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# Intake of processed foods and selected food additives among teenagers (13-19 years old) of Delhi, India.

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**Abstract:** The present study assessed intake of selected 14 food additives among 311 teenagers (13-19 years old) of Delhi, India. A cross-sectional design was used and intake was assessed using a Food Frequency Questionnaire (FFQ) and 3-day Food Diary. The mean consumption for processed foods and additives was calculated by combining food intake data from the 3-day Food Diary and the percent regular consumers from the FFQ. Significant difference ($p<0.05$) in intakes of sports drink, energy drinks, cakes/pastries and sauces was observed with the younger age group (13-15 years) consuming significantly higher amounts than the older group (16-19 years). Females consumed significantly higher ($p<0.05$) amounts of sauces and males consumed a significantly higher amount of sports drink. Significant difference ($p<0.05$) in intake of Benzoates, Carmoisine, Sunset Yellow FCF and Erythrosine was seen between the two age groups but not between the two sexes. The 13-15 year olds were consuming significantly more ($p<0.05$) quantities of these additives. The mean probable daily intake for all additives was well below the acceptable daily intake (ADI). Only for Sulphites and Erythrosine, the intake for high consumers was 105% and 344% of the ADI respectively. Regular monitoring of intake of food additives is vital. Both consumers and manufacturers of food products need to be sensitized to this issue of food safety. Resource limitations restricted chemical analysis of additive levels in foods.

**Keywords:** food additive, colours, preservatives, exposure assessment, processed foods, antioxidants, sweeteners

## Introduction

Changing lifestyles, food habits, organized food retail market and urbanization are the key factors for increased processed and packaged/convenience food consumption in India **(Kearney, 2010; MOFPI, 2006; Reardon et al., 2003).** With increase in processed food consumption, the intake of food additives has also increased. This is a matter of concern as many of these additives can have adverse effects on human health if consumed in excess **(Suh et al., 2005).** The toxic effects of various food additives have been documented by Joint FAO/WHO Expert Committee on Food Additives (JECFA).

One of the most well-known studies to date eliciting the toxic effects associated with food additive intake is the Southampton study to examine if artificial food colours and preservatives affected childhood behavior in 155, 3-year olds and 144, 8-9 year old children. The authors of the study concluded that artificial colours and/or Sodium Benzoate increased hyperactivity in both groups of children **(EFSA, 2008).**

To assess whether these food additives pose a health hazard, their intake levels needs to be defined **(Poulsen, 1991).** The acceptable daily intake (ADI) used for assessing exposure does not represent an absolute threshold for toxicity. If the intake for an individual or a group of individuals exceeds the ADI, this simply means that there is a reduced margin of safety for the intake by that individual. However, it is a matter of concern if the intake exceeds the ADI for a prolonged period of time **(Walton et al., 1999).** The occasions when the ADI is exceeded are probably not frequent for most people but it may be difficult to prevent extreme consumers with bizarre food habits from exceeding the ADI **(Larsen & Richold, 1999).**

Exposure assessment for a food additive is a critical step in determining the risk involved with it **(Ilback & Busk, 2000).** Additives used at high levels in highly consumed foodstuffs, additives which are present in highly consumed foodstuffs, additives having a low ADI i.e. 0-5 mg/kg of body weight/day constitute the priority list of additives whose intake needs to be monitored. A low priority is usually given to additives which have a non specified ADI or to additives used according to good manufacturing practices (GMP) **(CAC, 1996).**

Developed nations of the world regularly monitor the intakes of food additives and contaminants and maintain stringent quality control of their food supply **(FDA, 2006; FSA, 2006; FSANZ, 2005).** For India's developing economy it is vital that the exposure of the population to substances which can potentially cause harm should be monitored.

However, studies in India are few majorly focused on artificial colour intake **(Dixit et al.,**

**2013; Dixit et al., 2010; Mathur & Sharma, 2000; Rao & Sudershan, 2008; Rao et al., 2005; Rao et al., 2004; Tripathi et al., 2010)** and artificial sweetener intake **(Singhal & Mathur, 2008; Tripathi et al., 2006).** Hence there is limited data available on dietary exposure of the population to other chemicals.

So, the present study was designed with the objective to assess the intake of selected food additives among teenagers (13-19 years old) of Delhi. Children and adolescents have always been considered to be a vulnerable group as far as food additives are concerned because of the food choices they make. Many studies have shown higher intake of processed foods among adolescents and children in India **(Gavaravarapu et al., 2009; Goyal et al., 2011; Gupta et al., 2010; Jain et al., 2012; Misra, 2009; Rao et al., 2007; Rustagi et al., 2011; Shrivastav & Thomas, 2009; Singh & Mishra, 2013; Vijayapushpam et al., 2003).**

**Materials and methods**

***The study was conducted in three phases:***

***I.*** *Selection of food additives*: The different food additives and their usage in the food industry were studied along with their toxicological profile. *Inclusion criteria* for additives was: additives having an ADI 0-5mg/kg body weight/day and additives permitted by Food Safety and Standards Authority of India (FSSAI) **(FSSAI, 2013).** *Exclusion criteria* was additives not found on label of food stuffs when the actual market survey was carried out, additives for which the levels of usage in food stuffs was defined as "GMP" as the level of additive in the foodstuff was difficult to determine and beyond the scope of this study. Additives which are also naturally present in foods were also excluded for the same reason.

***II.*** *Market survey*: The market survey was carried out in the city of Delhi which was geographically divided into five zones-North, South, East, West and Central. A total of 17 markets and 23 shops including big grocery stores, supermarkets, health food stores, bakeries, sweetmeat shops, drug stores and ice-cream vendors were covered. Information pertaining to type of products available, different brands and varieties of product available, different pack sizes and additives present in them was recorded. Owners of bakeries and sweetmeat shops were interviewed to see if they used food additives like synthetic colors and artificial sweeteners in their products. They were enquired about the usage levels of these additives in food stuffs.

***III.*** *Intake survey*: The target group selected was teenagers, in the age group of 13-19 years old, studying in public schools/colleges of the city and belonging to middle and high income groups, so that income was not a restricting factor for food purchase and consumption. Prior to conduction of intake survey, ethical clearance was obtained from Institutional Ethical Review Committee. Based on the discretion of the participating school/college authorities and the academic schedule, 370 students were enrolled for the study. The tools selected for conducting the intake survey were Food Frequency Questionnaire (FFQ) and 3-days Food Diary. The tools were selected based on the study **(Lambe et al., 2000)** which showed that when FFQ and 3-day Food Diary were used together, they provided estimates of mean consumer's only intakes comparable to 14-days food record. Pre-testing of tools was done and appropriate modifications were made. The FFQ was explained to the students and with the help of food models and standardized sets of utensils shown for estimating the portion sizes, the respondents filled the FFQ in the presence of the investigator. The 3-days Food Diary was also distributed in the same sitting and instructions for filling the same were given.

***Data analysis*:** Data from the FFQ was treated to categorize respondents into regular, occasional and non-consumers. Mean probable daily intakes for foods were derived based on the data obtained from combined FFQ and 3-days Food Diary. For each food contributing to additive intake, the 3-day mean total population intake from the diary was calculated and divided by the percent consumers for that food from the FFQ. Maximum Permissible Levels (MPL) given by FSSAI **(FSSAI, 2013)** was used for calculating the amount of additive consumed by multiplying the amount of food consumed per day by the MPL for that additive. MPL's have been used for calculating additive content in foods by many regulatory bodies and other studies where theoretical maximum daily intake for additives was calculated **(Bilau et al., 2008; Gisele et al., 2001; Sinkova & Janekova, 2006; Suh et al., 2005; Verger et al., 1998).**Range, mean and standard deviation were calculated for all the additives for the two age groups. The intake for various foods and the additives was compared across the two age groups (13-15 and 16-19 years) and gender wise using independent t-test. High consumers i.e. those with intakes above $95^{th}$ percentile were reported. The mean probable daily intake values of different additives were expressed as percent of ADI values given by Joint FAO/WHO Expert Committee on Food Additives **(JECFA, 2010)** using the actual intake data obtained from 3-days Food Diary. All the analysis was done on MS Excel (2010) and SPSS Version 16.0.

**Results and discussion**

***Phase I- Selection of food additives***

Review of literature was done to narrow down the list of additives which could be included as a part of this study. Earlier 54 food additives were shortlisted from the whole list of food additives given by JECFA based on their ADI being 0-5mg/kg body weight/day. Out of these 22 got eliminated as they were not permissible by FSSAI i.e. Indian regulatory authority, leaving only 32 additives for the purpose of the study. Further based on the exclusion criteria 18 food additives were excluded as they were not found labeled on the package of food products, were present naturally in foods and were used at GMP levels in food stuffs. So a final list of 14 food additives was prepared as shown in Table 1 for the purpose of assessment of intake which included Sulphites, Benzoates, Ferrocyanides, Nitrites, Butylated hydroxyanisole (BHA), Tert-butylated hydroquinone (TBHQ), Saccharin, Erythrosine, Carmoisine, Indigotine, Sunset Yellow FCF, Ponceau 4R, Calcium Disodium Ethylenediaminetetraacetate (EDTA) and Polydimethylsiloxane

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**Table 1 Additives selected for assessment of intake among adolescents**

| INS No. | Additive | ADI (mg/kg b.w/day) | Functional Class | Foods in which its Use is Permitted | MPL (mg/kg) FSSAI |
|---|---|---|---|---|---|
| 220, 221, 222, 223, 224, 225, 539 | Sulphites | 0-0.7 | Antibrowning agent, bleaching agent, preservative, antioxidant | Sausages & meats. | 450 |
| | | | | Fruit juice concentrate. | 1500 |
| | | | | Squashes, crushes, fruit syrups and juices, syrups, sherbets, lozenges. | 350 |
| | | | | Jam, marmalade, canned fruits. | 40 |
| | | | | White sugar, cube sugar, dextrose, *jaggery and misri*, ready to serve beverages, carbonated fruit beverages. | 70 |
| | | | | *Bura, chocolate* | 150 |
| | | | | Canned *rasgolla*, pickles and chutneys. | 100 |
| | | | | Sugar confectionery, chewing gum. | 2000 |
| 900a | Polydimethylsiloxane | 0-1.5 | Antifoaming agent | Edible oils & fats, sugar confectionery. | 10 |
| 385 | Calcium Disodium Ethylenediamine tetra acetate | 0-5 | Sequestrant, preservative | Fat emulsions, salad dressing, sandwich spread or fat spread. | 50 |
| 210, 211, 212, 213 | Benzoates | 0-5 | Antimicrobial preservative | Squashes, crushes, fruit juices, syrups, sherbets. | 750 |
| | | | | Jam, marmalade, preserves, jelly. | 200 |
| | | | | Ready to serve beverages, fat spreads. | 600 |
| | | | | Pickles, *chutneys.* | 120 |
| | | | | Tomato and other sauces. | 250 |
| 535, 536 | Ferrocyanides | 0-0.025 | Anticaking agent | Salts. | 10 |
| 320 | BHA | 0-0.5 | Antioxidant | Edible oils, ghee, butter, fat spreads, dry mixes of rasgollas and vadas. | 0.02%max |
| | | | | Breakfast cereals. | 50 |
| | | | | Chewing gum. | 250 |
| 249, 250 | Nitrites | 0-0.06 | Color fixative | Processed meat products | 200 |

| INS No. | Additive | ADI (mg/kg b.w/day) | Functional Class | Foods in which its Use is Permitted | MPL (mg/kg) FSSAI |
|---|---|---|---|---|---|
| 124 | Ponceau 4R | 0-4 | Synthetic color | Ice-cream & ice lollies, cream biscuits, candies, jams, marmalades, jellies, squashes, fruit bars, carbonated beverages & concentrates, *sharbats*, flavored milk & yoghurt. | 100 |
| 110 | Sunset Yellow FCF | 0-4 | | | |
| 122 | Carmoisine | 0-4 | | | |
| 132 | Indigotine | 0-5 | | | |
| 127 | Erythrosine | 0-0.1 | | | |
| 319 | TBHQ | 0-0.7 | Antioxidant | Edible oils & fats, fat spread, chocolates, soups, soup powders, sugar confectionary, chewing gum. | 20 |
| 954 | Saccharin | 0-5 | Sweetener | Carbonated water, soft drink concentrates. | 100 |
| | | | | Chocolate. | 500 |
| | | | | Sugar based confectionery, chewing gum. | 3000 |
| | | | | *Supari.* | 4000 |
| | | | | *Pan masala.* | 8000 |

***Phase II- Market survey***

The market survey was used to list food products containing the selected food additives. A total of 9 categories of foods like beverages, edible oils and fats, fruit and vegetable products, cereal products, sauces and spreads, desserts, processed meat products, confectioneries and miscellaneous products including sweetener, sweetmeats, betel leaf, betel leaf flavoring and *supari*, salt and sugar were covered under the survey.

***Phase III- Intake survey***

The study was conducted in 5 schools and 2 colleges that gave consent. A total of 370 students were initially recruited in the study, out of which 311 students completed the study.

*Pattern of consumption of processed foods*

Data from the FFQ were used to classify the respondents into regular (those who consumed the food at least once a week), occasional (those who consumed the food once a fortnight or less) and non-consumers (those who do not consume the food). For products like fruit juices, probiotic drinks, crushes, canned fruits, lozenges, table top sweeteners, betel leaf, betel leaf flavoring and *supari* there were no regular consumers. The 16-19 year olds consumed soft drinks, squashes, *sharbats*, ice creams, fruit yoghurt, cakes/pastries, sweetmeats, toffees, chewing gums, pickles, jams, jellies, *chutney*, *murabbas*, biscuits, cream biscuits, breakfast cereals, ketchups, sauces, processed meat products and mayonnaise more regularly than 13-15 year olds. On the other hand flavored milk, soft drink concentrate, sports drink, butter, fruit bars and spreads were consumed on a regular basis more by 13-15 year olds. Salad dressing and energy drinks were consumed on a regular basis equally by respondents from both the age groups. Between the two sexes, more males were consuming squashes, sports drink, butter, fruit bars, breakfast cereals and spreads regularly. On the other hand, flavored milk, soft drink concentrates, soft drinks, *sharbats*, energy drinks, ice creams, fruit yoghurt, cakes/pastries, sweetmeats, toffees, chewing gums, jams, pickles, *chutney*, *murabbas*, biscuits, cream biscuits, processed meat products, ketchups, sauces and mayonnaise had more females as regular consumers.

The mean consumption for all processed foods was calculated by combining the food intake data from the 3-day Food Diary and the percent regular consumers from the FFQ has been presented in Table 2.

The 13-15 year old respondents were consuming significantly higher ($p<0.05$) amounts of sports drink, energy drinks, sauces and cakes/pastries than 16-19 year old respondents (Table 2). Between the two sexes, males were consuming significantly higher ($p<0.05$) amounts of sports drink than females. On the other hand females were consuming significantly higher ($p<0.05$) amounts of sauces than males. No sex difference was seen for the intake of energy drinks and cakes/pastries. Products like crushes, lozenges, jellies, marmalades, probiotic drinks, fruit juices, canned fruits, table top artificial sweetener, betel leaf, sweetmeats, betel leaf flavoring material and *supari* were not consumed by any of the respondents. The mean intake of fruit bars was same across both age groups and sexes i.e. 8.3g/day. The intake of salt

used for cooking or as table salt was found to be 6.9g/CU/day for 13-15 year old respondents and 6.5g/CU/day for 16-19 year old respondents. This does not include salt consumed as an ingredient of salted processed foods like chips, savories etc. Sugar intake reported is restricted to the sugar added by respondents to food and beverages and not the sugar present in processed foods consumed. The mean intake of sugar was 8.4±2.9g/day for 13-15 year olds and 8.5±2.3g/day for 16-19 year olds. There was no significant difference in the intake of sugar between the two age groups and between males and females.

**Table 2 Mean intake of processed foods for respondents.**

| **Food Products** | | **Intake (g/day) 13-15 year olds** | **Intake (g/day) 16-19year olds** | **Intake(g/day) Males** | **Intake(g/day) Females** |
|---|---|---|---|---|---|
| | | **N=115** | **N=196** | **N=152** | **N=159** |
| **Beverages** Flavoured Milk | %Consumers | 14 | 12 | 11 | 13 |
| | Mean±SD | 141.9±60.5 | 145.7±58.5 | 155.7±61.3 | 131.8±57.8 |
| | Range | 60-220 | 60-220 | 60-220 | 60-220 |
| | $P_{95}$ | 220 | 208 | 220 | 180 |
| Soft drink concentrates | %Consumers | 50 | 22 | 18 | 22 |
| | Mean±SD | 9.8±4.5 | 7.0±3.9 | 8.1±4 | 8.7±4.4 |
| | Range | 5-15 | 5-15 | 5-15 | 5-15 |
| | $P_{95}$ | 15 | 15 | 15 | 15 |
| Soft drinks | %Consumers | 42 | 49 | 39 | 52 |
| | Mean±SD | 221.1±142.5 | 210.4±147.2 | 212.8±136.5 | 218.6±153.2 |
| | Range | 83.3-600 | 83.3-600 | 83.3-600 | 83.3-600 |
| | $P_{95}$ | 590.5 | 590.5 | 590.5 | 590.5 |
| Squashes | %Consumers | 4 | 8 | 8 | 6 |
| | Mean±SD | 13.8±1.5 | 13.7±3.2 | 11.6±2.1 | 16.1±3.3 |
| | Range | 10.3-35 | 11.7-35 | 10.3-35 | 11.7-35 |
| | $P_{95}$ | 24.2 | 27.3 | 24.2 | 27.3 |
| *Sharbats* | %Consumers | 10 | 15 | 1 | 16 |
| | Mean±SD | 18.5±4.5 | 25.5±3.2 | 26±0 | 25.6±5.4 |
| | Range | 11-26 | 23.4-30.6 | 26 | 23.4-30.6 |
| | $P_{95}$ | 24.2 | 30.6 | 26 | 30.6 |
| Sports drink | %Consumers | 10 | 7 | 8 | 7 |
| | Mean±SD | *324.8±136.4 | *227.2±79.3 | #286.7±140.6 | #265.4±124.9 |
| | Range | 166.7-500 | 166.7-500 | 166.7-500 | 166.7-500 |
| | $P_{95}$ | 500 | 500 | 500 | 500 |
| Energy drinks | %Consumers | 3 | 3 | 2 | 3 |
| | Mean±SD | *71.8±8.1 | *51.9±9.8 | 56.7±8.4 | 57.6±9.8 |
| | Range | 66.3-111.7 | 11.7-118.3 | 53.3-111.7 | 11.7-118.3 |
| | $P_{95}$ | 83.3 | 108.8 | 111.7 | 117.3 |
| **Desserts** Ice cream | %Consumers | 18 | 25 | 21 | 23 |
| | Mean±SD | 22.6±11.5 | 21.5±11.7 | 20.1±11 | 23±12.2 |
| | Range | 12-48 | 12-45 | 12-48 | 12-45 |
| | $P_{95}$ | 39 | 38 | 38 | 38 |
| Fruit yoghurt | %Consumers | 5 | 13 | 8 | 13 |
| | Mean±SD | 63.3±23.6 | 55.9±35.9 | 60±35.4 | 55.2±44.8 |
| | Range | 62.7-100 | 33.3-100 | 33.3-100 | 33.3-100 |
| | $P_{95}$ | 98.3 | 96.7 | 98.3 | 90.1 |
| Cakes/Pastries | %Consumers | 8 | 12 | 6 | 15 |
| | Mean±SD | *19.3±2.4 | *13.2±3.6 | 16.6±3.0 | 16.9±3.2 |
| | Range | 16.7-25 | 12-20 | 12-20 | 12-25 |

| **Food Products** | | **Intake (g/day) 13-15 year olds** | **Intake (g/day) 16-19year olds** | **Intake(g/day) Males** | **Intake(g/day) Females** |
|---|---|---|---|---|---|
| | | **N=115** | **N=196** | **N=152** | **N=159** |
| | $P_{95}$ | 24.5 | 18.8 | 18.8 | 20 |
| **Edible Oils & Fats** **Vegetable oil | %Consumers | 100 | 100 | 100 | 100 |
| | Mean±SD | 11.2±3.9 | 10.8±3.1 | 10.9±3.6 | 11.1±3.5 |
| | Range | 4.2-22.2 | 4.2-22.2 | 4.2-22.2 | 6.7-20 |
| | $P_{95}$ | 18.1 | 18.1 | 18.1 | 18.3 |
| Butter | %Consumers | 62 | 60 | 64 | 58 |
| | Mean±SD | 5.1±3.5 | 5.4±3.9 | 5.2±3.4 | 5.3±4.0 |
| | Range | 1.7-15 | 1.7-15 | 1.7-15 | 1.7-15 |
| | $P_{95}$ | 12 | 12 | 12 | 12 |
| **Confectioneries** Toffees | %Consumers | 22 | 26 | 22 | 48 |
| | Mean±SD | 5.8±4.8 | 5.9±4.8 | 5.5±3.1 | 6.3±4.8 |
| | Range | 1.7-18.5 | 1.7-18.5 | 1.7-18.5 | 1.7-18.5 |
| | $P_{95}$ | 15.9 | 15.9 | 14.1 | 15.3 |
| Chewing gums | %Consumers | 41 | 58 | 45 | 59 |
| | Mean±SD | 3.4±2.2 | 3.9±2.3 | 3.5±2.4 | 3.7±2.0 |
| | Range | 1.1-14 | 1.1-14 | 1.1-14 | 1.1-14 |
| | $P_{95}$ | 8.1 | 7.0 | 6.3 | 6.6 |
| Fruit bars | %Consumers | 5 | 4 | 5 | 1 |
| | Mean±SD | 8.3±0 | 8.3±0 | 8.3±0 | 8.3±0 |
| | Range | 8.3 | 8.3 | 8.3 | 8.3 |
| | $P_{95}$ | 8.3 | 8.3 | 8.3 | 8.3 |
| **Fruit & Vegetable Products** Pickles | %Consumers | 28 | 35 | 26 | 38 |
| | Mean±SD | 9.2±2.6 | 8.9±2.9 | 8.9±2.6 | 9.2±2.7 |
| | Range | 4-12 | 4-12 | 4-12 | 4-12 |
| | $P_{95}$ | 11 | 11 | 11 | 11 |
| Jams | %Consumers | 35 | 48 | 40 | 46 |
| | Mean±SD | 5.5±2.9 | 5.3±3.4 | 5.5±3.2 | 5.3±3.2 |
| | Range | 2.7-15 | 1.7-15 | 2.7-15 | 1.7-15 |
| | $P_{95}$ | 11.9 | 11.6 | 11.9 | 11.6 |
| Chutney | %Consumers | 7 | 8 | 7 | 1 |
| | Mean±SD | 9.2±1.5 | 10±0 | 9.2±1.7 | 10±0 |
| | Range | 3.3-10 | 10 | 3.3-10 | 10 |
| | $P_{95}$ | 10 | 10 | 10 | 10 |
| **Cereal Products** Breakfast cereals | %Consumers | 41 | 42 | 47 | 38 |
| | Mean±SD | 38.6±19 | 40.8±13.5 | 36.9±15.8 | 42.3±16.7 |
| | Range | 11-64.6 | 11-64.6 | 11-64.6 | 11-64.6 |
| | $P_{95}$ | 64.6 | 64.6 | 64.6 | 64.6 |
| Biscuits | %Consumers | 15 | 30 | 13 | 36 |
| | Mean±SD | 14.8±12.7 | 19.6±13 | 16.3±8.7 | 18.1±17 |
| | Range | 3.3-62.5 | 3.3-66.7 | 3.3-24 | 3.3-66.7 |
| | $P_{95}$ | 24.7 | 30.0 | 24 | 66.7 |
| Cream biscuits | %Consumers | 11 | 12 | 9 | 16 |
| | Mean±SD | 23.4±19.8 | 16.7±2.9 | 21.2±11.3 | 18.9±11.4 |
| | Range | 1.3-55.6 | 3.3-66.7 | 1.3-55.6 | 3.3-66.7 |
| | $P_{95}$ | 47.7 | 66.7 | 47.7 | 66.7 |
| **Spreads & Sauces** Ketchups | %Consumers | 47 | 52 | 44 | 57 |
| | Mean±SD | 5.8±3.1 | 5.5±2.8 | 5.6±2.8 | 5.7±3.1 |
| | Range | 1.7-10 | 1.7-10 | 1.7-10 | 1.7-10 |
| | $P_{95}$ | 10 | 10 | 10 | 10 |
| Sauces | %Consumers | 3 | 11 | 7 | 9 |
| | Mean±SD | *8.2±0.9 | *3.1±4.1 | #2.2±0.9 | #6.8±4.1 |

| Food Products | | Intake (g/day) 13-15 year olds | Intake (g/day) 16-19year olds | Intake(g/day) Males | Intake(g/day) Females |
|---|---|---|---|---|---|
| | | **N=115** | **N=196** | **N=152** | **N=159** |
| | Range | 1.7-10 | 1.7-10 | 1.7-10 | 1.7-10 |
| | $P_{95}$ | 10 | 10 | 10 | 10 |
| Salad dressing | %Consumers | 2 | 2 | 2 | 2 |
| | Mean±SD | 15±0 | 10±0 | 15±0 | 10±0 |
| | Range | 15 | 10 | 15 | 10 |
| | $P_{95}$ | 15 | 10 | 15 | 10 |
| Mayonnaise | %Consumers | 12 | 20 | 16 | 18 |
| | Mean±SD | 4±1.8 | 4.4±2.7 | 4.2±2.2 | 4.1±2.2 |
| | Range | 3-9 | 3-5.3 | 3-9 | 3-5.3 |
| | $P_{95}$ | 8.4 | 5.3 | 8.4 | 5.3 |
| Spreads | %Consumers | 3 | 2 | 4 | 1 |
| | Mean±SD | 12.5±3.9 | 15±0 | 10±7.1 | 15±0 |
| | Range | 5-15 | 15 | 5-15 | 15 |
| | $P_{95}$ | 15 | 15 | 15 | 15 |
| **Processed Meat Products** | %Consumers | 5 | 7 | 5 | 7 |
| | Mean±SD | 6.9±0 | 6.9±0 | 6.9±0 | 6.9±0 |
| | Range | 6.9 | 6.9 | 6.9 | 6.9 |
| | $P_{95}$ | 6.9 | 6.9 | 6.9 | 6.9 |

- *Significant difference in intake of foods of 13-15 year old and 16-19 year old respondents.
- #Significant difference in intake of foods of male and female respondents.
- **Unit of expression of intake of oil is g/CU/day.
- % Regular consumers were obtained from FFQ.
- N= Total number of respondents.
- $P_{95}$= 95$^{th}$ percentile value depicting high consumers.

*Mean probable daily intake of the selected additives*

The mean probable daily intake for the selected food additives have been obtained by combining the data from 3-day Food Diary and FFQ (Table 3). It was found that 13-15 year old respondents consumed significantly higher ($p<0.05$) amounts of additives like Benzoates, Carmoisine, Sunset Yellow FCF and Erythrosine than 16-19 year old respondents. No significant difference ($p>0.05$) was seen in the intake between males and females. The difference in consumption of Sunset Yellow FCF between the two age groups can be due to significantly higher ($p<0.05$) consumption of sports drink and cakes among 13-15 year old respondents as compared to 16-19 year old respondents. The difference in consumption of Carmoisine and Erythrosine between the two age groups can be due to significantly higher ($p<0.05$) consumption of cakes among 13-15 year old respondents than 16-19 year old respondents. The difference in Benzoic acid intake between the two age groups was due to significantly higher ($p<0.05$) consumption of energy drinks and sauces by 13-15 year old respondents as compared to the 16-19 year old respondents.

The percentage contribution of various food products to the intake of food additives was calculated. It was found that maximum contribution to Benzoate intake was made by soft drinks (40%), to TBHQ intake by edible oils (64%), to BHA intake by breakfast cereals (68%), to Sulphite intake by soft drinks (43%), to Erythrosine intake by flavored milk (61%), to Calcium Disodium EDTA intake by spreads (39%), to Carmoisine intake by flavored milk (50%), to Ponceau 4R intake by flavored milk (65%) and to Sunset Yellow FCF intake by soft drinks (34%). For Polydimethylsiloxane, Ferrocyanides, Indigotine and Nitrite 100% contribution to their intake was made by edible oils, salt, ice-cream and processed meat products respectively. Only 9% of respondents, all females, were not consuming Ferrocyanide. This is because they were consuming unprocessed rock salt instead of iodized sa

**Table 3 Mean probable daily additive intake of the respondents.**

| **Additive** | | **Intake 13-15 year olds (mg/kg b.w./day)** | **Intake 16-19 year olds (mg/kg b.w./day)** | **Intake Males (mg/kg b.w./day)** | **Intake Females (mg/kg b.w./day)** |
|---|---|---|---|---|---|
| | | **N=115** | **N=196** | **N=152** | **N=159** |
| Sulphites | %Consumers | 77 | 87 | 83 | 84 |
| | Mean±SD | 0.22±0.28 | 0.24±0.23 | 0.23±0.27 | 0.22±0.28 |
| | Range | 0.01-1.05 | 0.01-1.07 | 0.01-1.05 | 0.01-1.07 |
| | $P_{95}$ | 0.77 | 0.81 | 0.77 | 0.81 |
| Calcium Disodium EDTA | %Consumers | 28 | 36 | 31 | 35 |
| | Mean±SD | 0.01±0.01 | 0.02±0.01 | 0.01±0.02 | 0.02±0.01 |
| | Range | 0.01-0.02 | 0.01-0.03 | 0.01-0.02 | 0.01-0.03 |
| | $P_{95}$ | 0.02 | 0.03 | 0.02 | 0.03 |
| Polydimethylsiloxane | %Consumers | 100 | 98 | 100 | 97 |
| | Mean±SD | 0.002±0.005 | 0.002±0.001 | 0.002±0.005 | 0.002±0.001 |
| | Range | 0.001-0.006 | 0.001-0.005 | 0.001-0.006 | 0.001-0.006 |
| | $P_{95}$ | 0.006 | 0.005 | 0.006 | 0.006 |
| Ferrocyanides | %Consumers | 98 | 98 | 100 | 97 |
| | Mean±SD | 0.002±0.006 | 0.001±0.004 | 0.001±0.005 | 0.002±0.005 |
| | Range | 0.001-0.003 | 0.001-0.002 | 0.001-0.003 | 0.001-0.003 |
| | $P_{95}$ | 0.003 | 0.002 | 0.003 | 0.003 |
| Benzoates | %Consumers | 87 | 90 | 89 | 89 |
| | Mean±SD | *0.37±0.41 | *0.29±0.31 | 0.33±0.39 | 0.33±0.34 |
| | Range | 0.02-1.88 | 0.02-1.93 | 0.02-1.61 | 0.02-1.93 |
| | $P_{95}$ | 1.18 | 1.10 | 0.98 | 1.30 |
| TBHQ | %Consumers | 100 | 98 | 100 | 97 |
| | Mean±SD | 0.005±0.003 | 0.005±0.002 | 0.005±0.002 | 0.005±0.002 |
| | Range | 0.002-0.013 | 0.001-0.012 | 0.001-0.012 | 0.002-0.013 |
| | $P_{95}$ | 0.011 | 0.007 | 0.008 | 0.009 |
| BHA | %Consumers | 70 | 68 | 67 | 89 |
| | Mean±SD | 0.04±0.03 | 0.04±0.02 | 0.04±0.02 | 0.04±0.03 |
| | Range | 0.01-0.09 | 0.01-0.09 | 0.01-0.09 | 0.01-0.09 |
| | $P_{95}$ | 0.08 | 0.08 | 0.08 | 0.09 |
| Carmoisine | %Consumers | 56 | 69 | 66 | 62 |
| | Mean±SD | *0.05±0.09 | *0.03±0.05 | 0.04±0.08 | 0.04±0.07 |
| | Range | 0.01-0.49 | 0.01-0.39 | 0.01-0.49 | 0.01-0.39 |
| | $P_{95}$ | 0.20 | 0.11 | 0.18 | 0.12 |
| Ponceau 4R | %Consumers | 17 | 33 | 20 | 34 |
| | Mean±SD | 0.04±0.05 | 0.04±0.05 | 0.05±0.05 | 0.05±0.04 |
| | Range | 0.01-0.29 | 0.01-0.29 | 0.01-0.29 | 0.01-0.29 |
| | $P_{95}$ | 0.12 | 0.17 | 0.14 | 0.15 |
| Sunset Yellow FCF | %Consumers | 60 | 65 | 57 | 69 |
| | Mean±SD | *0.33±0.39 | *0.22±0.30 | 0.26±0.33 | 0.29±0.33 |
| | Range | 0.01-1.46 | 0.01-1.56 | 0.01-1.46 | 0.01-1.56 |
| | $P_{95}$ | 1.06 | 1.12 | 1.06 | 1.12 |
| Indigotine | %Consumers | 1 | 2 | 2 | 1 |
| | Mean±SD | 0.04±0 | 0.05±0.01 | 0.04±0.01 | 0.04±0 |
| | Range | 0.04 | 0.03-0.10 | 0.04-0.10 | 0.04 |
| | $P_{95}$ | 0.04 | 0.10 | 0.10 | 0.04 |
| Erythrosine | %Consumers | 17 | 23 | 16 | 25 |
| | Mean±SD | *0.09±0.04 | *0.06±0.04 | 0.09±0.04 | 0.08±0.01 |
| | Range | 0.01-0.47 | 0.01-0.37 | 0.01-0.47 | 0.01-0.37 |
| | $P_{95}$ | 0.36 | 0.23 | 0.36 | 0.23 |
| Saccharin | %Consumers | 3 | 4 | 3 | 3 |

| Additive | | Intake 13-15 year olds (mg/kg b.w./day) | Intake 16-19 year olds (mg/kg b.w./day) | Intake Males (mg/kg b.w./day) | Intake Females (mg/kg b.w./day) |
|---|---|---|---|---|---|
| | | **N=115** | **N=196** | **N=152** | **N=159** |
| | Mean±SD | 0.22±0 | 0.20±0.03 | 0.19±0.01 | 0.25±0.05 |
| | Range | 0.22 | 0.17-0.29 | 0.19-0.20 | 0.17-0.29 |
| | $P_{95}$ | 0.22 | 0.29 | 0.20 | 0.29 |
| Nitrites | %Consumers | 14 | 7 | 12 | 9 |
| | Mean±SD | 0.03±0.01 | 0.02±0.01 | 0.02±0.01 | 0.03±0.01 |
| | Range | 0.02-0.04 | 0.01-0.04 | 0.02-0.03 | 0.02-0.04 |
| | $P_{95}$ | 0.03 | 0.03 | 0.03 | 0.03 |

- [*] Significant difference in intake of additives of 13-15 year olds and 16-19 year old respondents
- [#]Significant difference in intake of additives of male and female respondents.
- % Regular consumers obtained from FFQ.
- $P_{95}$= 95$^{th}$ percentile value depicting high consumers.

*Comparison of Mean Probable Daily Additive Intake with ADI Values*

The mean probable daily intake for all additives was compared with ADI values given by JECFA **(JECFA, 2010).** This has been presented in Table 4.

It was found that for all the additives the mean intake was well below the ADI. But the intake of high consumers for additives like Sulphites and Erythrosine exceeded the ADI values. Nitrite consumption was about half of the ADI with the major contributor to intake being processed meat products. A study in Belgium has also shown the intake of Nitrites among Belgian (10-19 year olds) respondents to be below the ADI for both average and high consumers **(Temme et al., 2011)**.

The intake of Sulphite for average consumers was 34.2% of the ADI, however for high consumers was 105.1% of the ADI. The intake for 93 percent of the consumers was below the ADI. The major contributor to its intake was soft drinks. The intake of Benzoic acid for average consumers was 7% of the ADI and for high consumers was found out to be 24.2%. The major contributor to its intake was soft drinks. A study in New Zealand estimated dietary exposure to preservatives like Benzoates and Sulphites for 10-19 year old respondents. The intake for both was well below the ADI for average consumers as well as for high consumers. The major contributors were sausages and soft drinks for Sulphite intake and soft drinks for Benzoate intake **(Cressey & Jones, 2009).**

**Table 4 Comparison of mean probable daily intake of additives with ADI.**

| Additive | | Intake (mg/kg/body weight/day) | JECFA ADI Values (mg/kg body weight/day) | % ADI |
|---|---|---|---|---|
| Sulphites | Mean±SD | 0.24±0.26 | 0-0.7 | 34.2 |
| | Range | 0.01-1.07 | | |
| | $P_{95}$ | 0.74 | | |
| Benzoates | Mean±SD | 0.35±0.39 | 0-5 | 7.0 |
| | Range | 0.02-1.93 | | |
| | $P_{95}$ | 1.21 | | |
| Polydimethylsiloxane | Mean±SD | 0.002±0.001 | 0-1.5 | 0.1 |
| | Range | 0.001-0.006 | | |
| | $P_{95}$ | 0.004 | | |
| TBHQ | Mean±SD | 0.005±0.002 | 0-0.7 | 0.7 |
| | Range | 0.003-0.013 | | |
| | $P_{95}$ | 0.01 | | |
| BHA | Mean±SD | 0.04±0.02 | 0-0.5 | 8.0 |
| | Range | 0.01-0.09 | | |
| | $P_{95}$ | 0.08 | | |

| Additive | | Intake (mg/kg/body weight/day) | JECFA ADI Values (mg/kg body weight/day) | % ADI |
|---|---|---|---|---|
| Ferrocyanides | Mean±SD | 0.001±0.001 | 0-0.025 | 5.2 |
| | Range | 0.001-0.003 | | |
| | $P_{95}$ | 0.002 | | |
| Nitrites | Mean±SD | 0.03±0.01 | 0-0.06 | 50 |
| | Range | 0.02-0.04 | | |
| | $P_{95}$ | 0.03 | | |
| Saccharin | Mean±SD | 0.21±0.04 | 0-5 | 4.2 |
| | Range | 0.17-0.29 | | |
| | $P_{95}$ | 0.29 | | |
| Calcium disodium EDTA | Mean±SD | 0.01±0.01 | 0-2.5 | 0.4 |
| | Range | 0.01-0.03 | | |
| | $P_{95}$ | 0.02 | | |
| Sunset Yellow FCF | Mean±SD | 0.27±0.34 | 0-4 | 6.8 |
| | Range | 0.01-1.56 | | |
| | $P_{95}$ | 1.05 | | |
| Carmoisine | Mean±SD | 0.04±0.07 | 0-4 | 1.0 |
| | Range | 0.01-1.56 | | |
| | $P_{95}$ | 1.05 | | |
| Erythrosine | Mean±SD | 0.09±0.01 | 0-0.1 | 90 |
| | Range | 0.01-0.47 | | |
| | $P_{95}$ | 0.34 | | |
| Ponceau 4R | Mean±SD | 0.05±0.05 | 0-4 | 1.2 |
| | Range | 0.01-0.29 | | |
| | $P_{95}$ | 0.22 | | |
| Indigotine | Mean±SD | 0.05±0.04 | 0-5 | 1.0 |
| | Range | 0.03-0.11 | | |
| | $P_{95}$ | 0.10 | | |

The intake of all color additives for average consumers was well below the ADI. However, for high consumers the ADI for Sunset Yellow FCF was 26.3% of ADI as per JECFA specifications. The major contributors to its intake were soft drinks followed by sports drink. For high consumers the ADI for Carmoisine was also 26.3% of ADI given by JECFA. The major contributors to its intake were flavored milk and ice creams. The intake of Erythrosine for high consumers was 344% of the ADI as per JECFA specifications. About 15% of the respondents were consuming this additive above the ADI. The major contributors to its intake were flavored milk, confectionery items and cakes/pastries. A study on risk assessment of permitted synthetic food colors in Hyderabad showed that the mean intake of 6-18 year old respondents was well below the ADI for all synthetic colors. The intake of Sunset Yellow FCF, Tartrazine and Erythrosine for high consumers was 284%, 104% and 200% of the ADI respectively **(Rao & Sudershan, 2008).**

A theoretical calculation was done to estimate the quantity of food which consumers would need to eat in order to exceed the ADI for each food additive. For Sulphites, where the major contributor to its intake is soft drinks, this figure came to 449ml for 13-15 year old respondents and 480ml for 16-19 year old respondents. An intake above 15.7g of fruit bars by 13-15 year old respondents and above 18.4g by 16-19 year old respondents can also lead to an intake exceeding the ADI. Consuming above 20.9g of soft drink concentrate by 13-15 year old respondents and above 22.5g by 16-19 year respondents can also lead to an intake exceeding the ADI. An intake of Sulphites above the ADI for prolonged periods can lead to toxic effects as documented by JECFA like irritation of stomach and intestine, vomiting reflex, hemorrhages **(JECFA, 1965).** It can also lead to bronchoconstriction **(Bush & Montalbano, 2008).**

In order to exceed the ADI of Erythrosine, the intake of the major contributor i.e. flavored milk needs to be above 50.6ml by13-15 year old respondents and above 54.8ml by 16-19 year old respondents. Eating above the ADI for prolonged periods can lead to toxic effects like body weight reduction, tumors, hepatic cirrhosis and diarrhea **(JECFA, 1970).**

The only contributor of Nitrite in the diet was processed meat products. An intake of processed

meat products above 15.2g by 13-15 year old respondents and above 16.9g by 16-19 year old respondents can lead to an intake exceeding the ADI. This can lead to toxic effects like anaphylactic reaction, hypertension **(Hawkins & Katelaris, 2000)**, growth depression and death **(JECFA, 1965).**

In order to exceed the ADI for Saccharin the teenagers need to consume 43g i.e. more than 2 betel leaves a day. A study **(Tripathi et al., 2006)** showed that the intake of Saccharin through betel leaf exceeded the ADI for adults. This can lead to toxic effects like acute poisoning, allergy and growth depression **(JECFA, 1968).**

However, it was found that exceeding the ADI for additives like Benzoates, Polydimethylsiloxane, Ferrocyanide, Carmoisine, Sunset Yellow FCF, Ponceau 4R, Indigotine, Calcium Disodium EDTA, BHA and TBHQ is not feasible as the quantity of foods that the respondents would need to eat in a day in order to exceed the ADI is not possible. However, in a study by **Rao & Sudershan (2008)** was reported that ADI for Sunset Yellow FCF and Tartrazine was exceeded due to the intake of beverages, sweetmeats, confectionery items and desserts. The level of synthetic colors in these products was higher than the maximum permissible levels given by Indian regulatory authorities so the intake exceeded the ADI. Even studies **(Rao et al., 2004; Padmaja et al., 2004)** showed that synthetic colors were present at higher levels than MPL's in food products especially those manufactured by unorganized sector.

Intakes above the ADI, for prolonged periods of time, are a matter of concern **(Walton et al., 1999).** Therefore exposure to these additives needs to be monitored on a regular basis. Consumers need to be educated so that they can make informed food choices to limit their consumption of potentially harmful additives. Even the manufacturers of food products especially in the small scale and unorganized sector needs to be made aware of the ill effects of adding additives in excess.

**Conclusion**

Several Indian studies have shown that with lifestyle transition the consumption of packaged and convenience food is increasing especially among children and adolescents. With increase in consumption of packaged foods, the intake of additives has also increased which is a matter of concern especially because of the presence of small scale and unorganized sector of the food industry which does not necessarily follow good manufacturing practices. The present study is a snapshot study that looked at exposure of teenagers to selected 14 food additives probably posing health risk to the population using maximum permissible levels of additives in food stuffs by local regulatory body of the country. The mean probable daily intake for all additives was well below the ADI however for Sulphites and Erythrosine, the intake for high consumers was 105% and 344% of the ADI respectively. Hence regular monitoring of intake of food additives is vital. Both consumers and manufacturers of food products need to be sensitized to this issue of food safety.

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