INTAKE PATTERN OF SYNTHETIC COLOURS BY DIFFERENT AGE AND SOCIO-ECONOMIC CONSUMER GROUPS OF LUCKNOW, INDIA

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Abstract: Exposure assessment of synthetic food colours in different age and socioeconomic groups of consumers revealed that on average intake of food commodities, only Erythrosine exceeded the acceptable daily intake (ADI) limit in the 1–10 and 11–20 years age groups through sugar toys on both normal (19–115%) and festive occasions (8–236%). However, on maximum likely intake of foods, Sunset Yellow FCF, Tartrazine, Carmoisine and Erythrosine were found to exceed the ADI limits several times, ranging between 14–1, 138% in 1–10 year and 45–765% in 11–20 year age subjects. Among foods predominantly consumed by children, crushed ice, ice-candy, ice cream, beverages, sweets and sugar toys were identified as the culprits leading to excessive intake of colours. The permitted levels of colours allowed in food commodities, need to be reviewed periodically and should be governed by technological necessity and the consumption profiles of the food commodity so that colours do not cross the prescribed ADI-based safety umbrella and pose a threat to vulnerable populations.

Keywords: food colours; exposure assessment; ADI; acceptable daily intake; vulnerable consumers.

INTRODUCTION

Food intake studies are carried out for the formulation of nutrition policy and food chemical intake assessments (Gibney, 1999). Dietary pattern provides the background information to determine the maximum permitted level (MPL) for the approval for use of a chemical or an additive in food (Miguel, 1998). Also, the intake data forms the baseline information for implementing monitoring programmes to update the available knowledge on the safety of current exposure to potentially harmful substances in foods or the risk of unbalanced diets (Conacher et al., 1989; Gilsenan et al., 2003; James et al., 1998; Turrini et al., 1991).

Although, additives are required as technological necessities for certain desirable characteristics in foods, there has been a constant concern about the potential

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toxicological risk associated with daily exposures to these chemicals in the diet. The safety assessment of approved food additives is ensured by national and international bodies such as the Scientific Committee on Food Additives (SCF) in the European Union, US-FDA and the FAO-WHO Joint Expert Committee on Food Additives (JECFA) (Burdock, 1996). The outcome of such a risk assessment is the derivation of an acceptable daily intake (ADI) value of that particular additive. The ADI value serves as an upper limit and refers to the amount of the food additive that can be taken daily in the diet, over a lifetime, without any health risk. Thus, if the intake of an additive is well within its ADI, it is reasonable to assume that there is no cause for concern. However, if intake exceeds the ADI limit, it is then necessary to take remedial measures such as to reduce levels of the additive in foods or reduce the range of foods in which this additive is permitted.

The calculation of an ADI is followed by the authorisation for use of the additive in different foodstuffs and their potential intake (Fondu, 1992). Thus, the intake studies are of fundamental importance to maintain adequate safety of foods (Lindsay, 1986; Loukary et al., 1990; Macdonald, 1991). Many of the developed countries have undertaken national level surveillance to collect information on food additive intakes (FSA, 2000; Leclercq et al., 1999, 2000; NZFSA, 2008; Rhodes et al., 1991). However, no such organised programmes have been launched by food regulatory authorities in many of the developing countries.

Colours form a major class among food additives in India and many location-based studies on the pattern of use of colours have been conducted which show product and area specific variations in the use of colours (Biswas et al., 1994; Dixit et al., 1995; Jonnalagadda et al., 2004; Khanna et al., 1973, 1985; Tripathi et al., 2007). Recently in one study, exposure assessment to food colours in a selected population around the city of Hyderabad has been attempted (Rao et al., 2004).

The ADI of the food colours recommended by JECFA varies from 0.1 to 25 mg kg^{-1} body weight, that is, a difference of 250 times (JECFA, 2003). Against this wide variation of ADI, fixing a uniform permissible limit of 100 ppm for all food colours in different foods under the Indian food rules appears unrealistic (PFA, 2008). Primarily, this is due to a lack of dietary intake data in the Indian context. Hence, the actual intake of colours from various coloured foods has to be evaluated so as to evolve a scientific yardstick to fix technology and safety-based levels of colours on a commodity-to-commodity basis. The present study describes the intake pattern of commonly used synthetic colours through various foodstuffs in different age and socioeconomic groups of populations in order to identify the typical foods and colours which have scope for exceeding ADI limits and thus need immediate attention.

MATERIAL AND METHODS

Reagents

Among the eight food colours permitted in India, Carmoisine (CI 14720), Erythrosine (CI 45430), Indigo Carmine (CI 73015), Ponceau 4R (CI 16255), Sunset Yellow FCF (SSYFCF) (CI 15985) and Tartrazine (CI 19140) were purchased from Hickson and Dadaji, Mumbai, India while Brilliant Blue FCF (BBFCF) (CI 42090) and Fast Green FCF (FGFCF) (CI 42053) were gifted by Bush Boake Allen, Chennai, India. Among the commonly encountered six non-permitted colours in India, Auramine (CI 41000), Blue VRS (CI 42045), Malachite Green (CI 42000) and Orange II (CI 15510) were procured from Vesco Products Co., Kolkata, India; Metanil Yellow (CI 13065) was the product from Lobachemie, Indoaustranal Co. Mumbai and Rhodamine B (CI 45170) was obtained from S.D.Fine Chemicals, Mumbai, India.

ExelaR grade acetic acid and liquor ammonia (specific. gravity 0.91) and HPLC grade ammonium acetate were sourced from Qualigens, Mumbai, India. GR grade petroleum ether and trisodium citrate were the product from Merck Limited, Mumbai, India. HPLC grade acetonitrile was purchased from Fisher Scientific, Fair Lawn, New Jersey. Whatman Number 1 chromatography grade paper was procured from Whatman International Ltd., Maidstone, England. All the other chemicals used in the study were of analytical grade and obtained from commercial sources.

Consumption survey of coloured foods

This study was sponsored by Ministry of Food Processing Industries (MFPI), Government of India to assess intake pattern of food colours from three locations of the country namely, Lucknow, Hyderabad and Mysore. Replicate analysis of the spiked coloured food samples was first undertaken as a part of an inter-laboratory quality assurance programme among three participating centres. The samples were exchanged and the analysis of synthetic colours was undertaken by each laboratory. The results were comparable and hence for further analysis the identified method was used.

The food consumption data were collected through a household survey. As the food intake pattern varies during normal and festive occasions and to some extent in two major seasons, the survey was conducted during summer and winter (normal period) and during festive occasions, for example, Dussherra, Deepawali, Christmas, Id, Holi and marriages, birthdays and various celebrations. The target populations covered during normal periods consisted of 314 families from urban and 200 families from rural areas comprising of a total of 514 families with 2,771 subjects. The distribution of chosen families and subjects among each of the urban and rural set-up were based on monthly household income and were subdivided into low income group (LIG), middle income group (MIG) and high income group (HIG). The LIG had income up to Rs 10,000, MIG Rs 10,000–25,000 and HIG above Rs 25,000. In urban areas, 100 HIG, 114 MIG and 100 LIG families comprising of 1,638 and in rural populations, 100 families each of MIG and LIG having 1,133 subjects were surveyed. In festivals and special functions, 378 families were taken covering 273 families with 1,442 subjects from urban and 105 families with 583 subjects from rural areas consisting of a total of 2,025 subjects (Table 1).

These income groups were divided into four age groups '1–10', '11–20', '21–30' and 31 years plus. The intake survey was accomplished through the food frequency recall (FFR) method (Burdock, 1996). The tool employed during the survey was a food frequency questionnaire (FFQ) to elicit information on the habitual frequency of consumption and approximate portion sizes consumed by the individual members. In each family, the mother was preferably interviewed to give detailed information on intake of coloured foods at the household level. The questionnaire was designed to seek information about the respondent's name, age and gender followed by the questions on the consumption of specified foodstuffs including the amount and frequency of the products consumed. The brand of all the packaged products consumed was noted including

Table 1 Number of families and subjects surveyed from urban and rural populations to assess intake of coloured eatables during normal periods and festive occasions

	Urban		Rural	
Group	Families	Subjects	Families	Subjects
Normal periods				
HIG	100	490	Nil	Nil
MIG	114	582	100	553
LIG	100	566	100	580
Total	314	1638	200	1133
Festive occasions				
HIG	73	357	Nil	Nil
MIG	100	519	54	288
LIG	100	566	51	295
Total	273	1442	105	583

Note: HIG: High income group; MIG: Middle income group; LIG Low income group.

the variety and flavour, colour and package size. In case of non-branded or unpackaged (loose) products, the displayed variety, flavour, colour and quantity purchased (instead of package size) were enquired.

Portion sizes or quantities of food items consumed were recorded using standard stainless steel measuring vessels. This helped to estimate the quantities of foods like halwa, kheer, custard, etc. consumed at the household levels. For beverages like bulk aerated drinks or soft drink concentrates and squashes prepared at home, the details of variety, type of colours and quantities used *vis-à-vis* demonstrated set of standard measuring glasses were sought. Information was also collected on the pattern of usage of various colouring substances employed in household cookery during normal periods and festive occasions. Statistical analysis was carried out by Independent Samples t test using Prism 3.0 software.

Usage pattern of colours in food items

The type and actual quantity of colours were analysed in 1,199 coloured foodstuffs purchased from urban and rural areas of Lucknow (Tripathi et al., 2007), and the data were used for calculating the intake of food colours as follows:

> Actual intake of colour = I multiplied by C and dividing the result by BW (mg kg^{-1} bwt)
> here *I* = amount of coloured food consumed (g or ml), C = conc of colour present in food (mg kg^{-1}) and BW = Body weight.

The amount of intake of colours was then compared with the ADI-based maximum permissible limit of colour intake in different age groups. The average body weight of population surveyed was taken from body weight for age chart of the National Centre for Health Statistics, USA, due to absence of anthropometrics data of Indian standards (Rao and Vijayaraghavan, 1996).

RESULTS

The percentage of households consuming domestically cooked coloured food items in urban/rural areas in normal periods and in festive occasions is shown in Figure 1. The percentage of urban families using individually bought colours in household cooking in normal periods (39/314) was found to be higher than rural families (15/200). In both areas, use of colours during festive occasions was substantially higher compared to day-to-day use.

The average, minimum and maximum amounts of various coloured food commodities consumed per day in both urban and rural areas are given in Figure 2. There was not much difference in the average consumption pattern of the majority of commodity groups in these two areas. The minimum consumption of a coloured product was 5 g in the case of hard-boiled sugar confectionery (lemon drops) and sugar toys, 8 g for bakery items, 10 g for jams and jellies (in urban population only) and savoury items and 20–50 g for the rest of the commodities, except beverages where a minimum daily consumption of 200 ml was recorded. The maximum daily consumption of an individual commodity was 30–55 g in the case of savoury and hard-boiled sugar confectionery (lemon drops). For jams and jellies, bakery items and sugar toys the maximum intake ranged from 60 to 100 g per day. In the case of ice-candy/ice cream, milk sweets, non-milk sweets, crushed ice and beverages, the respective maximum intakes were 110, 130, 150, 200 and 535 g per day, respectively. Virtually no intake of colours was noted through consumption of jams and jellies in rural areas.

The range of average intake of colours and respective percent saturation of ADI in different age groups in normal periods and festive occasions is given in Table 2. In the 1–10 years' age group, Erythrosine consumption worked out to be higher than its permissible ADI limit and exceeded it by 114.8%. The highest consumption level of Sunset Yellow FCF (SSYFCF), Tartrazine, Carmoisine, Ponceau 4R and Brilliant Blue FCF (BBFCF) was found to be well within the permissible ADI limits for various foodstuffs, with a maximum level of 97% of ADI for SSYFCF, 26% for Tartrazine, 35.7% for Carmoisine, 22.6% for Ponceau 4R and 1.7% for BBFCF (Table 2). Also on the festive occasions, consumption of Erythrosine

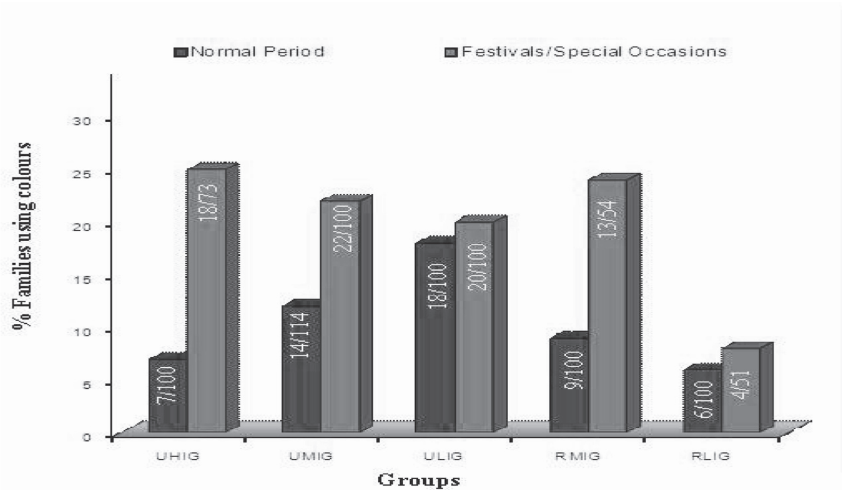

Figure 1 Percentage of families consuming domestically cooked coloured food items in urban/rural areas during normal periods and festive occasions (see online version for colours)

Note: Digits indicated in bars show the actual number of families using colours in domestically cooked food out of total families surveyed in the respective group.

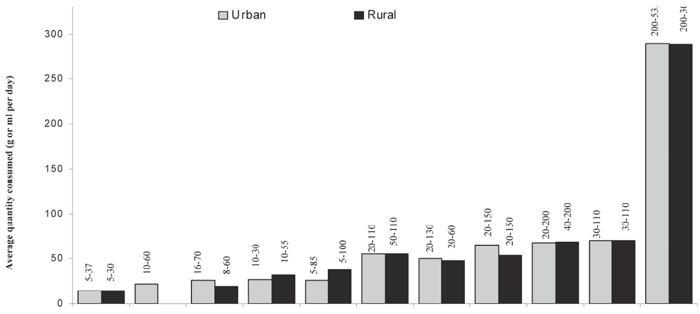

Figure 2 Average consumption of various coloured food commodities by urban and rural populations (see online version for colours)

Note: Values above bar indicate range of quantity consumed (g or ml day^{-1}).

Table 2 Range of consumption of colours and percent saturation of their ADI limits on the basis of average intake in normal periods and festive occasions

Colours	1–10 years		11–20 years		21–30 years		31 + years	
	Amount consumed[a]	% ADI exceedance	Amount consumed	% ADI exceedance	Amount consumed	% ADI exceedance	Amount consumed	% ADI exceedance
Normal periods								
SSYFCF	0.018–2.429	0.70–97.1	0.008–0.529	0.31–21.2	0.004–0.296	0.16–11.8	0.005–0.191	0.20–7.6
Tartrazine	0.056–1.952	0.74–26.0	0.017–0.425	0.22–5.7	0.007–0.237	0.09–3.2	0.016–0.228	0.21–3.0
Carmoisine	0.012–1.429	0.30–35.7	0.005–0.308	0.12–7.7	0.005–0.186	0.136–4.6	0.003–0.175	0.086–4.3
Ponceau 4R	0.013–0.009	0.38–22.6	0.006–0.242	0.15–6.1	0.004–0.267	0.11–5.0	0.007–0.188	0.16–4.6
Erythrosine[b]	0.003–0.214	2.86–114.8	0.001–0.119	1.35–19.2	0.001–0.04	1.0–40.3	0.0009–0.0169	0.96–67.7
BBFCF	0.007–0.219	0.06–1.7	0.003–0.133	0.02–1.0	0.002–0.093	0.02–0.7	0.002–0.085	0.02–0.6
Festive occasions								
SSYFCF	0.015–0.337	0.61–13.5	0.007–0.157	0.29–6.3	0.004–0.113	0.15–4.5	0.004–0.121	0.14–4.7
Tartrazine	0.047–0.262	0.63–3.5	0.016–0.123	0.22–1.6	0.011–0.089	0.15–1.2	0.0153–0.094	0.20–1.2
Carmoisine	0.020–0.279	0.51–7.0	0.007–0.113	0.183–2.8	0.006–0.07	0.14–1.7	0.005–0.067	0.13–1.7
Ponceau 4R	0.014–0.229	0.34–5.7	0.005–0.11	0.12–2.7	0.003–0.074	0.08–1.9	0.003–0.072	0.078–1.8
Erythrosine[b]	0.005–0.338	5.2–236.0	0.002–0.125	1.73–25.0	0.07–0.08	70–80.6	0.0008–0.099	0.82–99.6
BBFCF	0.07–0.343	0.05–2.7	0.002–0.0165	0.02–1.3	0.002–0.119	0.01–0.9	0.002–0.126	0.01–1.0

[a] Amount consumed represents the average value of that group.

[b] Exposure to Erythrosine was statistically significant ($p < 0.05$).

Note: Range of consumption of colours are expressed as mg day^{-1} kg bwt^{-1} (bodyweight).

was found to exceed the ADI by 236%. The highest intake of the remaining colours was well within the ADI limits, reaching only 13.5% for SSYFCF, 3.5% for Tartrazine, 7% for Carmoisine, 5.7% for Ponceau 4R and 2.7% for BBFCF (Table 2).

In the 11–20 years age group, only the intake of Erythrosine was found to exceed the ADI levels, exceeding it by 19.2%. The percent saturation of the ADI limit was 21.2% for SSYFCF, 5.7% for Tartrazine, 7.7% for Carmoisine, 6.1% for Ponceau 4R and 1.0% for BBFCF in 11–20 years age group. Also on festive occasions, the intake of Erythrosine through sugar toys was found to exceed the ADI limit by 25%. The highest consumption of the remaining colours was well within the permissible ADI limits reaching only a maximum of 6.3% for SSYFCF, 1.6% for Tartrazine, 2.8% for Carmoisine, 2.7% for Ponceau 4R and 1.3% for BBFCF (Table 2).

In the 21–30 years age group, the percent saturation of the permissible ADI limit was 11.8% for SSYFCF, 3.2% for Tartrazine, 4.6% for Carmoisine, 5.0% for Ponceau 4R and 0.7% for BBFCF. On festive occasions, the highest consumption of all colours was found to be well within the ADI limits reaching 4.5% for SSYFCF, 1.2% for Tartrazine, 1.7% for Carmoisine, 1.9% for Ponceau 4R and 0.9% for BBFCF. The saturation of ADI for Erythrosine on normal and festive occasions was the highest and ranged between 40.3% and 80.6% (Table 2).

In the age group of 31 years and above all the colours consumed were within the ADI limits. The percent saturation of ADI were 7.6% for SSYFCF, 3% for Tartrazine, 4.6% for Ponceau 4R, 4.3% for Carmoisine and 0.6 % for BBFCF. Also on the festive occasions, the highest consumption of all colours was found to be well within the ADI limits, reaching to, 4.7% for SSYFCF, 1.2% for Tartrazine, 1.7% for Carmoisine, 1.8% for Ponceau 4R and 1.0% for BBFCF. Here also the maximum Erythrosine intake during both normal and festive occasions ranged between 67.7% and 99.6% of ADI (Table 2).

Commodities and colours, which exceeded the ADI limits in different socio-economic groups based on their average intake, are given in Table 3. According to average daily consumption, in the 1–10 years age group, the intake of Erythrosine through sugar toys exceeded ADI limits exceeding it by 21%, 41% and 115%, in urban high income group (UHIG), urban middle income group (UMIG) and urban low income group (ULIG), respectively. In the 1120 years age group also percent exceedance of ADI for Erythrosine was 19% in ULIG through sugar toys. During festive occasions only the intake of Erythrosine was found to exceed the ADI limits in the 1–10 and 11–20 years age groups exceeding it by 8–236% through the consumption of sugar toys (Table 3).

Table 3 Age and commodity wise intake of colours in excess of their respective ADI limits on the basis of average intake values

Age groups (years)	Colour	Groups	Food item	Intake (mg day^{-1} kg bwt^{-1})	% ADI exceedance
Normal period					
1–10	Erythrosine	UHIG	Sugar toys	0.121	21
		UMIG	Sugar toys	0.141	41
		ULIG	Sugar toys	0.214	114.8
11–20	Erythrosine	ULIG	Sugar toys	0.119	19
Festive occasions					
1–10	Erythrosine	UMIG	Sugar toys	0.336	236
		ULIG	Sugar toys	0.310	210
11–20	Erythrosine	UMIG	Sugar toys	0.108	8
		ULIG	Sugar toys	0.125	25

Note: On the day of consumption.

The percent saturation of ADI of different colours that were consumed in excessive amounts in all socioeconomic groups based on their maximal intake is shown in Table 4. The maximum intake of four colours *viz*, Sunset Yellow FCF, Tartrazine, Carmoisine and Erythrosine exceeded the ADI limits in the 1–10 years age groups. The intake range of Sunset Yellow FCF was 2.86–21.95 mg day^{-1} kg^{-1} bwt exceeding the ADI by 14–778%. Tartrazine through crushed ice was found to exceed the ADI limits by 152%. The maximum intake of Carmoisine through crushed ice was higher than the permissible limit of ADI, exceeding it by 260%. The maximum consumption of Erythrosine through hard-boiled sugar confectionery and sugar toys exceeded its ADI limit by 43% and 1,138%, respectively. In the 11–20 years age group, the maximum intake of Carmoisine and Sunset Yellow FCF through crushed ice exceeded the ADI limits by 45% and 255%. Similarly, the ADI limit of Erythrosine was exceeded by 765% in case of sugar toys. In the 21–30 years age group, only the maximum intake of Sunset Yellow FCF exceeded the ADI limit by 31%. In 31 and above years' age group, all the colours consumed were well within the permissible ADI limits (Table 4).

DISCUSSION

In the present study, food consumption data has been collected to evaluate the dietary intake pattern of synthetic colours between various age and socioeconomic groups. The findings indicate that the consumption of coloured food items do not vary considerably between urban and rural populations. However, the average consumption of sugar toys was relatively more in rural

Table 4 Age and commodity wise intake of colours in excess of their respective ADI limits on the basis of maximum intake values

Age groups (years)	Colours	Food items	Intake (mg day^{-1} kg bwt^{-1})	% ADI exceedance
1–10	Sunset Yellow FCF	Crushed ice	21.95	778
		Ice-candy	4.76	91
		Beverages	3.62	45
		Sweets (non-milk)	3.24	30
		Ice-cream	2.86	14
	Tartrazine	Crushed ice	18.91	152
	Carmoisine	Crushed ice	14.38	260
	Erythrosine	Hard-boiled sugar confectionery (lemon drops)	0.14	43
		Sugar toys	1.24	1138
11–20	Sunset Yellow FCF	Crushed ice	8.87	255
	Carmoisine	Crushed ice	5.81	45
	Erythrosine	Sugar toys	0.87	765
21–30	Sunset Yellow FCF	Crushed ice	3.29	31
31and above	Nil			

Note: On the day of consumption.

population (38 g) than in the urban population (26 g). The consumption of jams and jellies was found to be absent in the rural population. This may be due to the high cost of the product or its absence as part of food habits. It is important to note that the maximum intake of permitted colours was in commodities like crushed ice, ice-candy, beverages, sweets and sugar toys.

Based on maximum day-to-day consumption of foodstuffs, Erythrosine through hard-boiled sugar confectionery (lemon drops) and sugar toys exceeded the ADI limits (43–1,138%). However, on the basis of average daily consumption, Erythrosine exceeded the ADI only through sugar toys in the 1–10 years age group belonging to UHIG, UMIG and ULIG population (21–114.8%) in normal periods. Substantially, this was enhanced during the festive occasions and found to be statistically significant ($p < 0.05$), indicating that children (1–10 years) are the group most vulnerable to exposure to this colour. In subjects of 11–20 years age, sugar toys were again the only food item where the average intake of Erythrosine exceeded the ADI limits. During festive occasions, Erythrosine saturated the ADI by 8% and 25% in UMIG and ULIG, respectively. Incidentally both sugar toys and hard-boiled sugar confectioneries were earlier found to use much higher concentrations of Erythrosine than the maximum permissible limits (Tripathi et al., 2007). These studies could stimulate other developing countries to check similar possibilities in their regions as well.

The studies conducted in Australia and New Zealand (Baines, 2000; Larsen, 1991) showed that the average intake of Erythrosine through maraschino cherries was 0.02 mg kg^{-1} bwt day^{-1} saturating the ADI to 18.6% while for higher age group consumers it was 0.06 mg kg^{-1} bwt day^{-1} with a saturation of 63% of ADI (Baines, 2000). The ADI of Erythrosine was earlier lowered from 2.5 mg kg^{-1} bwt day^{-1} in 1978 to 0.1 mg kg^{-1} bwt day^{-1} in 1991 due to concern on its thyroid toxicity (JECFA, 1991).

Based on maximum daily intake, Sunset Yellow FCF, Tartrazine and Carmoisine were also found to exceed the ADI limits through consumption of crushed ice, ice-candy, beverages, sweets, ice-cream, hard-boiled sugar confectionery (lemon drops) and sugar toys in the 1–10 years age group. However, on the basis of average consumption, none of these colours exceeded the ADI through any of the food commodities in any age group, though Sunset Yellow FCF was found to saturate the ADI limit by 97% in 11–20 years age group through sugar toys. The maximum percent saturation of ADI for Sunset Yellow FCF, Tartrazine, Carmoisine and Ponceau 4R was on the higher side and ranged between 22% and 97%. None of the colours were consumed beyond the ADI limits in 21–30 years old subjects. We would like to point out that due to lack of anthropometric data from India, the body weight for age chart of NCHS, USA has been used to calculate the exposure estimates. But, since the weights of Indian population are likely to be low compared to USA, hence the intake figures are expected to be on slightly higher side. A similar study carried out on a selected population in the city of Hyderabad, in the southern State of India found that Tartrazine, Erythrosine and Sunset Yellow exceeded ADI limits by 104%, 200% and 284%, respectively (Rao and Sudershan, 2008; Rao et al., 2004). Also our results are in agreement with the outcome of the study in Kuwait on dietary exposure of children to artificial colours which revealed that four colours namely Tartrazine, SSYFCF, Carmoisine and Allura red exceeded their ADI by 2–8 folds (Hussain et al., 2006).

It is interesting to note that the intake of colours in the majority of developed countries is invariably on a much lower scale. Tartrazine and Sunset Yellow FCF were found to saturate 0.5% and 2% of their respective ADI in Brazilian children (Toledo et al., 1992), while values estimated for US were approximately 3% and 8% (IFT, 1986) and those for Italians were 4% and 12% of the permissible ADI (Quattrucci and Saletti, 1983). Similarly, the intake of Ponceau 4R, Carmoisine and Amaranth reached 0.2% of the ADI for Swiss children weighing 35 kg (Hunziker and Zimmerli, 1984). Carmoisine saturated the ADI to an extent of 13–26% in the Italian population (Quattrucci and Saletti, 1983). In Finland, the colour intake was found to be less than 3% of the ADI in the case of children (average weight 20 kg) and less than 1% of the ADI in the case of adults (Pentilla, 1996).

In the Indian scenario, the use of non-permitted colours was also frequently encountered in savouries, sugar toys, powdered spices and sweets due to easy availability and cheaper price structure (Biswas et al., 1994; Dixit et al., 1995; Jonnalagadda et al., 2004; Khanna et al., 1973, 1985; Tripathi et al., 2007). Though non-permitted colours are not quantified, nonetheless, the actual intake of colours taken together, that is, permitted and non-permitted will obviously be greater. The findings of our previous study showed that various permitted colours were used in much higher quantities in many food products and ranged between 6 and 20 times the permissible limits (Tripathi et al., 2007). This could be the prime source of higher intake of colours and not necessarily because of the intake of large amount of food items. The present work reveals that in ULIG, RMIG, RLIG, the intake of non-branded food products has been the common feature where the intake of various non-permitted colours along with high intake of permitted colours was noted. The intake of Indigo carmine and Fast Green FCF either in the urban or rural population could not be recorded due to their absence in any of the foodstuffs. Thus, the blanket use of maximum permissible levels of synthetic colours at 100 ppm in specified foods permitted under the Indian rules of PFA Act needs to be reviewed. Various countries permit only need-based use of colours in different food preparations. These ranged from as low as 2 ppm to as high as 500 ppm in specific foods (Burdock, 1996). The permissible quantity of a colour in commodities, which are generally consumed in large volumes/quantities such as soft drinks, ice cream, milk preparations etc., should be lower. The maximum allowable concentration of a colour in a food should hence be realistic, keeping in view the technological necessity of the product *vis-a-vis* its consumption pattern and the ADI-based safety limits so that the intake of colours may be reduced substantially in vulnerable population groups. This is all the more relevant as increasing tourism and international trade in foodstuffs exposes all categories of consumers to locally available food preparations and hence such measures can reduce their threat.

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BIOGRAPHY

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REFERENCES

Baines, J. (2000) 'Evaluation of national assessments of intake of Erythrosine', *WHO Food Additive Series*, No. 44, pp.499–508.

Biswas, G., Sarkar, S. and Chatterjee, T.K. (1994) 'Surveillance on artificial colours in food products marketed in Calcutta and adjoining areas', *Journal of Food Science and Technology*, Vol. 31, pp.66–67.

Burdock, G.A. (1996) *Encyclopaedia of Food and Colour Additives*. Florida: CRC Press, Inc.

Conacher, H.B.S., Grahamand, R.A., Newsom, W.H., Graham, G.F. and Verdier, P. (1989) 'The health protection branch total diet program, an overview', *Journal de l' Institute Canadien de Science et Technologic Alimentaire*, Vol. 22, pp.322–326.

Dixit, S., Pandey, R.C., Das, M. and Khanna, S.K. (1995) 'Food quality surveillance on colours in eatables sold in rural markets of Uttar Pradesh', *Journal of Food Science and Technology*, Vol. 32, pp.373–376.

Fondu, M. (1992) 'Food additive intake', *Food Additives and Contaminants*, Vol. 9, pp.535–539.

FSA (2000) *Food Standards Agency. Survey of Colours in Sauces* (November 03/00), Available at: http://www.foodstandards.gov.uk/science/surveillance/fsis-2000/3 colour. accessed on 1 March 2001.

Gibney, M.J. (1999) 'Dietary intake methods for estimating food additive intake', *Regulatory Toxicology and Pharmacology*, Vol. 30, pp.531–533.

Gilsenan, M.B., Lambe, J. and Gibney, M.J. (2003) 'Assessment of food intake input distributions for use in probabilistic exposure assessments of food additives', *Food Additives and Contaminants*, Vol. 20, pp.1023–1033.

Hunziker, H.R. and Zimmerli, B. (1984) 'Intake estimation of food additives: red synthetic food colours', *Mittelungen aus dem Gebiete der Lebensmittelunterschung und Hygiene*, Vol. 75, pp.77–92.

Hussain, A., Sawaya, W., Al-Omair, A., Al-Zenki, A., Al-Amiri, H., Ahmed, N. and Al-Sinan, M. (2006) 'Estimates of dietary exposure of children to artificial food colors in Kuwait', *Food Additives and Contaminants*, Vol. 23, pp.245–251.

IFT (1986) 'Food colours a scientific status summary', *Institute of Food Technologists. Expert Panel on Food Safety and Nutrition*, Chicago, IL.

James, W.P.T., Ferro-Luzzi, A., Isaksoon, B. and Szostak, W.B. (1998) 'Healthy nutrition', *WHO Regional Publications, European Series*, Copenhagen: WHO, Vol. 24, pp.8–13.

JECFA (1991) 'Evaluation of certain food additives and contaminants, 37th report', *Technical Report Series No. 806*, Geneva: World Health Organization.

JECFA Evaluation (2003) *Summary of Evaluation Performed by the Joint FAO/WHO Expert Committee on Food Additives*. Available at: http://www.inchem.org/pages/jecfa.html. Accessed on 19 March 2003.

Jonnalagadda, P.R., Rao, P., Bhat, R.V. and Naidu, A.N. (2004) 'Type, extent and use of colours in ready-to-eat (RTE) foods prepared in the non-industrial sector-a case study from Hyderabad, India', *Int. J. Food Science and Technology*, Vol. 39, pp.125–131.

Khanna, S.K., Singh, G.B. and Dixit, A.K. (1985) 'Use of synthetic dyes in eatables of rural area', *Journal of Food Science and Technology*, Vol. 22, pp.269–273.

Khanna, S.K., Singh, G.B. and Singh, S.B. (1973) 'Non-permitted colours in food and their toxicity', *Journal of Food Science and Technology*, Vol. 10, pp.33–36.

Larsen, J.C. (1991) 'Erythrosine: toxicological evaluation of certain food additives and contaminants', *WHO Food Additive Series*, Vol. 28, pp.171–180.

Leclercq, C., Berardi, D., Sorbillo, M.R. and Lambe, J. (1999) 'Intake of saccharin, aspartame, acesulfame-K and cyclamate in Italian teenagers: present levels and projections', *Food Additives and Contaminants*, Vol. 16, pp.99–109.

Leclercq, C., Molinaro, M.G., Piccinelli, R., Baldini, M., Arcella, D. and Stacchini, P. (2000) 'Dietary intake exposure to sulphites in Italy-analytical determination of sulphite containing foods and their combination into standard meals for adults and children', *Food Additives and Contaminants*, Vol. 17, pp.979–989.

Lindsay, D.G. (1986) 'Estimation of dietary intake of chemical in food', *Food Additives and Contaminants*, Vol. 3, pp.71–88.

Loukary, K., Scott, A.O. and Salminen, S. (1990) 'Estimation of food additives intakes', In A.L. Branon, P.M. Davidson and S. Salminen (Eds.), *Food Additives*. New York: Marcel Dekker, Inc., pp.9–32.

Macdonald, I. (1991) 'Monitoring dietary intakes', *International Life Sciences Institute*, Berlin, Heidelberg: Springer-Verlag.

Miguel Jr., M. (1998) 'Estimates of maximum limits of food colours use in Brazil through the Danish budget method and the Bar and Wurtzen-modified method', *Food Additives and Contaminants*, Vol. 15, pp.481–486.

NZFSA (2008) 'Synthetic colours in highly coloured foods', Available at: http://www.nzfsa. govt.nz/consumers/chemicals-nutrients-additives-and-toxins/food-colourings/foodcolouring. htm. Accessed on 2 December 2008.

Pentilla, P.L. (1996) 'Estimation of food additive intake: Nordic approach', *Food Additives and Contaminants*, Vol. 13, pp.421–426.

PFA (2008) *Prevention of Food Adulteration Act of India, 1954 and Rules*. Lucknow, India: Eastern Book Company.

Quattrucci, E. and Saletti, M.C. (1983) 'Determinazione analitica ed ingestion potenziale dicolouranti artificiali negli alimenti', *L Rivista della Societa Italiana di Scienza Dell Alimentazione,* Vol. 12, pp.28–36.

Rao, D.H. and Vijayaraghavan, K. (1996) 'Anthropometric assessment of nutritional status', In M.S. Bamji, P.N. Rao and V. Reddy (Eds.), *Textbook of Human Nutrition*. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd., pp.148–162.

Rao, P., Bhat, R.V., Sudershan, R.V., Krishna, T.P. and Naidu, N. (2004) 'Exposure assessment to synthetic food colours of a selected population in Hyderabad, India', *Food Additive and Contaminants*, Vol. 21, pp.415–421.

Rao, P. and Sudershan, R.V. (2008) 'Risk assessment of synthetic food colours: a case study in Hyderabad, India', *Int. J. Food Safety, Nutrition and Public Health*, Vol. 1, pp.68–87.

Rhodes, J., Alison, C., Titherley, J.A., Norman, R.W. and David, W.L. (1991) 'A survey of the monosodium glutamate content of foods and an estimation of the dietary intake of monosodium glutamate', *Food Additives and Contaminants*, Vol. 8, pp.663–672.

Toledo, M.C.F., Guerchon, M.S. and Rogazzi, S. (1992) 'Potential weekly intake of artificial food colours by 3–14 year old children in Brazil', *Food Additives and Contaminants*, Vol. 9, pp.291–301.

Tripathi, M., Khanna, S.K. and Das, M. (2007) 'Surveillance on use of synthetic colours in eatables vis a vis Prevention of Food Adulteration Act of India', *Food Control*, Vol. 18, pp.211–219.

Turrini, A., Saba, A. and Lintas, C. (1991) 'Study of the Italian reference diet for monitoring food constituents and contaminants', *Nutrition Research*, Vol. 11, pp.861–874.