method of benzoic acid had been developed. It has been used as a preservative or flavouring agent in food, cosmetic, hygiene and pharmaceutical product. The disadvantage of benzoic acid is less solubility to the aqueous and protic solvents such as water and alcohols that limits the range of the usage. To expand its application to foods, the salts of benzoic acid such as sodium benzoate, potassium benzoate and calcium benzoate have been produced by the neutralization reaction that are available.

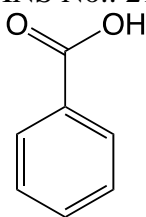
Benzoic acid is synthesized by liquid-phase oxidation of toluene with molecular oxygen (Maki and Takeda 2000). The oxidation reaction is carried out under the existence of cobalt naphtherate catalyst. In the oxidation process, several by-products such as benzaldehyde, benzyl alcohol and benzyl benzoate are formed. Small amount of benzyl formate, benzyl acetate, biphenyl and methyl biphenyls, and phthalic acid can be also formed. For food and pharmaceutical uses, benzoic acid is upgraded by further processing. Sublimation, recrystallisation and neutralisation processes have been proposed. To remove phthalic acid, whose presence is not allowed for food uses, treatment with amines and rinsing is required.

Benzoic acid has been used as a source to industrially synthesize the derivatives and more than 90% of commercial one goes to the derivatives production by oxidative decarboxylation, hydrogenation oximation and Beckmann rearrangement that synthesizes the derivatives of benzoic acid and related benzenic compounds such as benzyl alcohols, benzaldehydes, alkyl benzoate esters, hydroxybenzoate esters (parabens) and benzoyl peroxide.

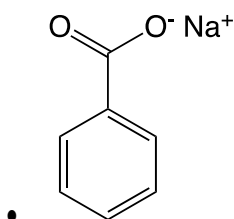
#### 4. Chemical characterization

Benzoic acid is the aromatic carboxylic acid that a carboxylic group conjugated to the benzene ring. The molecular formula for benzoic acid is  $C_7H_6O_2$ . Sodium benzoate is the sodium salt of benzoic acid and the molecular formula is  $C_7H_5NaO_2$ . Potassium benzoate is the potassium salt of benzoic acid and the molecular formula (anhydrous) is  $C_7H_5KO_2$ . JECFA specifications for potassium benzoate refers to the anhydrous and trihydrate forms. Calcium benzoate is the calcium salt of benzoic acid, which is existed as calcium dibenzoate and the molecular formula (anhydrous) is  $C_{14}H_{10}CaO_4$ . JECFA specification of calcium benzoate refers to the anhydrous, monohydrate and trihydrate forms. The JECFA specifications on benzoic acid and its sodium, potassium and calcium salts are shown in table 1 and the specific information and all of the structures are given below:

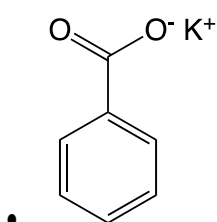
- Benzoic acid
  - Synonyms: benzenecarboxylic acid, phenolcarboxylic acid
  - Chemical names: benzoic acid,
  - Molecular formula:  $C_7H_6O_2$
  - Molecular weight: 122.12
  - CAS No.: 65-85-0
  - INS No.: 210



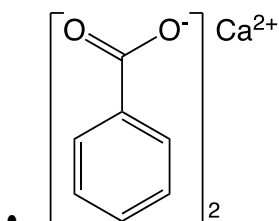
- Sodium benzoate
  - Synonyms: sodium salt of benzenecarboxylic acid, sodium salt of phenolcarboxylic acid
  - Chemical names: sodium benzoate
  - Molecular formula:  $C_7H_5NaO_2$
  - Molecular weight: 144.11
  - CAS No.: 532-32-1
  - INS No.: 211



- Potassium benzoate
  - Synonyms: potassium salt of benzenecarboxylic acid, potassium salt of phenolcarboxylic acid
  - Chemical names: potassium benzoate
  - Molecular formula:  $C_7H_5KO_2 \cdot 3H_2O$
  - Molecular weight: 160.22 (anhydrous), 214.27 (trihydrate)
  - CAS No.: 582-25-2 (anhydrous)
  - INS No.: 212



- Calcium benzoate
  - Synonyms: calcium dibenzoate, calcium salt of benzenecarboxylic acid, calcium salt of phenolcarboxylic acid
  - Chemical names: calcium benzoate
  - Molecular formula:  $C_{14}H_{10}CaO_4$  (anhydrous),  $C_{14}H_{10}CaO_4 \cdot H_2O$  (monohydrous),  $C_{14}H_{10}CaO_4 \cdot 3H_2O$  (trihydrous)
  - Molecular weight: 282.31 (anhydrous), 300.32 (monohydrate), 336.36 (trihydrate)
  - CAS No.: 2090-05-3 (anhydrous)
  - INS No.: 213



## 4.2

Table 1 JECFA Specifications for benzoic acid, sodium benzoate, potassium benzoate and calcium benzoate

	Benzoic acid INS: 210	Sodium benzoate INS: 211	Potassium benzoate INS: 212	Calcium benzoate INS: 213
<b>Definition</b>				
Assay	Not less than 99.5%	Not less than 99.0%	Not less than 99.0%	Not less than 99.0%

	on the dried basis	on the dried basis	on the dried basis	on the dried basis
<b>Description</b>	White crystalline solid, usually in the form of scales or needles, having not more than a faint characteristic odour	White, crystalline powder, flakes or granules	White crystalline powder	White or colourless crystals, or white powder
<b>Identification</b>				
Solubility (vol.4)	Slightly soluble in water, freely soluble in ethanol	Freely soluble in water, sparingly soluble in ethanol	Freely soluble in water, soluble in ethanol	Sparingly soluble in water
Melting range (vol.4)	121 – 123°	-	-	-
Test for benzoate (vol.4)	Passes test Use 0.1 g of the sample with 0.1 g of calcium carbonate and 5 ml of water	Passes test Use a 10% solution of the sample	Passes test Use a 10% solution of the sample	Passes test
Test for sodium (Vol.4)	-	Passes test	-	-
Test for potassium (Vol.4)	-	-	Passes test Use a 10% solution of the sample	-
Test for calcium (Vol.4)	-	-	-	Passes test
pH (vol.4)	About 4.0 (solution in water)	-	-	-
Loss on drying (vol.4)	Not more than 0.5% (over sulfuric acid, 3 h)	Not more than 1.5% (105°, 4 h)	Not more than 26.5% (105°, 4 h)	Not more than 17.5% (105°, 4 h)
Water insoluble matter	-	-	-	Not more than 0.3% Dissolve 10 g of the sample, weighed to the nearest mg, in 100 ml of hot water. Filter through a Gooch crucible, tared to an accuracy of $\pm 0.2$ mg, and wash any residue with hot water. Dry the crucible for 2 h at 105°. Cool, weigh and calculate as percentage.
Acidity or alkalinity	-	Passes test Dissolve 2 g of the sample, weighed to the nearest mg, in 20 ml of freshly	Passes test Dissolve 2 g of the sample, weighed to the nearest mg, in 20 ml of freshly	Passes test Dissolve 2 g of the sample, weighed to the nearest mg, in 20 ml of freshly

		boiled water. Not more than 0.5 ml of either 0.1N sodium hydroxide or 0.1N hydrochloric acid should be required for neutralization, using phenolphthalein TS as indicator.	boiled water. Not more than 0.5 ml of either 0.1N sodium hydroxide or 0.1N hydrochloric acid should be required for neutralization, using phenolphthalein TS as indicator.	boiled water. Not more than 0.5 ml of either 0.1N sodium hydroxide or 0.1N hydrochloric acid should be required for neutralization, using phenolphthalein TS as indicator.
Sublimation test	Place a small amount of the sample in a dry test tube. Wrap the test tube about 4 cm from the bottom with moistened filter paper. Heat the test tube over a low flame. Benzoic acid sublimes and crystals deposit in the colder part of the test tube leaving no residue at the bottom.	-	-	-
Sulfated ash (Vol.4)	Not more than 0.05%	-	-	-
Fluoride (Vol.4)	-	-	-	Not more than 10 mg/kg  Weigh 5 g of the sample to the nearest mg and proceed as directed in the Limit Test (Method I or III)
Lead	Not more than 2 mg/kg  Determine using a method appropriate to the specified level. The selection of sample size and method of sample preparation may be based on the principles of the method described in Volume 4, "Instrumental Methods."	Not more than 2 mg/kg  Determine using a method appropriate to the specified level. The selection of sample size and method of sample preparation may be based on the principles of the method described in Volume 4, "Instrumental Methods."	Not more than 2 mg/kg  Determine using a method appropriate to the specified level. The selection of sample size and method of sample preparation may be based on the principles of the method described in Volume 4, "Instrumental Methods."	Not more than 2 mg/kg  Determine using a method appropriate to the specified level. The selection of sample size and method of sample preparation may be based on the principles of the method described in Volume 4, "Instrumental Methods."
Readily carbonizable substances (Vol. 4)	Passes test  Dissolve 0.5 g of the sample, weighed to the	Passes test  Dissolve 0.5 g of the sample, weighed to the	Passes test  Dissolve 0.5 g of the sample, weighed to the	

	nearest mg, in 5 ml of sulfuric acid TS. The colour produced should not be darker than a light pink ("Matching Fluid Q").	nearest mg, in 5 ml of sulfuric acid TS. The colour produced should not be darker than a light pink ("Matching Fluid Q")	nearest mg, in 5 ml of sulfuric acid TS. The colour produced should not be darker than a light pink ("Matching Fluid Q")	
Readily oxidizable substances	<p>Passes test</p> <p>Add 1.5 ml of sulfuric acid to 100 ml of water, heat to boiling and add 0.1N potassium permanganate in drops, until the pink colour persists for 30 sec. Dissolve 1 g of the sample, weighed to the nearest mg, in the heated solution, and titrate with 0.1N potassium permanganate to a pink colour that persists for 15 sec. Not more than 0.5 ml should be required.</p>	<p>Passes test</p> <p>Add 1.5 ml of sulfuric acid to 100 ml of water, heat to boiling and add 0.1N potassium permanganate, dropwise, until the pink colour persists for 30 sec. Dissolve 1 g of the sample, weighed to the nearest mg, in the heated solution, and titrate with 0.1N potassium permanganate to a pink colour that persists for 15 sec. Not more than 0.5 ml should be required.</p>	<p>Passes test</p> <p>Add 1.5 ml of sulfuric acid to 100 ml of water, heat to boiling and add 0.1N potassium permanganate, dropwise, until the pink colour persists for 30 sec. Dissolve 1 g of the sample, weighed to the nearest mg, in the heated solution, and titrate with 0.1N potassium permanganate to a pink colour that persists for 15 sec. Not more than 0.5 ml should be required.</p>	<p>Passes test</p> <p>Add 1.5 ml of sulfuric acid to 100 ml of water, heat to boiling and add 0.1N potassium permanganate in drops, until the pink colour persists for 30 sec. Dissolve 1 g of the sample, weighed to the nearest mg, in the heated solution, and titrate with 0.1N potassium permanganate to a pink colour that persists for 15 sec. Not more than 0.5 ml should be required.</p>
Chlorinated organic compounds (Vol. 4)	<p>Not more than 0.07% (as Cl<sub>2</sub>)</p> <p>Test 0.25 g of the sample dissolved in 10 ml of 0.1 N sodium hydroxide, using 0.5 ml of 0.01N hydrochloric acid in the control.</p>	<p>Not more than 0.07% (as Cl<sub>2</sub>)</p> <p>Test 0.25 g of the sample using 0.5 ml of 0.01N hydrochloric acid in the control</p>	<p>Not more than 0.07% (as Cl<sub>2</sub>)</p> <p>Test 0.25 g of the sample using 0.5 ml of 0.01N hydrochloric acid in the control</p>	<p>Not more than 0.07% (as Cl<sub>2</sub>)</p> <p>Test 0.25 g of the sample, using 0.5 ml of 0.01N hydrochloric acid in the control.</p>
<b>Method of assay</b>	<p>Weigh, to the nearest mg, 2.5 g of the dried sample. Dissolve in 15 ml of warm ethanol previously neutralized using phenol red TS as indicator. Add 20 ml of water and titrate with 0.5N sodium hydroxide, using phenolphthalein TS as indicator.</p> <p>Each ml 0.5N sodium hydroxide is equivalent to</p>	<p>Weigh, to the nearest mg, 3 g of the sample previously dried for 4 h at 105° and transfer to a 250-ml Erlenmeyer flask. Add 50 ml of water to dissolve the sample. Neutralize the solution, if necessary, with 0.1N hydrochloric acid, using phenolphthalein TS as indicator. Add 50 ml of ether and a few drops of bromophenol blue</p>	<p>Weigh to the nearest 0.1 mg, 2.5 to 3 g of the dried sample, and transfer to a 250-ml Erlenmeyer flask. Add 50 ml of water to dissolve the sample. Neutralize the solution, if necessary, with 0.1N hydrochloric acid, using phenolphthalein TS as indicator. Add 50 ml of ether and a few drops of bromophenol blue TS and titrate with</p>	<p>Weigh accurately 0.6 g of the dried sample, dissolve in a mixture of 20 ml of water and 2 ml of dilute hydrochloric acid TS, and dilute to 100 ml with water. While stirring (preferably with a magnetic stirrer) add about 30 ml of 0.05M disodium ethylenediaminetetraacetate from a 50-ml buret, then add 15 ml of sodium hydroxide TS, 40 mg of murexide indicator</p>

	61.06 mg of $C_7H_6O_2$ .	TS, and titrate with 0.5N hydrochloric acid, shaking the flask constantly, until the colour of the indicator begins to change. Transfer the lower aqueous layer to another flask. Wash the ethereal layer with 10 ml of water, and add the washing and an additional 20 ml of ether to the separated aqueous layer. Complete the titration with the 0.5N hydrochloric acid, shaking constantly the flask.  Each ml of 0.5N hydrochloric acid is equivalent to 72.05 mg of $C_7H_5NaO_2$ .	0.5N hydrochloric acid, shaking constantly the flask, until the colour of the indicator begins to change. Transfer the lower aqueous layer to another flask. Wash the ethereal layer with 10 ml of water, and add the washing and an additional 20 ml of ether to the separated aqueous layer. Complete the titration with the 0.5N hydrochloric acid, shaking constantly the flask.  Each ml of 0.5N hydrochloric acid is equivalent to 80.11 mg of $C_7H_5KO_2$ .	preparation (an alternative indicator is hydroxynaphthol blue, of which 0.25 g is used - in this case the naphthol green TS is omitted) and 3 ml of naphthol green TS, and continue the titration until the solution is deep blue in colour.  Each ml of 0.05M disodium ethylenediamine tetraacetate is equivalent to 14.116 mg of $C_{14}H_{10}CaO_4$ .
--	---------------------------	---	---	--

Note: All the specifications of benzoic acid and its salts were editorially revised and updated at the 92nd JECFA (2021).

The maximum limits for specific elemental impurities for benzoic acid and its salts as reported in four different monographs (JECFA, USA (FCC12), EU, and Japan) are presented (Table 2). JECFA and USA (FCC12) only stipulate the maximum limit of lead. However, according to the EU specifications for benzoic acid and its salts, impurities of the toxic elements arsenic, lead, and mercury are accepted up to a concentration of 3, 2, and 1 mg/kg, respectively. Contamination at those levels would significantly impact the exposure to these metals, for which the exposure already is close to the health-based guidance values established by EFSA (EFSA CONTAM Panel 2009, 2010, 2012). Japan also stipulates the limits of arsenic and lead except for mercury that refer to EU specifications.

**Table 2. The maximum limits for specific elemental impurities for benzoic acid and its salts in four different monographs**

	JECFA	USA (FCC3)	EU	Japan <sup>a)</sup>
Arsenic (mg/kg)	-	-	≤3	≤3
Lead (mg/kg)	≤2	≤2	≤2	≤2
Mercury (mg/kg)	-	-	≤1	-

a) Potassium benzoate and calcium benzoate are not designated on the Japanese food sanitation act and not permitted to be used as food additives.

### 4.3 Analytical methods

The titrimetric assay method for determination of benzoic acid is included in Table 1. Most specifications for benzoic acid and its salts only refer to the titrimetric method of assay for benzoic

acid, whereas the *Food Chemicals Codex* (FCC12 2S) employs an HPLC method and a benzoic acid reference material.

## 5. Functional uses

### 5.1 Technological functions

The current JECFA specifications of benzoic acid and its salts only list a functional use of antimicrobial preservative. They are mainly used in acidic foodstuffs, since the antimicrobial activity is maximized at pH values between 2.5 and 4.5. They can be directly added or used in edible coatings in a great diversity of foods, including fish, seafood, meat, and egg products, sauces, soft drinks, beverages and juices, canned foods, chemical leavened baked goods, condiments, fruit, and vegetable products. Mixtures of benzoic acid or its salts together with other acids such as sorbic, citric, propionic, lactic, and ascorbic, or with nitrates or nitrites, are used in fermented vegetables (Casado et al., 2011).

### 5.2 Food categories and use levels

Benzoic acid and its salts are currently listed for use in the Codex General Standard for Food Additives (GSFA) as antimicrobial preservatives in the following food categories (Table 3).

**Table 3. GSFA Provisions for benzoates**

Number	Food Category	Max Level (mg/kg)
1.7	Dairy-based desserts (e.g. pudding, fruit or flavoured yoghurt)	300
02.2.2	Fat spreads, dairy fat spreads and blended spreads	1,000
2.3	Fat emulsions mainly of type oil-in-water, including mixed and/or flavoured products based on fat emulsions	1,000
2.4	Fat-based desserts excluding dairy-based dessert products of food category 01.7	1,000
04.1.2.2	Dried fruit	800
04.1.2.3	Fruit in vinegar, oil, or brine	1,000
04.1.2.5	Jams, jellies, marmelades	1,000
04.1.2.6	Fruit-based spreads (e.g. chutney) excluding products of food category 04.1.2.5	1,000
04.1.2.7	Candied fruit	1,000
04.1.2.8	Fruit preparations, including pulp, purees, fruit toppings and coconut milk	1,000
04.1.2.9	Fruit-based desserts, including fruit-flavoured water-based desserts	1,000
04.1.2.10	Fermented fruit products	1,000
04.1.2.11	Fruit fillings for pastries	1,000
04.1.2.12	Cooked fruit	1,000
04.2.2.2	Dried vegetables (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweeds, and nuts and seeds	1,000
04.2.2.3	Vegetables (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), and seaweeds in vinegar, oil, brine, or soybean sauce	2,000
04.2.2.5	Vegetable (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweed, and nut and seed purees and spreads (e.g., peanut butter)	1,000
04.2.2.6	Vegetable (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweed, and nut and seed pulps and preparations (e.g. vegetable desserts and sauces, candied vegetables) other than food category 04.2.2.5	3,000



04.2.2.7	Fermented vegetable (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera) and seaweed products, excluding fermented soybean products of food categories 06.8.6, 06.8.7, 12.9.1, 12.9.2.1 and 12.9.2.3	1,000
04.2.2.8	Cooked or fried vegetables (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), and seaweeds	1,000
05.1.3	Cocoa-based spreads, including fillings	1,500
05.1.5	Imitation chocolate, chocolate substitute products	1,500
5.2	Confectionery including hard and soft candy, nougats, etc. other than food categories 05.1, 05.3 and 05.4	1,500
5.3	Chewing gum	1,500
5.4	Decorations (e.g. for fine bakery wares), toppings (non-fruit) and sweet sauces	1,500
06.4.3	Pre-cooked pastas and noodles and like products	1,000
6.5	Cereal and starch based desserts (e.g. rice pudding, tapioca pudding)	1,000
7	Bakery wares	1,000
08.2.1.2	Cured (including salted) and dried non-heat treated processed meat, poultry, and game products in whole pieces or cuts	1,000
08.3.1.2	Cured (including salted) and dried non-heat treated processed comminuted meat, poultry, and game products	1,000
09.2.4.2	Cooked mollusks, crustaceans, and echinoderms	2,000
09.2.5	Smoked, dried, fermented, and/or salted fish and fish products, including mollusks, crustaceans, and echinoderms	200
9.3	Semi-preserved fish and fish products, including mollusks, crustaceans, and echinoderms	2,000
10.2.1	Liquid egg products	5,000
10.4	Egg-based desserts (e.g. custard)	1,000
11.4	Other sugars and syrups (e.g. xylose, maple syrup, sugar toppings)	1,000
11.6	Table-top sweeteners, including those containing high-intensity sweeteners	2,000
12.2.2	Seasonings and condiments	1,000
12.3	Vinegars	1,000
12.4	Mustards	1,000
12.5	Soups and broths	500
12.6	Sauces and like products	1,000
12.7	Salads (e.g. macaroni salad, potato salad) and sandwich spreads excluding cocoa- and nut-based spreads of food categories 04.2.2.5 and 05.1.3	1,500
13.3	Dietetic foods intended for special medical purposes (excluding products of food category 13.1)	1,500
13.4	Dietetic formulae for slimming purposes and weight reduction	1,500
13.5	Dietetic foods (e.g. supplementary foods for dietary use) excluding products of food categories 13.1 - 13.4 and 13.6	2,000
13.6	Food supplements	2,000
14.1.2.1	Fruit juice	1,000
14.1.2.3	Concentrates for fruit juice	1,000
14.1.3.1	Fruit nectar	1,000
14.1.3.3	Concentrates for fruit nectar	1,000
14.1.3.4	Concentrates for vegetable nectar	600
14.1.4	Water-based flavoured drinks, including "sport," "energy," or "electrolyte" drinks and particulated drinks	250
14.1.5	Coffee, coffee substitutes, tea, herbal infusions, and other hot cereal and grain beverages, excluding cocoa	1,000
14.2.2	Cider and perry	1,000
14.2.4	Wines (other than grape)	1,000
14.2.5	Mead	1,000
14.2.7	Aromatized alcoholic beverages (e.g. beer, wine and spirituous cooler-type beverages, low alcoholic refreshers)	1,000
15.1	Snacks - potato, cereal, flour or starch based (from roots and tubers, pulses and legumes)	1,000

Note: Unless otherwise specified, food additive provisions apply to the food category indicated (e.g. Dairy), as well as to all subcategories of that category (e.g. cheese, ripened cheese, etc.).

## 6. Reactions and Fate in Food

Benzoic acid and its salts are expected to be stable in foods. In the presence of ascorbic acid in some foods and beverages, small amounts of benzene are produced by the decarboxylation of benzoic acid and its salts (Lachenmeier et al., 2008). The formation of benzene by the reaction between benzoic and ascorbic acids can be influenced by other factors such as the presence of  $\text{Cu}^{2+}$  and  $\text{Fe}^{3+}$  ions, pH, UV light, and temperature; sugar and EDTA salts can inhibit benzene formation (FDA, 2013). In a survey of 86 non-alcoholic beverages performed by the FDA in 2007, benzene levels ranged from nondetectable to 88.9 ppb, with concentrations above the maximum level allowed in water for eight of the beverages. However, the oral exposure of benzene from beverages could be minor compared to the environmental exposure and so the health risk is very low. For example, the UK Food Standards Agency says people would need to drink more than 20 L of a drink containing benzene at the WHO water quality guideline level to equal the amount of benzene you would breathe from city air in a day (FSA News Item, 2006). In addition, several measures are used by food manufacturers to decrease the formation of benzene, including reducing the concentration of precursors and controlling storage temperature and time for beverage products.

## 7. References

Toxicological evaluation of certain food additives with a review of general principles and of specifications (17<sup>th</sup> report of the Joint FAO/WHO Expert Committee on Food Additives, 1973). WHO Technical Report Series, No. 539, 1973.

Evaluation of certain food additives and contaminants (27<sup>th</sup> report of the Joint FAO/WHO Expert Committee on Food Additives, 1983). WHO Technical Report Series, No. 696, 1983.

Evaluation of certain food additives and contaminants (46<sup>th</sup> report of the Joint FAO/WHO Expert Committee on Food Additives, 1996). WHO Technical Report Series, No. 868, 1997.

Evaluation of certain food additives (63<sup>rd</sup> report of the Joint FAO/WHO Expert Committee Expert on Food Additives, 2004). WHO Technical Report Series, No. 928, 2005.

EFSA Panel on Food Additives and Nutrient Sources (ANS), Scientific Opinion on the re-evaluation of benzoic acid (E 210), sodium benzoate (E 211), potassium benzoate (E 212) and calcium benzoate (E 213) as food additives. EFSA Journal 2016; 14(3): 4433.

Maki, T., and Takeda, K., 2012. Benzoic Acid and Derivatives, in 'Ullmann's Encyclopedia of industrial Chemistry' pp 329-342, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim.

Monographs of benzoic acid, sodium benzoate, potassium benzoate and calcium benzoate, Food Chemicals Codex 12th Edition, p.121, 1144, 947, 185, US Pharmacopeia 2020.

CAS presents "Common Chemistry", Substance details of benzoic acid, sodium benzoate, potassium benzoate, calcium benzoate. (<https://commonchemistry.cas.org>).

FAO/WHO Food Standards, Food category of Benzoates, GSFA online, CODEX alimentarius. Updated up to the 42<sup>nd</sup> Session of the Codex Alimentarius Commission (2019). (<http://www.fao.org/gsfaonline/groups/details.html?id=162>).

Data on benzene in soft drinks and other beverages. Data through May 16, 2007, updated in 2013. FDA (Food and Drug Administration).

(<http://www.fda.gov/Food/FoodborneIllnessContaminants/ChemicalContaminants/ucm055131.htm>).

CONTAMINANTS - Agency publishes survey into levels of benzene in soft drinks in the UK. FSA News Item, March 13, 2006. (<http://www.reading.ac.uk/foodlaw/news/uk-06023.htm>)

Benzene in flavoured beverages. April 2013. FSANZ (Food Standards Australia New Zealand). (<https://www.foodstandards.gov.au/consumer/chemicals/benzene/Pages/default.aspx>)

Lachenmeier, D. W., Reusch, H., Sproll, C., Schoeberl, K. and Kuballa, T., Occurrence of benzene as a heat-induced contaminant of carrot juice for babies in a general survey of beverages. Food Addit. Contam. Part A. 2008; 25: 1216–1224.

Casado, F. J., Sánchez, A. H., De Castro, A., Rejano, L., Beato, V. M. and Montañó, A., Fermented vegetables containing benzoic and ascorbic acids as additives: Benzene formation during storage and impact of additives on quality parameters. J. Agr. Food Chem. 2011; 59: 2403–2409