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Benzoate and Synthetic Color Risk Assessment of Fast Food Sauces Served at Street Food Joints of Lucknow, India

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Abstract: Quality compliance of benzoate and food colors in the two common fast food accessories, namely tomato and chilli sauces, served at Street Food Joints (SFJs) has been evaluated and compared with the counterpart branded products. Both sauces served at SFJs employed excessive amounts of benzoic acid in comparison with branded products ($p < 0.05$). In spite of ban, presence of artificial colors such as Amaranth, Carmoisine, Erythrosine, Ponceau 4R, Sunset Yellow and Tartrazine were noted in a vast majority of SFJ sauce samples. All branded sauces, however, adhered to the prescribed limit of benzoate and contained no artificial color. Intake estimates for benzoate and one of the colors, Sunset Yellow, in high consumers among children are likely to saturate 33 and 20% of the ADI at 95th percentile levels, respectively, which appears to be on higher side considering intake from a single commodity. Street Food Joints (SFJs) cater to the demand of floating domestic/foreign tourist populations and serve as a source of employment generation. This sector needs some assistance to enable them to survive in the competitive markets but not at the cost of quality. Effective risk communication and food safety awareness measures designed for street vending outlets are required so that such lapses of street vending outlets could be minimized.

Key words: Quality compliance, sauces, benzoate, colors

INTRODUCTION

With the changing lifestyles, fast foods have become increasingly popular among all sections of the society, Street Food Joints (SFJs) cater to the demand of inexpensive foods for many poor urban house holds and floating populations and serve as a source of livelihood/self employment generation (Codjia, 2000). WHO has advocated that governments should formulate supportive policies for improvements in the small-scale enterprises and street food vendors (WHO, 2006a). It is felt that this sector needs some measures of protection to enable them to survive in the competitive markets but none-the-less at the cost of quality of food products. This is the crust of recently launched program on Healthy Food Markets initiative (WHO, 2006b). The Ministry of Health and Family Welfare in India has commissioned a survey on street foods and the findings indicate that this sector is striving to attract more consumers, it appears to pay less attention in meeting quality and safety norms (Gupta, 2006).

Both tomato and chilli sauces are the most common fast food accessories. The existing food legislation covered under the Prevention of Food Adulteration (PFA) Act of India and rules therein permit benzoic acid as one of the class II preservatives, with a maximum allowable limit of 750 mg kg^{-1} in case of tomato and other sauces (PFA, 2005). It is feared that some informal domestic units and Street Food Joints adapt to measures of approximation and may ignorantly add

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excess quantities of preservatives to extend shelf life of the product. Also, some informal units tend to substitute tomatoes by cheaper vegetable raw material, though the rules specifically prohibit the use of other vegetables in tomato sauce/ketchup (PFA, 2005). For such products, the processors then resort to use of synthetic colors to disguise cheap vegetable sauce and offer it as tomato sauce. It is precisely for such reasons that the existing rules do not permit use of any extraneous synthetic color in tomato sauce/ketchup (PFA, 2005). Among the food processing units, the organized sector producing branded products, invariably adhere to the prescribed permissible limits of food additives while, the same may not be always true with the informal domestic scale units or SFJs. It was hence a matter of curiosity to monitor the use pattern of benzoate and synthetic colors in tomato and chilli sauces vended at SFJs and compare these with the branded products and undertake the health risk assessment in the consumers.

MATERIALS AND METHODS

Chemicals

Benzoic acid was procured from BDH, India. The synthetic colors Amaranth, Carmoisine, Erythrosine, Ponceau 4R, Sunset Yellow FCF and Tartrazine were purchased from Hickson and Dadajee, Ltd., Mumbai, India. HPLC grade acetonitrile and methanol were obtained from Merck Limited, Mumbai, India. Analytical grade Potassium dihydrogen ortho phosphate and ExelaR grade acetic acid and liquor ammonia (specific gravity 0.91) were the products of Qualigen India. Whatman Number 1 chromatography grade paper was purchased from Whatman International Ltd., Maidstone, England. All other chemicals used were of analytical grade, available commercially.

Sample Procurement

The samples of tomato and chilli sauce were collected from local markets around the city of Lucknow, India during 2006. Among branded products, 50 tomato sauce bottles of Maggi, Kissan (Hindustan Lever), Heinz, Nestle, Everest and Tops and 43 tomato sauce sachets of Cremica, Kissan and Tops and 25 chilli sauce bottles (Pouchong, Continental, Top-up, Samrat and Goyal) were procured from local retail markets. In the non-branded category, 100 tomato sauce and 25 chilli sauce samples vended at Street Food Joints were collected.

Sample Processing

A 2.5 g portion of the sample was extracted thrice using 5 mL of methanol each time and centrifuged. The methanolic extracts were pooled and volume was made up to 15 mL for determination of benzoic acid and synthetic colors.

Determination of Benzoic Acid

High Pressure Liquid Chromatography (HPLC) based AOAC (2000) method was adopted for the detection and quantitation of benzoic acid in tomato and chilli sauce samples. Waters LC module (Waters Associates, Vienna, Austria) equipped with a dual pump (model # 510), Rheodyne injector with 20 μ L loop and tunable absorbance detector (model # 486) were used, employing the reversed phase C_{18} μ -Bondapak column (3.9 \times 300 mm; Waters) with a pre-column of the same type. One milliliter of the methanolic extract was filtered through 0.45 μ m Millipore filter and 20 μ L was injected. A standard solution of benzoic acid (10 μ g mL⁻¹) in methanol was used for comparison. The elution was carried out at ambient temperature (25°C) with isocratic solution of 0.01 M phosphate buffer, pH 2.3: acetonitrile (6:4, v/v) at a flow rate of 1.0 mL min⁻¹. The measurement was carried out at 230 nm and retention time and peak areas were recorded. The chromatograms were recorded and processed by Waters Millennium[®] software. The Limit of Detection (LOD) of benzoic acid is

5 mg kg⁻¹. As part of validation, spectral analysis of eluted fractions coming out of HPLC column was performed and matched with that of standard benzoic acid. The recovery of benzoic acid from spiked sauce samples was found to be > 85%.

Separation, Identification and Quantitation of Colors

For detecting the presence of colors in sauce samples, 5 mL of methanolic extract was concentrated to 1 mL. The colors were selectively picked up on wool, eluted and resolved on paper chromatograms using the method followed by Tripathi *et al.* (2007). The quantification of various colors was undertaken by measuring absorbance at respective λ_{max} along with standards, employing double beam spectrophotometer (Perkin Elmer Lambda Bio 20). The spectral characteristics of detected colors were compared and matched with standard reference colors as a validation measure. The values of detected colors have been corrected for their respective mean recoveries from individual color spiked sauce samples.

Survey on Consumption of Tomato Sauce

The consumption pattern of tomato sauce in Lucknow area was assessed by a limited household dietary survey through a Food Frequency Recall method (Burdock, 1997). The 24 h dietary recall questionnaire was designed to provide information about the name, age and sex followed by the questions on the consumption of tomato sauce including amount and frequency of consumption. A total of 60 families having 238 subjects (age 5-70 years) with 189 adults (84 males and 95 females) and 59 children were surveyed. Average body weight of children (30 kg) and adults (60 kg) has been drawn from National Center for Health Statistics, USA (WHO, 1983). The consumption data was recorded on Food frequency Questionnaire while interviewing with the subjects and then data was transferred to Microsoft Excel Sheet. The mean value represented the average consumers and that of 95th percentile, as high consumers of tomato sauce and was used to calculate benzoate intake.

Statistical Analysis

Student's t-test was employed to calculate the significance of the differences between branded and street food joints samples (Fisher, 1950). A $p < 0.05$ was considered to be significant.

RESULTS

Analysis and Validation of Benzoic Acid and Colors

Figure 1A shows the HPLC profile of benzoic acid. The retention time of standard and extracted benzoic acid from tomato sauce samples matched at 7.55 min. The results were validated by taking the spectra of the HPLC eluted peak of standard and extracted benzoic acid showing a λ_{max} at 222 nm (Fig. 1B). The resolution of colors employed in sauce samples was carried out by paper chromatography and the spectra of eluted colors was recorded and matched with standard reference colors (Fig. 2). Some samples confirmed the presence of colors such as Amaranth, Carmoisine, Erythrosine, Ponceau 4 R, Sunset yellow FCF and Tartrazine.

Surveillance on Benzoic Acid

In the 93 branded bottled and sachet tomato sauce samples, the maximum level of benzoate detected was 745 mg kg⁻¹, which is within the Indian permissible limit of 750 mg kg⁻¹. All six samples of one branded product contained no preservative while the minimum content in others was 151 mg kg⁻¹. The mean and the 95th percentile values of benzoate for branded tomato sauce samples were 392±20.48 and 725 mg kg⁻¹, respectively.

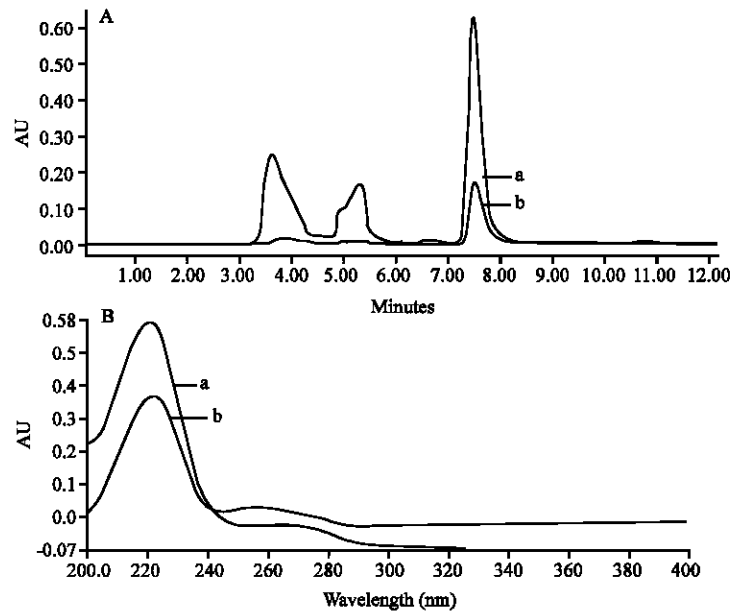


Fig. 1: HPLC resolution profile (A) and spectral characteristics (B) of standard benzoic acid (a) and tomato sauce sample having benzoic acid (b)

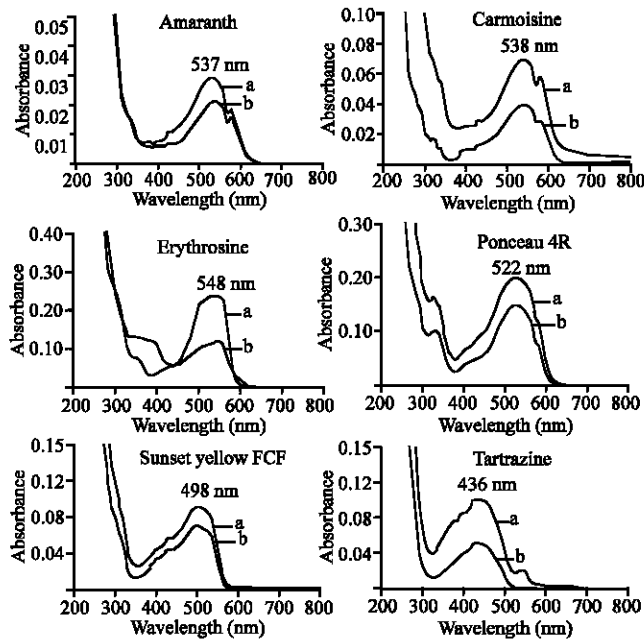


Fig. 2: Spectral characteristics of individual standard food colors (a) and extracted colors from tomato sauce samples (b). The horizontal and vertical axis represents wavelength (nm) and absorbance (A), respectively

In case of tomato sauce samples from SFJs, 59% exceeded the prescribed limit of benzoate. The minimum and maximum benzoate levels detected were 353 and 2119 mg kg⁻¹, respectively. The mean and 95th percentile values for SFJ vended tomato sauces were 903±44.26 mg kg⁻¹ and 1636 mg kg⁻¹, respectively (Table 1). In case of chilli sauce, none of the branded bottled samples exceeded prescribed limit of benzoate (with a mean content of 556±28.64 mg kg⁻¹) while all the samples of chilli sauce vended at SFJs contained higher than permissible levels of preservative. The respective minimum and maximum contents of benzoate used were found to be 772 and 2104 mg kg⁻¹. The mean and 95th percentile values worked out to 1052±58.36 mg kg⁻¹ and 1657 mg kg⁻¹, respectively (Table 1). The values of benzoate in tomato sauce samples vended at SFJs showed significant change (p<0.05) when compared to branded samples.

Surveillance on Synthetic Colors

None of the branded tomato sauce samples showed the presence of synthetic colors, the use of which is legally prohibited in tomato sauce. However, a vast majority (80%) of SFJs vended tomato sauce samples were found to contain artificial colors (Table 2). Among colors, blends of Sunset yellow FCF with Amaranth (172-742 mg kg⁻¹), with Carmoisine (148-597 mg kg⁻¹) and with Ponceau 4R (154-825 mg kg⁻¹) were most commonly encountered (79%). Individual colors, Erythrosine (37-46 mg kg⁻¹), Sunset yellow FCF (99-1624 mg kg⁻¹), Ponceau 4R (104-124 mg kg⁻¹) and Orange II (81 mg kg⁻¹) were also encountered in some samples (21%) (Table 2). Both Amaranth and Orange II even otherwise are not included in the list of permitted food colors in India.

In case of chilli sauce, none of the 25 branded bottled products showed presence of artificially added colors but 80% of the SFJs vended samples were found to contain synthetic color, Tartrazine. The maximum quantity noted was 500 mg kg⁻¹, with the mean and 95th percentile values of 166 and 391 mg kg⁻¹, respectively (Table 2).

Table 1: Concentration profile of benzoate in tomato and chilli sauce served at Street Food Joints (SFJs): Comparison with branded products

Category	No. of samples			Benzoic acid (mg kg ⁻¹)		
	Total	Within limit ^a	Above limit (%) ^a	Range	Mean±SE	95th percentile
Tomato sauce						
SFJ Products	100	41	59(59)	353-2119	903±44.26*	1636
Branded Products	93	93	Nil	151-745	392±20.48	725
Chilli sauce						
SFJ Products	25	Nil	25(100)	772-2104	1052±58.36*	1657
Branded Products	25	25	Nil	293-734	556±28.64	717

^a: The permissible limit of benzoic acid in tomato and chilli sauce is 750 mg kg⁻¹ under the PFA Act of India, *: p<0.05, when compared to branded products

Table 2: Presence of synthetic colors in tomato and chilli sauce served at Street Food Joints (SFJs): Comparison with branded products

Category	No. of samples			Synthetic colors (mg kg ⁻¹)		
	Total	Without color	With color (%)	Range	Mean±SE	95th Percentile
Tomato sauce						
SFJ products	100	20	80(80) ^a	37-1624	303±31.07	825
Branded products	93	93	Nil	Nil	Nil	Nil
Chilli sauce						
SFJ products	25	5	20(80) ^b	93-500	166±28.44	391
Branded products	25	25	Nil	Nil	Nil	Nil

^a: Individual colors: Erythrosine (37-46 mg kg⁻¹), Sunset yellow FCF (99-1624 mg kg⁻¹), Ponceau 4R (104-124 mg kg⁻¹), Orange II (81 mg kg⁻¹) were detected in 21% samples while blends of Sunset Yellow FCF with Amaranth (172-742 mg kg⁻¹), with Carmoisine (148-597 mg kg⁻¹) and with Ponceau 4R (154-825 mg kg⁻¹) were detected in 79% of total analyzed samples, ^b: Only Tartrazine was detected in between 93-500 mg kg⁻¹ levels

Tomato Sauce Consumption Pattern in Local Household Consumers

A limited survey on tomato sauce consumption among 238 subjects ranged between 10 to 50 g per intake. Majority of consumers were in the category of 10-25 g (91%) while only about 9% consumers used higher quantities. The mean (designated as average consumers) and 95th percentile (designated as high consumers) tomato sauce consumption values come to 19 and 30 g, on per intake basis, respectively (Table 3).

Intake of Benzoate Through Tomato Sauce

A conservative intake estimate of benzoate and the percentage saturation of the ADI in average and high consumers of sauce at mean and 95th percentile levels of benzoate are shown in Table 4. The intake of benzoate through branded tomato sauce samples in children and adults for average and high consumers ranged between 0.13 to 0.42 mg kg⁻¹ b.wt. day⁻¹, saturating the ADI values between 2.6 to 8.4% only at the mean levels of benzoate detected in surveyed samples. At the 95th percentile levels of benzoate detected in surveyed branded tomato sauce samples, the intake ranged between 0.25 to 0.81 mg kg⁻¹ b.wt. day⁻¹, with concomitant ADI saturation levels of 5.0 and 16.2% (Table 4).

Since much higher levels of benzoic acid have been detected in SFJs vended tomato sauce samples, the intake among average and high children and adult consumers at 95th percentile benzoate levels work to 0.52 to 1.64 mg kg⁻¹ b.wt. day⁻¹ which tends to saturate 10 to 33% of ADI through this commodity. In case of children population, SFJs vended tomato sauce consumption even at mean levels of benzoate in average and high consumers saturated the ADI between 11.4 to 18.0% (Table 4).

Intake of Colors Through Tomato Sauce

The intake of colors from tomato sauce served at SFJs is given in Table 5. Among detected colors, Amaranth, Carmoisine, Erythrosine and Ponceau 4R have been found to saturate only 1.2-3.5% of their respective ADI limits even in high consumers of tomato sauce in children population. However, Sunset Yellow at 95th percentile detected levels appears to saturate 20% of its ADI from this source (Table 5).

Table 3: Limited household surveillance on tomato sauce consumption pattern in Lucknow area

Daily consumption (g) ^a	No. of respondent	Percentage out of total
10	62	26.0
15	56	23.5
20	30	12.6
25	69	29.0
30	17	7.1
50	4	1.7

^a: The mean and 95th percentile consumption values for 238 respondents work out to 19 and 30 g, respectively

Table 4: Intake of benzoic acid in average and high consumers of tomato sauce and saturation of ADI^a

Tomato sauce consumption level	Intake of benzoic acid mg kg ⁻¹ b.wt. day ⁻¹			
	Children ^b		Adults ^b	
	Branded product	SFJ product	Branded product	SFJ product
Average consumers				
Mean	0.27 (5.4)	0.57 (11.4)	0.13 (2.6)	0.29 (5.8)
95th percentile	0.51 (10.2)	1.04 (20.8)	0.25 (5.0)	0.52 (10.4)
High consumers				
Mean	0.42 (8.4)	0.90 (18.0)	0.21 (4.2)	0.45 (9.0)
95th percentile	0.81 (16.2)	1.64 (32.8)	0.40 (8.0)	0.82 (16.4)

^a: ADI of benzoic acid has been taken as 5 mg kg⁻¹ b.wt. day⁻¹ (JECFA, 2001) and the values in parentheses represent its % saturation, ^b: The average body weight of children (30 kg) and adult (60 kg) is based on National Center for Health Statistics, USA (WHO, 1983)

Table 5: Percent saturation of ADI limits by individual colors in high consumers of tomato sauce among children population

Colors	Levels detected mg kg ⁻¹		Intake (mg day ⁻¹)		% Saturation of ADI limit
	Mean	95th percentile	Permissible as per ADI limit	At 95th percentile levels of detected color	
Amaranth	120	187	15.0	0.19	1.3
Carmoisine	100	144	12.0	0.14	1.2
Erythrosine	39	44	3.0	0.04	1.3
Ponceau4R	262	421	12.0	0.42	3.5
Sunset Yellow	972	1533	7.5	1.53	20.4

DISCUSSION

Of more than 5000 fruit and vegetable processing units in India, only 13% are large-scale organized units and almost 75% are informal home or cottage scale (Pai, 2001). The demand for fast food accessory sauces is showing steady increase with growing popularity of fast foods among all sections of consumers. Both organized (branded products) and informal units catering to SFJs (as well as some SFJs themselves) are engaged in tomato and chilli sauce processing. Though the former are known to strictly adhere to quality specifications, the latter face market compulsions to sell foods at affordable, competitive prices for economic imperatives which often result in their resorting to cheaper alternatives leading to compromised quality of the products. Street food trade is considered an important source of employment, particularly for poor strata of society and serves as a poverty alleviation measure (Abdussalam and Kaferstein, 1993; Codjia, 2000). However, the perception that some street-food vendors may lack appreciation for safe food handling continues to be looked as an area of public health concern (WHO, 1996).

In the present study, quality compliance of the two most common fast food accessories, namely, tomato and chilli sauces, served at SFJs revealed that these employed excessive amounts of benzoic acid and a variety of artificially added colors in majority of samples, whereas none of the branded products exceeded the prescribed benzoic acid limit or showed presence of extraneously added color. Variable amounts of benzoic acid at 750 or 1000 mg kg⁻¹ are allowed in tomato sauce/ketchup by different agencies (EC, 1995; FDA, 1999; Codex, 2004; PFA, 2005). A survey on Italian foods and beverages revealed that the content of benzoic acid in most cases was lower than that prescribed technically (Luca *et al.*, 1995). Similar monitoring in UK revealed that only 4 samples out of 122 exceeded the permitted statutory limit of the benzoic acid (MAFF, 1995).

The intake of benzoate for average consumers in France (Verger *et al.*, 1998), Norway (Bergsten, 2000), Brazil (Tfouni and Toledo, 2002) and Korea (Yoon *et al.*, 2003) were well within the ADI limits. The estimates of total dietary intake of benzoate in China, Finland, France, Spain, UK and USA, using different methodologies revealed saturation of ADI in range of 9-28%. A conservative estimate of benzoate in the present study, through branded tomato sauce, in children consuming 30 g sauce (95th percentile) daily may saturate 8 and 16% of ADI at respective mean and 95th percentile levels of benzoate detected. However, some subjects will saturate 18 and 33% of ADI from the similar consumption of tomato sauce served at SFJs, which appears to be on higher side considering intake from a single commodity.

Addition of synthetic colors is not permitted in tomato sauce under the existing rules in India (PFA, 2005), as technologically there is no requirement. Artificially imitated tomato sauce made out of pumpkin (*Cucurbita pepo* L.) pulp not having even a speck of tomatoes obviously works out to be a cheaper substitute. A vast majority of SFJ vended tomato sauce samples were found to employ single or blend of colors and contained Amaranth, Carmoisine, Erythrosine, Ponceau 4R and Sunset Yellow FCF. A study by Food Standard Agency, UK on color usage in sauces used for marinating found two samples showing higher usage of Tartrazine and Carmoisine and took immediate action to ensure that consumers are not exposed to high levels of colors (FSA, 2000).

A vast majority of the ready-to-eat (RTE) foods prepared in the non-industrial sector at Hyderabad, India, were found to employ colors exceeding statutory limit and Sunset Yellow was most frequently encountered color after Tartrazine (Jonnalagadda *et al.*, 2004). Another study on exposure assessment to various food colors in children conducted at same location, revealed that intake of both Tartrazine and Sunset yellow exceeded the permissible ADI limits (Rao *et al.*, 2004). Similarly, the consumption pattern of colored foods among children in Kuwait showed that Tartrazine, Sunset Yellow and Carmoisine exceeded their ADI limits (Husain *et al.*, 2006; Sawaya *et al.*, 2007). In the present study, Sunset Yellow was the most excessively used color in tomato sauce and in high consumers among children population it saturated 20% of the ADI from this single commodity, which appears to be on much higher side. This is apparent from a New Zealand Food Safety Authority study on highly colored foods preferably consumed by children which indicated that the average and high consumer dietary exposure estimates for all food colors were less than 5 and 15% of the relevant ADIs, respectively (NZFSA, 2002).

Under street vended conditions, the common conceivable hazards include microbiological, chemical and physical contamination. But serving artificially colored vegetable sauce and use of higher quantities of preservative, as found in the present study, either ignorantly or presumably to shield handling lapses under street vended conditions, appears a part of intentional market driven phenomenon where economic gains prevail. Thus, effective risk communication (Tobin, 2006) and sector based quality awareness programs should be intensified to enable the principles of food safety to become a reality.

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