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**Exposure assessment of food preservatives (sulfites, benzoic and sorbic acid) in Austria**

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Methods/Techniques:	Exposure assessment
Additives/Contaminants:	Preservatives, Sulfite
Food Types:	
Abstract:	An exposure assessment was performed to estimate the potential intake of preservatives in the Austrian population. Food consumption data of different population groups, such as preschool children aged 3-6 years, female and male adults aged 19-65 years were used for calculation. Levels of the preservatives in food were derived from analyses conducted from January 2007 to August 2010. Dietary intakes of the preservatives were estimated and compared to the respective acceptable daily intakes (ADIs). In the average intake scenario, assuming that consumers randomly consume food products that do or do not contain food additives, estimated dietary intakes of all studied preservatives are well below the ADI for all population groups. Sulfite exposure accounted for 34%, 84% and 89% of the ADI in preschool children, females and males, respectively. The mean estimated daily intake of benzoic acid was 32% (preschool children), 31% (males) and 36% (females) of the ADI. Sorbic acid intakes correspond to 7% of the ADI in preschool children and 6% of the ADI in adults. In the high intake scenario assuming that consumers always consume food products that contain additives and considering a kind of brand loyalty of consumers, the ADI is exceeded for sulfites among adults (119 and 124%, respectively). Major contributors to the total intake of sulfites were wine and dried fruits for adults. Mean estimated dietary intakes of benzoic acid exceeded the ADI in all population groups, 135% in preschool children, 124% in females, and 118% of the ADI in males, respectively. Dietary

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	intakes of sorbic acid are well below the ADI, accounting for a maximum of 30% of the ADI in preschool children. The highest contributors to benzoic and sorbic acid exposure were fish and fish products mainly caused by high consumption data of this large food group including also mayonnaise containing fish salads. Other important sources of sorbic acid were bread, buns and toast bread, and fruit and vegetable juices.

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3 **Exposure assessment of food preservatives (sulfites, benzoic and sorbic**  
4 **acid) in Austria**  
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29 An exposure assessment was performed to estimate the potential intake of  
30 preservatives in the Austrian population. Food consumption data of different population  
31 groups, such as preschool children aged 3-6 years, female and male adults aged 19-65  
32 years were used for calculation. Levels of the preservatives in food were derived from  
33 analyses conducted from January 2007 to August 2010. Dietary intakes of the  
34 preservatives were estimated and compared to the respective acceptable daily intakes  
35 (ADIs). In the average intake scenario, assuming that consumers randomly consume  
36 food products that do or do not contain food additives, estimated dietary intakes of all  
37 studied preservatives are well below the ADI for all population groups. Sulfite exposure  
38 accounted for 34%, 84% and 89% of the ADI in preschool children, females and males,  
39 respectively. The mean estimated daily intake of benzoic acid was 32% (preschool  
40 children), 31% (males) and 36% (females) of the ADI. Sorbic acid intakes correspond to  
41 7% of the ADI in preschool children and 6% of the ADI in adults. In the high intake  
42 scenario assuming that consumers always consume food products that contain  
43 additives and considering a kind of brand loyalty of consumers, the ADI is exceeded for  
44 sulfites among adults (119 and 124%, respectively). Major contributors to the total  
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3 intake of sulfites were wine and dried fruits for adults. Mean estimated dietary intakes of  
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5 benzoic acid exceeded the ADI in all population groups, 135% in preschool children,  
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7 124% in females, and 118% of the ADI in males, respectively. Dietary intakes of sorbic  
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9 acid are well below the ADI, accounting for a maximum of 30% of the ADI in preschool  
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11 children. The highest contributors to benzoic and sorbic acid exposure were fish and  
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13 fish products mainly caused by high consumption data of this large food group including  
14  
15 also mayonnaise containing fish salads. Other important sources of sorbic acid were  
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17 bread, buns and toast bread, and fruit and vegetable juices.  
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21 **Keywords:** dietary exposure, food additive, preservatives, sulfites, benzoic  
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23 acid, sorbic acid  
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## Introduction

Sulfur dioxide and sulfites (E220-E228), benzoic acid (E210), sorbic acid (E200) and their salts (benzoates, sorbates) are widely used preservatives in a variety of foods. Preservatives are used due to their antibacterial, antifungal and antioxidant properties. Sulfites may inhibit enzymatic and non-enzymatic browning reactions in food.

Besides its usage as a food additive, benzoic acid may naturally be present in foods (Hegnauer 1966, Sieber et al. 1989). Concentrations of 300 – 1300 mg free benzoic acid per kg fruit have been found in ripe fruits of several *Vaccinium* species (cranberries, bilberries) (Hegnauer 1966). Smaller amounts were reported for other foods such as dairy products (Sieber et al. 1989). Milk, cheese and yoghurt were found to contain mean concentrations of up to 40 mg/kg benzoic acid (World Health Organization (WHO) 2000). Sulfites can occur naturally in foods as a consequence of fermentation in wine and beer (Taylor et al. 1986).

The Joint FAO/WHO Expert Committee on Food Additives (JECFA) has evaluated the safety of these compounds (JECFA 1994, 1996, 1999). The respective acceptable daily intakes (ADIs) are:  $0.7 \text{ mg kg}^{-1} \text{ day}^{-1}$  for sulfite,  $5 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  for benzoic acid and  $25 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  for sorbic acid. The acute toxicity of benzoates is low. However, possible adverse effects of benzoates include non-immunological contact reactions (pseudoallergy) in sensitive patients suffering from urticaria or asthma. This effect is rare in healthy subjects (WHO 2000). A mixture of artificial colours and benzoic acid was associated with hyperactivity in children (McCann et al. 2007).

Maximum permitted use levels and food groups in which the respective food additive is allowed are given in European Directive 95/2/EC on food additives other than colours and sweeteners. The content of total sulphur dioxide of wine which may not be exceeded is listed in Annex V of Council Regulation (EC) No. 1493/1999 on the common organisation of the market in wine. An  $\text{SO}_2$  content of not more than  $10 \text{ mg kg}^{-1}$  or  $10 \text{ mg l}^{-1}$  is not considered to be present. Regulation (EC) No. 1331/2008 and Regulation (EC) No. 1333/2008 lay down approval and use of food additives. The use and consumption of food additives shall be monitored on a regular basis.

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3 The objective of the present study was to estimate the dietary exposure to  
4 preservatives in the Austrian population using national food consumption data and  
5 occurrence levels in selected food categories. Estimated intakes were compared to the  
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The objective of the present study was to estimate the dietary exposure to preservatives in the Austrian population using national food consumption data and occurrence levels in selected food categories. Estimated intakes were compared to the respective ADIs. Additionally, the food groups contributing the most to the total dietary intake of the respective food additive were identified.

## Material and methods

### *Sample handling and storage*

The edible portion of solid samples was homogenised thoroughly in a food blender with stainless steel cutters. Liquid samples were sonicated to remove carbon dioxide. Aliquots were stored frozen until the day of analysis.

### *Analytical methods*

#### *Sulfites*

Sulfites were determined using a modified Monier-Williams method (Kirk and Sawyer 1991). Sulfur dioxide was liberated in the presence of phosphoric acid, collected in hydrogen peroxide and oxidised to sulphuric acid. Solvents were concentrated to small volumes and filled up with deionised water several times to eliminate volatile organic compounds like acetic acid. Sulfuric acid was determined acidimetrically with 0.01 N sodium hydroxide solution and Tashiro indicator (Schneyder 1979, Pfenninger 1993). The limit of quantification was 8 mg kg<sup>-1</sup> for solid samples and 1 mg l<sup>-1</sup> for liquid samples.

For products, which did not comply with the legal requirements, an additional high performance liquid chromatography (HPLC) analysis was performed. In samples containing large amounts of acetic acid only results obtained by HPLC were considered.

The analysis was performed with HPLC and conductivity detector according to ISO 10304 (International Organisation for Standardisation (ISO)). Separation was carried out on a Polyspher<sup>®</sup> IC AN-1 column (100 x 4.6 mm, 12 µm particle size) with a Polyspher<sup>®</sup> IC AN-1 precolumn (10 x 4.6 mm, 12 µm particle size). The mobile phase consisted of phthalic acid, tris(hydroxyl-methyl)-aminomethane and boric acid (0.25 g phthalic acid, 0.17 g tris(hydroxyl-

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3 methyl)-aminomethane, 18.5 g boric acid in 1000 g deionised water) at a flow rate of  
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5 1 ml min<sup>-1</sup>. The quantification was performed using an external calibration with standard  
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7 solutions of sulfate in water. Results were expressed as sulphur dioxide. The limit of  
8  
9 quantification was 1 mg kg<sup>-1</sup> sulphur dioxide.

#### 10 *Benzoic and sorbic acid*

11  
12 Benzoic and sorbic acid were determined by HPLC analysis with diode array detection  
13  
14 (DAD). Aliquots of solid samples were sonicated for 30 to 45 min in an extracting agent  
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16 consisting of 6.1 g 1M sodium acetate buffer (pH 4.6) in 320 ml methanol and 600 g  
17  
18 deionised water. Extracted samples were clarified using Carrez reagents.

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21 Liquid samples were diluted with 1M sodium acetate solution and deionised water  
22  
23 and cleaned up on glass fibre pre-filters. The separation was carried out on a Hypersil ODS  
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25 column (100 x 4.6 mm, 5 µm particle size) with a Supelguard<sup>®</sup> LC-18-DB precolumn (20 x  
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27 4.6 mm, 5 µm particle size). Analyses were performed using a mobile phase consisting of  
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29 7.6 g 1 M sodium acetate buffer (pH 4.6) in 198 g methanol and 750 g deionised water, at a  
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31 flow rate of 1 ml min<sup>-1</sup>. Diode array detector spectra were recorded from 200 to 400 nm  
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33 (detection at 230 nm for benzoic acid and at 254 nm for sorbic acid). For quantification, an  
34  
35 external calibration with standard solutions of benzoic acid and sorbic acid in extraction  
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37 solvent was used. Results were expressed as sorbic or benzoic acid equivalents. The limit of  
38  
39 quantification in liquid samples was 5 mg l<sup>-1</sup> for benzoic acid and 1 mg l<sup>-1</sup> for sorbic acid, in  
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41 solid samples 20 mg kg<sup>-1</sup> and 10 mg kg<sup>-1</sup>, respectively.

#### 42 **Food additive occurrence data**

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45 From January 2007 to August 2010 food and beverage samples were collected and analysed  
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47 for the presence of preservatives at the Austrian Agency for Health and Food Safety (AGES).  
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49 Samples consisted of routine (targeted) and suspect samples (assumed to contain the  
50  
51 respective preservative), which were taken from the Austrian retail market and samples  
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53 submitted by private persons. Of the samples, 1059 were analysed for sulfites, 2333 for  
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55 benzoic acid, and 2350 for sorbic acid. Average concentrations of preservatives in foods  
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3 were calculated in two ways: one only including samples with an analytical determined value  
4 above the limit of quantification and another including all the analysed samples. For values  
5 below the limit of detection, a zero concentration was used for the calculation of average  
6 concentrations.  
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### 10 ***Food consumption data***

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12 Exposure assessment was performed using consumption data from a food consumption  
13 survey conducted within the scope of the Austrian Nutrition report 2003 (Elmadfa and  
14 Freisling 2004). Food consumption data of male and female adults were collected by a 24-  
15 hour recall, for preschool children the 3 day weighing method was applied. Food  
16 consumption data of a total of 2581 adults were recorded. 1568 females, 1013 males and  
17 151 preschool children completed the survey. Mean body weights were 20 kg for preschool  
18 children aged 3-6 years, 60 kg for adult females aged 19-65 years and 70 kg for adult males  
19 aged 19-65 years.  
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### 29 ***Exposure assessment***

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31 Dietary exposure to sulfite, benzoic and sorbic acid was estimated by combining mean levels  
32 of these preservatives in food and national consumption data of Austrian preschool children  
33 and adults.  
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37 Two intake scenarios were used for exposure assessment: one called “average  
38 intake”, where the analytical determined mean value for all samples (including zero values)  
39 was used for intake calculation assuming that the consumers randomly consume food  
40 products that do or do not contain food additives. For the “high intake” scenario, the  
41 analytical determined mean value for all samples containing a preservative above the limit of  
42 quantification (LOQ) was used for intake calculation. In this scenario it is assumed that  
43 consumers always consume food products that contain additives considering a kind of brand  
44 loyalty of consumers. Comparable methods for exposure assessment have been already  
45 applied and published by others (Bemrah et al. 2008, Leth et al. 2010).  
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55 As a kind of conservative assessment, food consumption data of consumers, people  
56 who actually consume the specific food, were used. The dietary intakes of food additives  
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3 were calculated for average and high consumers using mean and 95<sup>th</sup> percentile values of  
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5 consumption data based on 24-hour recalls. For risk characterisation, the mean estimated  
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7 daily intakes of sulfite, benzoic and sorbic acid of preschool children and adults were  
8  
9 compared to the respective ADI values.  
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## 11 12 **Results and discussion**

### 13 ***Concentrations in food***

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15 From January 2007 to August 2010, the Austrian Agency for Health and Food Safety (AGES)  
16  
17 analysed a variety of food and beverage samples for the presence of sulfites, benzoic and  
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19 sorbic acid, and their salts. The concentrations of sulfites, benzoic and sorbic acid in food  
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21 and beverages are given in Table 1. The number of samples, the number of samples with a  
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23 content above the limit of quantification (LOQ), the average concentration of all samples, as  
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25 well as the average of samples containing a quantifiable amount of the preservative are  
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27 shown.  
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#### 30 *Sulfite*

31  
32 Nearly all of the wine samples contain sulfite with a mean content of 92.4 mg l<sup>-1</sup>. Other  
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34 studies reported mean concentrations in the range of 75 – 115 mg l<sup>-1</sup> (Mareschi et al. 1992,  
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36 MAFF 1995, Leclerq et al. 2000, Vandevijvere et al. 2010). Looking at white and red wines  
37  
38 separately, our study revealed average sulfite concentrations of 109.8 mg l<sup>-1</sup> (white wine)  
39  
40 and 81.3 mg l<sup>-1</sup> (red wine), respectively. The average concentration in red wine found in our  
41  
42 study was similar to other studies which reported mean concentrations of 78.6 mg l<sup>-1</sup> and  
43  
44 81 mg l<sup>-1</sup>, respectively (Bemrah et al. 2008, Vandevijvere et al. 2010) while red wine from  
45  
46 Australia contained lower concentrations of sulfite (55 mg l<sup>-1</sup>; FSANZ 2005). For white wine,  
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48 other studies reported slightly higher concentrations than in the current survey.  
49  
50 Concentrations were in the range of 118 – 139 mg l<sup>-1</sup> (FSANZ 2005, Bemrah et al. 2008,  
51  
52 Vandevijvere et al. 2010). Lower concentrations were found for white and red wines (82 and  
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54 46 mg l<sup>-1</sup>, respectively) in New Zealand (Cressey and Jones 2009).  
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3 The average concentration of sulfite in dried fruits ( $339.5 \text{ mg kg}^{-1}$ ) was similar to the  
4  $384 \text{ mg kg}^{-1}$  found in a Belgian study (Vandevijvere et al. 2010) and lower than  
5 concentrations found in studies from UK and France that reported a mean content of  
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7  $500 \text{ mg kg}^{-1}$  and  $1005.9 \text{ mg kg}^{-1}$ , respectively (MAFF 1995, Bemrah et al. 2008). Higher  
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9 concentrations of sulfite have also been reported for dried apples and apricots ( $1252 \text{ mg kg}^{-1}$   
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Quantifiable amounts of sulfites of up to  $6.5 \text{ mg l}^{-1}$  were found in individual samples of beverages such as fruit and vegetable juices, fruit nectars and other non alcoholic drinks. Others have reported a mean concentration in soft drinks (non-cola) of  $5 \text{ mg l}^{-1}$  (Cressey and Jones 2009).

Concentrations of sulfite in vegetables in vinegar, oil or brine ( $64 \text{ mg kg}^{-1}$ ) were consistent with another study which reported mean concentrations of sulfites in the range of  $48 - 67 \text{ mg kg}^{-1}$  (Leclercq et al. 2000). The average concentration of sulfite in jams of  $13.5 \text{ mg kg}^{-1}$  was similar to the  $16 \text{ mg kg}^{-1}$  which was found in a Belgian study (Vandevijvere et al. 2010).

#### *Benzoic acid*

The average concentration of benzoic acid in non alcoholic drinks ( $69.8 \text{ mg l}^{-1}$ ) was similar to concentrations that were reported in studies from France ( $71.2 \text{ mg l}^{-1}$ ; Bemrah et al. 2008) and New Zealand ( $63.1 \text{ mg l}^{-1}$  in soft drinks (cola); Cressey and Jones 2009). However, other studies reported higher mean concentrations in the range of  $120.5 - 259.2 \text{ mg l}^{-1}$  (MAFF 1995, Tfouni and Toledo 2002, FSANZ 2005, Vandevijvere et al. 2009).

Jam, jellies and marmalades analysed in the current study had a mean concentration of  $465 \text{ mg kg}^{-1}$  higher than concentrations found in Denmark ( $382 \text{ mg kg}^{-1}$ ; Leth et al. 2010) and the UK ( $216 \text{ mg kg}^{-1}$ ; MAFF 1995). The average concentration of benzoic acid in stewed fruit ( $579.5 \text{ mg kg}^{-1}$ ) was higher than in Danish products ( $377 \text{ mg kg}^{-1}$ ; Leth et al. 2010). Higher concentrations in our study might partly be explained by the fact that particularly products containing cranberries were analysed which already have a high natural content of benzoic acid (Hegnauer 1966).

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3 For fat containing food groups such as prepared salads, dressings and mayonnaise a  
4 Belgian study (Vandevijvere et al. 2009) reported concentrations of up to  $768.6 \text{ mg kg}^{-1}$   
5 (dressings) compared to  $333.2 \text{ mg kg}^{-1}$  (prepared salads) and  $585.6 \text{ mg kg}^{-1}$  (dressings,  
6 mayonnaise) found in the current survey.  
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11 Limited comparative data were found for the food group "fish and fish products", in  
12 our study also including mayonnaise-containing fish salads. Other studies reported the  
13 benzoic acid content of various fish products separately. Fish and fish products analysed in  
14 the current study had average concentrations of  $350 \text{ mg kg}^{-1}$  and  $719.9 \text{ mg kg}^{-1}$ ,  
15 respectively. A higher content was reported for pickled herring ( $773 \text{ mg kg}^{-1}$  and  $987 \text{ mg kg}^{-1}$ ,  
16 respectively) and a lower content was found in tuna in water/oil, sardines in oil  
17 ( $153 \text{ mg kg}^{-1}$  and  $438 \text{ mg kg}^{-1}$ , respectively; Leth et al. 2010). The UK has reported only  
18 one sample of preserved fish with a content of  $653 \text{ mg kg}^{-1}$  (MAFF 1995).  
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#### 27 *Sorbic acid*

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29 The average concentration of sorbic acid in jam, jellies and marmalades ( $118.5 \text{ mg kg}^{-1}$  and  
30  $440.5 \text{ mg kg}^{-1}$ ) was less than values reported in the UK ( $654 \text{ mg kg}^{-1}$ ; MAFF 1995) and in  
31 Denmark ( $273 \text{ mg kg}^{-1}$  and  $564 \text{ mg kg}^{-1}$ ; Leth et al. 2010).  
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36 Levels of sorbic acid in non alcoholic drinks ( $15$  and  $75.6 \text{ mg l}^{-1}$ , respectively) were  
37 consistent with results from a Danish study ( $19 - 45 \text{ mg l}^{-1}$  and  $65 - 69 \text{ mg l}^{-1}$ ; Leth et al.  
38 2010). Tfouni and Toledo (2002) reported a mean concentration of  $47.1 \text{ mg l}^{-1}$  for soft drinks  
39 from Brazil.  
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43 Fish products analysed in the current survey had an average sorbic acid  
44 concentration of  $700.8 \text{ mg kg}^{-1}$ . Results are in between contents reported by Leth et al.  
45 (2010) who found mean concentrations of  $574 \text{ mg kg}^{-1}$  in pickled herring and  $760 \text{ mg kg}^{-1}$  in  
46 tuna in water/oil.  
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51 Lower concentration than in our study ( $779.5 \text{ mg kg}^{-1}$ ) were found in Australian table  
52 spreads with a mean content of  $421 \text{ mg kg}^{-1}$  (FSANZ 2005). The overall mean concentration  
53 of prepared salads and spreads ( $650.6 \text{ mg kg}^{-1}$ ) in the current study is similar to the  
54 concentration of  $670 \text{ mg kg}^{-1}$  in fat based salads and spreads reported by Leth et al. (2010).  
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3 The same authors reported a mean content of  $788 \text{ mg kg}^{-1}$  and  $820 \text{ mg kg}^{-1}$ , respectively,  
4 in dressings, mayonnaise which is lower than the  $739.8 \text{ mg kg}^{-1}$  and  $1008.8 \text{ mg kg}^{-1}$  found  
5 in our study.  
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### 10 11 ***Dietary intake of preservatives***

12  
13 Table 2 shows the estimated daily intake of sulfites, benzoic acid and sorbic acid for different  
14 Austrian population groups. In the “average intake calculation” it was assumed that  
15 consumers randomly consume foods that contain the respective preservative or not. Results  
16 of the “high intake” calculation where it was assumed that consumers always consume foods  
17 that contain quantifiable amounts of the respective preservative are shown in Table 3.  
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21 The mean estimated daily intakes of sulfite, benzoic and sorbic acid of preschool  
22 children and adults were compared to the respective ADI values. The percentage of the ADI  
23 for each preservative at average and high intake (scenario 1 and 2) is given in Table 2 and 3.  
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### 26 27 ***Sulfite***

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29 The mean estimated daily intake of sulfites was  $0.24 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  for preschool  
30 children, representing 34% of the ADI. The mean estimated intakes for adults were  
31  $0.59 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  (females) and  $0.62 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  (males), corresponding to 84  
32 and 89% of the ADI (Table 2). Hence, for consumers that randomly select foods that contain  
33 preservatives or not, the ADI is not exceeded. Similar to the current study, Cressey and  
34 Jones (2009) reported mean estimates well below the ADI.  
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37  
38 In the “high intake” scenario, the ADI is exceeded for sulfites among adults.  
39 Estimated mean daily exposures of sulfites were in the range of  $0.61 \text{ mg kg}^{-1} \text{ bw day}^{-1}$   
40 (preschool children) –  $0.87 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  (males), corresponding to 88 – 124% of the  
41 ADI (Table 3). In Italy, dietary intakes of consumers were calculated from modelled meals  
42 largely based on foods containing added sulfites (Leclercq et al. 2000). Estimates using  
43 analytical data revealed intakes of  $23.4 \text{ mg day}^{-1}$  ( $0.78 \text{ mg kg}^{-1} \text{ bw day}^{-1}$ ) for children, and  
44  $50.3 \text{ mg day}^{-1}$  ( $0.84 \text{ mg kg}^{-1} \text{ bw day}^{-1}$ ) for adults, corresponding to 111 and 120% of the  
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3 ADI (Leclercq et al. 2000). Intakes calculated for the French population are lower than those  
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5 estimated in our study (Bemrah et al. 2008). The ADI is not exceeded for consumers that  
6  
7 randomly consume food additive containing foods or not. Mean estimated intakes in France  
8  
9 were  $0.2 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  (28.4% of the ADI) for adults and  $0.1 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  (14.6%  
10  
11 of the ADI) for children. For assumption 2 (consumers always consume foods that contain  
12  
13 additives), mean dietary intakes of  $0.27 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  for adults (39.1% of the ADI) and  
14  
15  $0.25 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  for children (35.6% of the ADI) were estimated. However, the authors  
16  
17 stated that sulfite intakes estimated from wine are probably underestimated (Bemrah et al.  
18  
19 2008).

20  
21 It seems that differences in dietary intakes mainly result from food consumption data.  
22  
23 Wine consumption of females and males in our study was 283.1 and 368.3 g, respectively  
24  
25 compared to 113 g for French adults. Consumption data of dried fruits in France were 1.5 g  
26  
27 for children and 2.8 g for adults compared to 17 g (preschool children) and 32.7 g (adults) in  
28  
29 the current study. Vandevijvere et al. (2010) conducted Tier 2 and Tier 3 calculations for  
30  
31 sulfite intake. At Tier 3, a mean intake of sulfites of  $0.19 \text{ mg kg}^{-1} \text{ bw day}^{-1}$ , corresponding to  
32  
33 27% of the ADI, was reported. High consumers of wine might have an intake around the ADI.  
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35 However, others reported intakes above the ADI. Sulfite exposure of high consumer in  
36  
37 Australia and New Zealand was 130% of the ADI for males and females, whereas the mean  
38  
39 estimated dietary exposure was less than or equal to 80% of the ADI for all population  
40  
41 groups. Mean estimated dietary exposure was 35% of the ADI for males and 30% of the ADI  
42  
43 for females (FSANZ 2005). Sulfite intake in the UK was estimated to be  $1.0 \text{ mg kg}^{-1}$   
44  
45  $\text{bw day}^{-1}$  (MAFF 1995).

#### 46 47 48 49 *Benzoic acid*

50  
51 The mean estimated daily intake of preschool children of  $1.59 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  (32% of the  
52  
53 ADI) in the average intake scenario is comparable to that of males ( $1.57 \text{ mg kg}^{-1} \text{ bw day}^{-1}$ ;  
54  
55 31% of the ADI). The intake of benzoic acid is highest for females with  $1.78 \text{ mg kg}^{-1}$   
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57  $\text{bw day}^{-1}$  (females), representing 36% of the ADI (Table 2). Mean estimated daily intakes of  
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3 benzoic acid in the high intake calculation exceeded the ADI in all population groups. For  
4 preschool children, a mean daily exposure of  $6.77 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  (135% of the ADI) was  
5 calculated. Estimated mean exposures of adults were  $6.2 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  (females) and  
6  
7  $5.9 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  (males), respectively, representing 124 and 118% of the ADI  
8  
9 (Table 3). Similar calculations than in the current study were performed to estimate intakes of  
10  
11 benzoic acid in Denmark (Leth et al. 2010). Calculations based on the average of all the  
12  
13 samples show that more than 5% of the people will have an intake higher than the ADI. For  
14  
15 the high intake calculation, about 10% of men and women have an intake of benzoic acid  
16  
17 over the ADI with a maximum intake of  $28 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  for a boy and  $31 \text{ mg kg}^{-1}$   
18  
19  $\text{bw day}^{-1}$  for a girl (7-10 years old).  
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23 Most of the studies reported intakes of benzoic acid well below the ADI (Cressey and  
24 Jones 2009, MAFF, 1995, Vandevijvere et al. 2009, Tfouni and Toledo 2002). In Australia  
25 and New Zealand, the mean estimated dietary exposure to benzoic acid was less than 50%  
26  
27 of the ADI for all population groups. Looking at males and females separately, the mean  
28  
29 estimated dietary exposure was 15% and 10% of the ADI, respectively. For high consumer,  
30  
31 dietary exposures of 60% (males) and 50% of the ADI (females) were reported. Only the 95<sup>th</sup>  
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33 percentile estimates exceeded the ADI for young boys (140%) and girls (120%) (FSANZ  
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35 2005).  
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#### 41 *Sorbic acid*

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43 In the average intake scenario, the mean estimated intake of sorbic acid is  $1.75 \text{ mg kg}^{-1}$   
44  
45  $\text{bw day}^{-1}$  for preschool children, corresponding to 7% of the ADI. Among adults, exposures  
46  
47 were approximately  $1.5 \text{ mg kg}^{-1} \text{ bw day}^{-1}$ , which is equal to 6% of the ADI for both females  
48  
49 and males (Table 2). Intakes of sorbic acid were below the ADI for all population groups in  
50  
51 the high intake calculation. Preschool children had a mean estimated intake of  $7.53 \text{ mg kg}^{-1}$   
52  
53  $\text{bw day}^{-1}$  (30% of the ADI). For adults, mean estimated intakes of  $5.31 \text{ mg kg}^{-1} \text{ bw day}^{-1}$   
54  
55 (females) and  $5.49 \text{ mg kg}^{-1} \text{ bw day}^{-1}$  (males) were estimated, representing 21 and 22% of  
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57 the ADI (Table 3).  
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3 The calculated intakes of sorbic acid for average and high intake scenarios are well below  
4 the ADI. Similar results (ADI not exceeded) were reported from a study conducted in  
5 Australia and New Zealand (FSANZ 2005, Cressey and Jones 2009). The mean and 95<sup>th</sup>  
6 percentile estimated dietary exposure to sorbic acid was less or equal to 40% of the ADI for  
7 all population groups assessed. The mean estimated dietary exposure was 3% of the ADI for  
8 both males and females: high consumer intake was approximately 15% (males) and 10%  
9 (females) of the ADI (FSANZ 2005).  
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13 Depending on food consumption data used for calculation, the average daily intake of  
14 sorbates in Brazil was 0.17 and 0.33 mg kg<sup>-1</sup> bw, respectively, exhibiting lower intakes than  
15 found in the current survey. However, dietary intakes were calculated only for selected food  
16 categories (Tfouni and Toledo 2002). Dietary intake estimates of Leth et al. (2010) who  
17 performed similar calculations than in the current study showed that in the high intake  
18 scenario more than 10% of men and more than 5% of women will have an intake over the  
19 ADI. Children aged 4-6 years will have an intake more than three times of the ADI with a  
20 maximum intake of 147 mg kg<sup>-1</sup> bw day<sup>-1</sup> (boy) and 112 mg kg<sup>-1</sup> bw day<sup>-1</sup> (girl). The ADI is  
21 not exceeded when the calculation is based on average of all samples.  
22  
23

24 Differences might be explained by lower concentrations of sorbic acid in bread in the  
25 current study. Possible other reasons might be that sorbic acid plays a minor role as a  
26 preservative in bread or that consumer may favour bread which does not contain any  
27 preservative.  
28  
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30 In general, the comparison of dietary intakes between different studies is difficult due  
31 to differences in the methodology used and assumptions made in the exposure assessment.  
32 In the past, dietary exposures were calculated using a tiered approach, or intakes were  
33 assessed from modelled meals largely based on foods containing added preservatives.  
34 Furthermore, maximum permitted levels instead of actual concentrations were used for  
35 intake calculation.  
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38 Another limitation may be represented by the use of consumption data derived from a single  
39 24-h dietary recall. Intake calculations obtained by this method may lead to an over- or  
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3 underestimation of dietary exposures for some consumers and therefore may not provide an  
4 accurate estimation of an individual's habitual exposure. In addition, 95<sup>th</sup> percentile estimates  
5 based on individual 24-hour recall records tend to overestimate the variability in habitual  
6 long-term dietary exposures. Especially children have a higher consumption per kg of body  
7 weight. However, a relatively high intake among children is an age effect, and the ADIs refer  
8 to lifetime exposure (Löwik 1996). Additionally, preservative levels were not determined in all  
9 the food categories in which the preservatives are legally permitted. However, these foods do  
10 not contribute much to the total intake or are not consumed on a regular basis.

11  
12 To overcome the resource intensive analytical determination of food additive concentrations  
13 and a possible bias in the sample population, actual usage data from the food industry may  
14 be used to provide a more realistic dietary exposure assessment. The European  
15 Commission funded project FACET (Flavourings, Additives and food Contact materials  
16 Exposure Task) will facilitate this approach by developing databases of European  
17 consumption data, along with data on food additive concentrations provided by industry.  
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### 20 21 22 23 24 25 26 27 28 29 30 31 32 33 ***Contribution of food groups to dietary intake***

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35 Table 6 shows the contribution of different food groups to the mean dietary exposure to  
36 sulfite, benzoic and sorbic acid for different population groups.  
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39 Overall, minimal differences in the contribution of food groups were found for the total  
40 mean dietary exposure of females and males. For adults, sulfite intake was mainly due to  
41 consumption of wine and dried fruits. The major contributors to sulfite exposure of preschool  
42 children were dried fruits, fruit nectars, and vegetables and mushrooms in vinegar, oil or  
43 brine. These results are comparable to studies carried out in New Zealand and Italy where  
44 high sulfite exposures were typically related to high consumption of dried fruit and wine  
45 (Leclercq et al 2000, Cressey and Jones 2009). Wine contributed to more than 50% to the  
46 total intake of sulfite in Belgium (Vandevijvere et al., 2010) and to 85% in France (Mareschi  
47 et al. 1992). Major contributors to sulfite exposure in Australia and New Zealand were beef  
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3 sausages, dried apricots and cordial for children and white wine, beef sausages and dried  
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5 apricots for adults (FSANZ 2005).  
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7 Benzoic acid exposure for all population groups was mainly due to the consumption  
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9 of fish and fish products, accounting for 43 – 68% in the average intake calculation, and for  
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11 25 – 33% in the high intake scenario. These results might be explained on the one hand by  
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13 the fact that fish and fish products covered in the current study exhibit a large food group  
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15 including also mayonnaise-containing fish salads, and on the other hand by a high  
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17 consumption of fish and fish products (61.9 g for preschool children, 129.9 g for females and  
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19 146.1 g for males). Limited comparative studies were found, however, Leth et al (2010)  
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21 reported a contribution of tuna and pickled herring of 13.8% for the average and 12.8% for  
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23 the high intake calculation.  
24

25 In contrast to other studies which reported non alcoholic flavoured drinks, soft drinks or  
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27 carbonated beverages as the most important contributors to benzoic acid exposure (FSANZ  
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29 2005, Cressey and Jones 2009, Vandevijvere et al. 2009, Leth et al. 2010), this food group  
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31 seems to be less important in our study (6 – 10%). However, a major contributor to benzoic  
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33 acid exposure in the current study was stewed fruit, ranging from 26.7 – 36.1% in the  
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35 average scenario, and 19 – 27.7% in the high intake scenario. However, these results have  
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37 to be interpreted with caution since most of the samples of stewed fruits contained  
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39 cranberries where benzoic acid has been described to be present in higher amounts  
40  
41 (Hegnauer 1966).  
42

43 Most important contributors to sorbic acid exposure for all population groups are  
44  
45 bread, buns, and toast bread (average intake scenario: 8.9 – 12.4%, high intake scenario:  
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47 28 – 34%). Although the values are lower in the current survey, these results are in line with  
48  
49 those from Denmark, where bread is the dominating source of sorbic acid (average intake  
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51 calculation: 46.2%, high intake calculation: 67.8%; Leth et al 2010). Fish and fish products  
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53 were the major contributors to the average and high intake of sorbic acid, ranging from  
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55 38% – 47 % and 27% – 29 %, respectively. As already mentioned above, this food group  
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57 also contains mayonnaise-containing fish salads, therefore a direct comparison to results  
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3 from other studies does not seem to be feasible. Dressings and mayonnaise contributed to a  
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5 maximum of 19.5% to the average intake of sorbic acid in adults which is slightly higher than  
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7 reported in Denmark (13.7%; Leth et al. 2010). In the high intake scenario, the contribution of  
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9 fruit and vegetable juices to sorbic acid exposure was 29.5% in preschool children, 10.5% in  
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11 females, and 12.7% in males. Australia and New Zealand reported that the major food  
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13 contributing to dietary sorbic acid exposure is orange juice (FSANZ 2005, Cressey and  
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15 Jones 2009). The contribution of non alcoholic drinks (around 10%) is consistent with results  
16  
17 from Denmark where an average intake of soft drinks contributed to 10.3% to the total intake  
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19 of sorbic acid (Leth et al. 2010).  
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### 23 **Conclusions**

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25 In this study, levels of sulfites, benzoic and sorbic acid in various food samples were  
26  
27 analysed, and dietary exposures for 3 different population groups were assessed. In  
28  
29 conclusion, it was shown that mean estimated daily intakes for average consumers are within  
30  
31 the respective acceptable daily intakes. In the high intake scenario, dietary exposures  
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33 exceeded the ADI for sulfites for female and male adults, mainly due to consumption of wine.  
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35 Hence, the estimated daily intake of sulfites for preschool children was lower, not exceeding  
36  
37 the ADI. Mean estimated intakes of benzoic acid were slightly above the ADI for high  
38  
39 consumers in all population groups whereas estimated dietary exposures of sorbic acid were  
40  
41 well below the ADI.  
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43  
44 Based on the current food consumption data and occurrence levels, it can be  
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46 concluded, that the risk of exceeding the ADI for consumers that randomly consume foods  
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48 that contain preservatives or not is low. However, even if the ADI is exceeded on occasion  
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50 this does not necessarily pose a health risk to consumers since the acceptable daily intake  
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52 refers to a life time exposure of the consumer. Concerns may be raised especially in case of  
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54 individuals with unbalanced diet who consume preferentially preservative containing foods.  
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Table 1: Concentrations of preservatives in different foods (mg kg<sup>-1</sup> or mg l<sup>-1</sup>)

Food	Sulfite				Benzoic acid				Sorbic acid			
	No. of samples	No. of samples > LOQ	Average concentration	Average concentration*	No. of samples	No. of samples > LOQ	Average concentration	Average concentration*	No. of samples	No. of samples > LOQ	Average concentration	Average concentration*
Beer, alcoholic beverages with beer	8	0	0	0	9	1	2.4	21.8	9	3	0.9	2.6
Bread, buns, toast bread	-	-	-	-	47	0	0	0	47	4	62.3	729.8
Candied fruits	8	4	19.9	38.7	-	-	-	-	-	-	-	-
Confectionary	-	-	-	-	10	0	0	0	12	5	86.4	204.2
Dressing, mayonnaise	-	-	-	-	43	5	68.2	585.6	45	33	739.8	1008.8
Dried fruits	119	50	143.2	339.5	33	2	8.9	138.6	37	23	253.5	407.2
Fermentation vinegar	89	37	9.7	22.8	-	-	-	-	-	-	-	-
Fish, fish products	10	5	7.6	14.8	97	47	350	719.9	97	37	267.5	700.8
Fruit and vegetable juices	21	2	2.1	5.7	74	3	8.6	210.7	74	1	0.1	7.8
Fruit nectars	23	1	2	6.5	80	2	0.7	23.2	80	2	0.2	8.8
Jam, jelly, marmalades, fruit-based spreads	267	78	4.3	13.5	663	41	29.1	465	670	180	118.5	440.5
Muesli	3	0	0	0	-	-	-	-	-	-	-	-
Mustard	2	0	0	0	56	2	7.6	195.5	56	2	4.2	118.5
Non-alcoholic drinks	62	1	1.9	5.2	420	85	14.5	69.8	420	83	15	75.6
Prepared salads	-	-	-	-	105	67	212.7	333.2	105	83	412.4	521.7
Raw sausages	-	-	-	-	21	0	0	0	21	10	35.1	73.6

Sauces	8	2	5.2	19.8	49	5	32.8	318.8	49	12	124.9	509.8
Seasonings, condiments	31	8	16.6	60.5	10	5	148.8	297.5	10	4	206	514.7
Shrimps, crustaceans, molluscs	-	-	-	-	12	8	693.2	1039.7	12	4	247.5	742.5
Soups	1	0	0	0	8	0	0	0	8	0	0	0
Soy products	-	-	-	-	16	1	6.4	96.9	16	0	0	0
Spreads	-	-	-	-	60	11	35.5	188.1	60	28	363.8	779.5
Stewed fruit	15	2	1.1	5.8	67	25	216.4	579.5	66	0	0	0
Tomato ketchup, tomato puree	-	-	-	-	22	8	287.6	788.7	22	2	44.2	486
Vegetables and mushrooms in vinegar, oil or brine	15	5	22	64	88	15	96	558.6	88	7	32.4	407.9
Wines	316	309	90.4	92.4	2	0	0	0	2	1	51.5	103

\*Average concentration of samples containing a content of the food additive >LOQ



Table 2: Estimated daily intake ( $\text{mg kg}^{-1}$  body weight  $\text{day}^{-1}$ ) of sulfite, benzoic acid and sorbic acid and % ADI for different Austrian population groups assuming that consumers randomly consume foods that contain the respective preservative or not.

Food	Sulfite			Benzoic acid			Sorbic acid		
	Preschool children Mean (95 perc.)	Females Mean (95 perc.)	Males Mean (95 perc.)	Preschool children Mean (95 perc.)	Females Mean (95 perc.)	Males Mean (95 perc.)	Preschool children Mean (95 perc.)	Females Mean (95 perc.)	Males Mean (95 perc.)
Beer, alcoholic beverages with beer	-	-	-	-	0.02 (0.04)	0.03 (0.07)	-	0.01 (0.02)	0.01 (0.03)
Bread, buns, toast bread	-	-	-	-	-	-	0.22 (0.48)	0.13 (0.27)	0.13 (0.27)
Candied fruits	-	0.01 (0.02)	-	-	-	-	-	-	-
Confectionary	-	-	-	-	-	-	0.11 (0.31)	0.05 (0.14)	0.05 (0.13)
Dressing, mayonnaise	-	-	-	-	0.03 (0.06)	0.02 (0.06)	-	0.28 (0.62)	0.26 (0.63)
Dried fruits	0.12 (0.50)	0.07 (0.24)	0.07 (0.52)	0.01 (0.03)	0.004 (0.01)	0.004 (0.03)	0.22 (0.89)	0.13 (0.42)	0.13 (0.92)
Fermentation vinegar	0.001 (0.002)	0.003 (0.01)	0.002 (0.01)	-	-	-	-	-	-
Fish, fish products	0.02 (0.05)	0.02 (0.03)	0.02 (0.03)	1.08 (2.45)	0.76 (1.23)	0.73 (1.50)	0.83 (1.87)	0.58 (0.94)	0.56 (1.15)
Fruit and vegetable juices	0.02 (0.05)	0.01 (0.02)	0.01 (0.03)	0.08 (0.22)	0.03 (0.07)	0.03 (0.11)	0.001 (0.003)	0.0003 (0.001)	0.0004 (0.001)
Fruit nectars	0.02 (0.06)	0.01 (0.03)	0.01 (0.03)	0.01 (0.02)	0.004 (0.01)	0.004 (0.01)	0.002 (0.01)	0.001 (0.003)	0.001 (0.003)
Jam, jelly, marmalade, fruit-based spreads	0.003 (0.01)	0.002 (0.004)	0.003 (0.01)	0.02 (0.06)	0.01 (0.02)	0.02 (0.09)	0.07 (0.23)	0.06 (0.10)	0.08 (0.35)
Mustard	-	-	-	0.001 (0.005)	0.002 (0.01)	0.002 (0.01)	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)
Non-alcoholic drinks	0.02 (0.06)	0.01 (0.03)	0.02 (0.04)	0.14 (0.47)	0.11 (0.24)	0.13 (0.31)	0.14 (0.49)	0.11 (0.25)	0.13 (0.32)
Raw sausages	-	-	-	-	-	-	0.04 (0.11)	0.03 (0.06)	0.03 (0.08)
Sauces	0.002 (0.01)	0.002 (0.01)	0.002 (0.01)	0.01 (0.05)	0.01 (0.04)	0.01 (0.04)	0.05 (0.17)	0.05 (0.15)	0.05 (0.13)
Soy products	-	-	-	-	0.01 (0.02)	0.01 (0.03)	-	-	-
Stewed fruit	-	0.003 (0.01)	0.002 (0.004)	-	0.64 (1.51)	0.42 (0.77)	-	-	-
Tomato ketchup, tomato puree	-	-	-	0.11 (0.40)	0.09 (0.24)	0.10 (0.30)	0.02 (0.06)	0.01 (0.04)	0.02 (0.05)
Vegetables and mushrooms in vinegar, oil or brine	0.03 (0.09)	0.01 (0.04)	0.01 (0.05)	0.13 (0.37)	0.06 (0.16)	0.06 (0.21)	0.04 (0.13)	0.02 (0.05)	0.02 (0.07)
Wines	-	0.43 (0.94)	0.48 (1.29)	-	-	-	-	-	-
<b>Total Mean (% ADI)</b>	<b>0.24 (34.4)</b>	<b>0.59 (83.6)</b>	<b>0.62 (89.0)</b>	<b>1.59 (31.8)</b>	<b>1.78 (35.6)</b>	<b>1.57 (31.4)</b>	<b>1.75 (7.0)</b>	<b>1.46 (5.8)</b>	<b>1.47 (5.9)</b>

Table 3: Estimated daily intake ( $\text{mg kg}^{-1}$  body weight  $\text{day}^{-1}$ ) of sulfite, benzoic acid and sorbic acid and % ADI for different Austrian population groups assuming that consumers always consume foods that contain quantifiable amounts of the respective preservative.

Food	Sulfite			Benzoic acid			Sorbic acid		
	Preschool children Mean (95 perc.)	Females Mean (95 perc.)	Males Mean (95 perc.)	Preschool children Mean (95 perc.)	Females Mean (95 perc.)	Males Mean (95 perc.)	Preschool children Mean (95 perc.)	Females Mean (95 perc.)	Males Mean (95 perc.)
Beer, alcoholic beverages with beer	-	-	-	-	0.19 (0.36)	0.24 (0.62)	-	0.02 (0.04)	0.03 (0.07)
Bread, buns, toast bread	-	-	-	-	-	-	2.54 (5.58)	1.51 (3.19)	1.55 (3.13)
Candied fruits	-	0.03 (0.03)	-	-	-	-	-	-	-
Confectionary	-	-	-	-	-	-	0.27 (0.74)	0.12 (0.34)	0.13 (0.31)
Dressing, mayonnaise	-	-	-	-	0.23 (0.49)	0.21 (0.50)	-	0.39 (0.84)	0.35 (0.86)
Dried fruits	0.29 (1.19)	0.17 (0.57)	0.17 (1.23)	0.12 (0.49)	0.07 (0.23)	0.07 (0.50)	0.35 (1.43)	0.21 (0.68)	0.20 (1.47)
Fermentation vinegar	0.003 (0.01)	0.01 (0.01)	0.01 (0.01)	-	-	-	-	-	-
Fish, fish products	0.05 (0.10)	0.03 (0.05)	0.03 (0.06)	2.23 (5.04)	1.56 (2.52)	1.50 (3.09)	2.17 (4.91)	1.52 (2.45)	1.46 (3.00)
Fruit and vegetable juices	0.05 (0.14)	0.02 (0.05)	0.02 (0.07)	2.00 (5.27)	0.65 (1.77)	0.75 (2.58)	0.07 (0.20)	0.02 (0.07)	0.03 (0.10)
Fruit nectars	0.07 (0.20)	0.04 (0.11)	0.04 (0.09)	0.26 (0.70)	0.14 (0.39)	0.14 (0.33)	0.10 (0.26)	0.05 (0.15)	0.05 (0.13)
Jam, jelly, marmalade, fruit-based spreads	0.01 (0.03)	0.01 (0.01)	0.01 (0.04)	0.29 (0.88)	0.23 (0.39)	0.30 (1.36)	0.27 (0.84)	0.22 (0.37)	0.29 (1.29)
Mustard	-	-	-	0.04 (0.12)	0.05 (0.13)	0.06 (0.14)	0.02 (0.07)	0.03 (0.08)	0.03 (0.08)
Non-alcoholic drinks	0.05 (0.17)	0.04 (0.09)	0.05 (0.11)	0.67 (2.27)	0.51 (1.16)	0.60 (1.49)	0.73 (2.46)	0.56 (1.26)	0.65 (1.62)
Raw sausages	-	-	-	-	-	-	0.09 (0.22)	0.06 (0.12)	0.07 (0.16)
Sauces	0.01 (0.03)	0.01 (0.02)	0.01 (0.02)	0.12 (0.45)	0.12 (0.37)	0.13 (0.34)	0.19 (0.71)	0.19 (0.59)	0.20 (0.55)
Soy products	-	-	-	-	0.13 (0.24)	0.14 (0.42)	-	-	-
Stewed fruit	-	0.01 (0.04)	0.01 (0.02)	-	1.72 (4.03)	1.12 (2.07)	-	-	-
Tomato ketchup, tomato puree	-	-	-	0.30 (1.10)	0.25 (0.67)	0.27 (0.82)	0.19 (0.68)	0.16 (0.41)	0.17 (0.50)
Vegetables and mushrooms in vinegar, oil or brine	0.09 (0.25)	0.04 (0.11)	0.04 (0.14)	0.75 (2.18)	0.35 (0.93)	0.36 (1.20)	0.55 (1.59)	0.26 (0.68)	0.26 (0.87)
Wines	-	0.44 (0.96)	0.49 (1.32)	-	-	-	-	-	-
<b>Total Mean (% ADI)</b>	<b>0.61 (87.8)</b>	<b>0.83 (119.1)</b>	<b>0.87 (123.9)</b>	<b>6.77 (135.5)</b>	<b>6.20 (124.0)</b>	<b>5.90 (118.0)</b>	<b>7.53 (30.1)</b>	<b>5.31 (21.2)</b>	<b>5.49 (22.0)</b>

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Table 4: Mean estimated daily intake ( $\text{mg kg}^{-1}$  body weight  $\text{day}^{-1}$ ) of sulfite, benzoic and sorbic acid and % ADI for children and adults: Scenario 1.

Scenario 1						
(Consumers randomly consume foods that contain the respective preservative or not)						
Food-additive	Preschool children		Females		Males	
	Mean	% ADI	Mean	% ADI	Mean	% ADI
Sulfite	0.24	34.4	0.59	83.6	0.62	89.0
Benzoic acid	1.59	31.8	1.78	35.6	1.57	31.4
Sorbic acid	1.75	7.0	1.46	5.8	1.47	5.9

Table 5: Mean estimated daily intake ( $\text{mg kg}^{-1} \text{body weight day}^{-1}$ ) of sulfite, benzoic and sorbic acid and % ADI for children and adults: Scenario 2.

Scenario 2 (Consumers always consume foods that contain quantifiable amounts of the respective preservative)						
Food additive	Preschool children		Females		Males	
	Mean	% ADI	Mean	% ADI	Mean	% ADI
Sulfite	0.61	87.8	0.83	119.1	0.87	123.9
Benzoic acid	6.77	135.3	6.20	124.0	5.90	118.0
Sorbic acid	7.53	30.1	5.31	21.2	5.49	22.0

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Table 64: Food groups contribution (%) to mean dietary exposure to sulfite, benzoic and sorbic acid.

Food	% contribution to mean dietary exposure (scenario 1/scenario 2)								
	Sulfite			Benzoic acid			Sorbic acid		
	Preschool children	Females	Males	Preschool children	Females	Males	Preschool children	Females	Males
Beer, alcoholic beverages with beer	—	—	—	—	1.2/3.0	1.7/4.1	—	0.5/0.4	0.7/0.5
Bread, buns, toast bread	—	—	—	—	—	—	12.4/33.8	8.9/28.5	9.0/28.2
Candied fruits	—	2.4/3.2	—	—	—	—	—	—	—
Confectionary	—	—	—	—	—	—	6.6/3.6	3.5/2.2	3.7/2.4
Dressing, mayonnaise	—	—	—	—	1.5/3.6	1.5/3.5	—	19.5/7.3	17.7/6.5
Dried fruits	50.6/47.0	12.4/20.6	11.5/19.6	0.5/1.7	0.3/1.1	0.3/1.2	12.3/4.6	8.8/3.9	8.6/3.7
Fermentation vinegar	0.5/0.5	0.4/0.7	0.4/0.6	—	—	—	—	—	—
Fish, fish products	9.8/7.5	2.8/3.8	2.5/3.6	68.1/32.9	42.6/25.1	46.5/25.5	47.4/28.8	39.7/28.6	38.0/26.6
Fruit and vegetable juices	8.3/8.8	1.1/2.1	1.2/2.3	5.1/29.5	1.5/10.5	1.9/12.7	0.1/1.0	0.0/0.5	0.0/0.5
Fruit nectars	9.1/11.6	2.1/4.8	2.0/4.7	0.5/3.8	0.2/2.3	0.3/2.5	0.1/1.3	0.1/1.0	0.1/1.0
Jam, jelly, marmalade, fruit-based spreads	1.1/1.4	0.4/0.8	0.5/1.0	1.1/4.2	0.8/3.7	1.2/5.2	4.2/3.6	4.0/4.1	5.3/5.3
Mustard	—	—	—	0.1/0.5	0.1/0.9	0.1/1.0	0.0/0.3	0.1/0.6	0.1/0.6
Non-alcoholic drinks	7.6/8.1	2.4/4.6	2.6/5.2	8.8/9.9	6.0/8.3	8.0/10.2	8.2/9.6	7.6/10.5	8.8/11.9
Raw sausages	—	—	—	—	—	—	2.4/1.2	2.0/1.2	2.2/1.2
Sauces	0.8/1.2	0.3/0.9	0.3/0.9	0.8/1.8	0.7/1.9	0.8/2.2	2.7/2.6	3.1/3.5	3.4/3.7
Soy products	—	—	—	—	0.5/2.1	0.6/2.4	—	—	—
Stewed fruit	—	0.6/1.4	0.3/1.3	—	36.1/27.7	26.7/19.0	—	—	—
Tomato ketchup, tomato puree	—	—	—	7.0/4.5	5.2/4.1	6.4/4.7	1.0/2.5	1.0/2.9	1.0/3.1
Vegetables and mushrooms in vinegar, oil or brine	12.2/14.0	2.4/4.8	2.3/4.8	8.1/11.1	3.4/5.7	3.9/6.1	2.5/7.3	1.4/4.9	1.4/4.8
Wines	—	72.8/52.3	76.4/56.1	—	—	—	—	—	—