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ASSESSMENT OF MAINSTREAM SMOKE CONSTITUENTS OF *BIDI*

L.K. PRASAD, C. CHANDRASEKHARA RAO, M. SHESHU MADHAV, N. JOHNSON, AND K. VEERANNA

ICAR-Central Tobacco Research Institute, Rajahmundry-533105.

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In India, smoking accounts for majority of total tobacco consumption (72%), and among the total smoking habits, 73 % is in the form of bidi. Hence, in the present study mainstream smoke constituents were analysed in bidis prepared from different bidi tobacco (*Nicotiana tabacum* L.) lines. Tar (NFDPM), nicotine and carbon monoxide (CO) were determined by using 20 port Linear Smoking Machine, SM 450 of CERULEAN. GC-TCD/FID (HP 5890 Series II). The mean values and ranges of tar, nicotine and carbon monoxide content in smoke of bidi samples were 70.66 (40.60-92.05) mg g^{-1}, 5.36 (1.98-7.20) mg g^{-1} and 43.01 mg g^{-1}, (25.78 – 61.06) respectively. While nicotine in leaf varied from 19.00 mg g^{-1} to 55.00 mg g^{-1} and the mean value was 34.80 mg g^{-1}. It was found that tar and carbon monoxide in bidi smoke had a linear positive and significant relationship (R^2 *value: 0.941).* Increased tar contents in bidi samples with increased CO levels was observed. The study indicated that low tar and low CO emitting bidis prepared from bidi tobacco with low tar levels would help in reducing the risk of direct & indirect health concerns, and also the environmental issues.

INTRODUCTION

"Bidis" or "beedis" are slim, hand-rolled, unfiltered tobacco smoking product. They are also called "beeris" in countries such as Bangladesh. Bidis are the most popular smoking form of tobacco in India and the cost of bidis are very less, thus bidis are known as the "poor man's cigarettes", as they are smaller and cheaper than cigarettes (Gupta *et al.,* 2008). Bidi tobacco occupies 30-35% of the total area under tobacco cultivation and is grown in Gujarat, Karnataka and Maharashtra with the yield ranging from 1000 to 1700 kg ha^{-1} (Gupta *et al.,* 2004).

India accounts for more than 85% of the world's bidi production (Chaman Bidi Export., 2003) and 34 % of the tobacco produced in India is used for making bidis. In India, smoking accounts for majority of total tobacco consumption (72%), and among the total smoking habits, 73 % is in the form of bidi and 27% is in the form of cigarette (Chaudhry *et al.,* 2000). Bidis account for over 50 % of total tobacco use, compared with less than 20 % by the cigarette segment. Roughly eight bidis are sold for every cigarette (Srivastava *et al.,* 2000*).*

Dark and sun-dried tobacco varieties are used in bidi making. A bidi consists of about 200 mg of sun-dried and processed bidi tobacco flakes rolled in tendu leaf (*Diospyrus melanoxylon*) or *temburni* leaf belonging to the family *Ebenaceae* and held together by a cotton thread (Gupta *et al.,* 2004). The *tendu* leaf constitutes 60% of the weight of the bidi. Tendu leaf is considered as the most suitable wrapper on account of the ease with which it can be rolled, texture, agreeable flavour, flexibility, resistance to decay, capacity to retain fire and availability. The morphological characters on which leaves are selected and categorized for Bidi making are size, thickness of leaves, texture, relative thickness of midrib and lateral veins (Table.1).

The length of the bidi varies from 4 to 8 cm with a diameter of 6 - 8 mm at the closed end and a width of 7 - 9 mm at the smoking end. Bidis are puffed more frequently than cigarettes to prevent them from extinguishing. When inhaled, carbon monoxide, instead of oxygen, is picked up by the hemoglobin of your red blood cells. The result is less oxygen being transported around your body and tar is a toxic residue that coats and paralyzes the cilia of the lungs. Therefore, it is pertinent to study the smoke constituents in the locally developed bidi tobacco lines to identify low tar lines

Key Words: Bidi, Nicotine, TAR, Carbon monoxide and Smoke condensate.

Table 1: Physicochemical characteristics of raw tendu leaf residues (mean ± SE).

Parameter			Parameter		
pH	:	8.2 ± 0.1	Iron (ppm)	:	35.0 ± 1.52
Carbon (%)	:	58.0 ± 2.07	Copper (ppm)	:	30.0 ± 1.00
Nitrogen (%)	:	1.38 ± 0.01	Manganese (ppm)	:	10.0 ± 0.01
Phosphorus (%)	:	0.084 ± 0.03	Zinc (ppm)	:	14 ± 1.52
Potassium (%)	:	0.43 ± 0.01	C/N ratio	:	42
Calcium (%)	:	1.20 ± 0.02			

Source: Dilip Kadam and Girish Pathade, (2014).

/ entries and the quantitative relationship between tar and carbon monoxide would help in producing bidis with lower levels of tar and carbon monoxide of tar and carbon-monoxide along with acceptable nicotine content.

MATERIALS AND METHODS

2.1 Sample preparation

The bidi samples were prepared using bidi tobacco lines obtained from ARS, *Nandyal*, Andhra Pradesh, India. The bidi samples were conditioned in a desiccator cabinet at 25 C and 60 % RH (ISO 3402: 1999a) for 48 hrs. Bidis within the range of ± 30 mg of average weight were selected by using analytical balance measuring to the nearest 0.1 mg. Bidis within the range of ± 2 mm of average length were selected using a length measuring device measuring to the nearest 0.5 mm. The bidis thus selected were grouped out, butt length marked , and smoked on a 20-port Linear Smoking Machine (SM 450, Cerulean, UK) by adopting the standard parameters as per ISO methods. The major smoke parameters TPM and NFDPM (ISO 17175:2017(E)), Water (ISO 10362-1:19996), Nicotine (ISO 10315- 2000b) and CO (ISO 8454-2007) were determined.

2.2 Determination of Total Particulate Matter (TPM)

The machine was setup by warming up cycles and puff volume of each channel was checked by using soap bubble flow meter. Air flow velocity was checked by using air velocity meter. Standard conditions of Puff duration (2 ± 0.02) s and puff frequency (30 ± 0.5) s and puff volume 35±0.3 ml was maintained for smoke run. The selected, and grouped bidis were inserted into the smoke trap fixed to the bidi holder, Initially the weight of the smoke trap with Cambridge filter pad kept inside was recorded and the front and back apertures were sealed with sealing devices. Cotton thread was used to terminate smoking at the butt mark. When each butt mark has been reached, the burning coal was removed from the bidi holder. The smoking process was repeated until the predetermined number of bidis were smoked as per the smoking plan into the smoke trap. The smoke trap was removed and covered the front and back apertures with sealing devices and the final reading of the holders was recorded. Total Particulate Matter (mg per bidi) was calculated by taking the difference of readings of before and after smoking process and mg/bidi was expressed as mg/g. The values of the tar, nicotine and CO in mg /g were calculated by taking bidi weight as a whole (Replacing bidi with its weight in grams converting it to per gram). Since the length and weight of the bidi vary from brand to brand, to know the difference among the values of different brands the values were expressed in uniform unit i.e mg per gram.

2.3 Determination of Water/moisture

After removing the sealing devices from the smoke trap, the filter pads were transferred to 150 ml Erlenmeyer flasks and 20 ml of Propan-2-ol prepared with dried methanol and *n-hepta decane* as internal standards (Merck) was added for determination of water and nicotine, respectively. The flasks were tightly sealed with Teflon and were shaken in a horizontal shaker for 20 minutes. A blank smoke trap was taken for blank determination of water. Gas Chromatograph (HP 5890 Series II, Agilent, USA) with TCD and a column (Length: 6 feet) of internal diameter between 2 mm and 4 mm with stationary phase

porapak QS was used. GC programme was maintained as oven temp: 170 C (isothermal), injector temp: 250 C, detector temp: 250 C, carrier gas helium, with flow rate 30 ml/min and injection volume of 2 µl. The unknown concentrations (mg/bidi) were measured using a graph plotted by running the water (Millipore) standards and mg/bidi moisture was expressed as mg/g.

2.4 Determination of Nicotine

Similarly, Gas Chromatograph (HP 5890 Series II, Agilent, USA) with FID and a column (length: 6 feet) of internal diameter between 2 mm and 4 mm with stationary phase:10% PEG 20000 plus 2% potassium hydroxide on an acid washed salinized support material, was used. GC programme was maintained as oven temp: 170 C (isothermal), injector temp: 250 C, detector temp: 250 C, carrier gas helium, with flow rate 30ml/min, auxiliary gases hydrogen and air were used for flame. Injection volume was 2 µl. The unknown concentrations (mg/bidi) were measured using a graph plotted by running the pure nicotine (Merck) standards.

2.5 Determination of Nicotine Free Dry Particulate Matter (NFDPM, or Tar)

Nicotine Free Dry Particulate Matter (NFDPM) which is also termed as tar. NFDPM (mg /bidi) was calculated by subtracting the values of water and nicotine from TPM and mg/bidi tar was expressed as mg/g.

2.6 Determination of Carbon monoxide (CO).

Carbon monoxide (mg/bidi) was measured using NDIR principle by COA 205 Analyser (Cerulean, UK) which was inbuilt in Smoking Machine, SM 450 and mg/bidi Carbon monoxide was expressed as mg/g.

RESULTS AND DISCUSSION

The bidi samples under investigation were analyzed for smoke parameters tar, nicotine, and carbon monoxide. In bidi leaf nicotine and reducing sugars were also analyzed. The values of physical parameters of bidi samples, smoke parameters and leaf quality parameters (expressed in mg g^{-1}) of bidi samples were given in Table.2. The average weight of the samples varied from 0.4697 to 0.5730 g with a mean value of 0.530 g. The length of the samples varied from 65 to 76 mm with a mean value of 70.6 mm.

3.1. Bidi mainstream smoke constituents

Samples of different bidi lines of four seasons of the study were assessed and the mean values of tar, smoke nicotine, leaf nicotine and carbon monoxide were 70.66 mg g^{-1}, 5.36 mg g^{-1}, 34.92 and 43.01 mg g^{-1}, respectively (Table.2). Among the bidi samples of different lines studied, tar content varied from 40.60 to 92.05 mg g^{-1} . Similarly, Carbon monoxide content ranged between 27.78 and 61.06 mg g^{-1}. Nicotine in smoke condensate varied from 1.98 to 7.26 mg g^{-1}. The nicotine concentration in the tobacco of bidi cigarettes was significantly greater than the tobacco from the commercial filtered and unfiltered cigarettes (Malson, et al. 2001). Bidi cigarettes can deliver high levels of tar (77.9±9.5 mg/bidi), nicotine (2.7±.4 mg/bidi), and CO (39.2±5.7 mg/bidi) (Clifford and Watson., 2003).

Moisture content in the smoke varied from 17.89 to 43.38 mg g^{-1} with a mean value of 26.92 (Table.2). The smoke quality of a bidi depends on the quality of bidi leaf tobacco and the natural wrapper (*Tendu* leaf) that is used for bidi making. The non-porous nature and higher moisture content of tendu leaf in bidis compared to cigarette wrapping paper led to higher levels of carbon monoxide and tar in bidi smoke compared to regular cigarette smoke (Oladipupo, et al, 2019).

3.2. Bidi Leaf quality

Leaf nicotine varied from 19.0 to 55.0 mg g^{-1}. No relationship was found between smoke nicotine with leaf nicotine. Reducing sugars in leaf tobacco of bidi varied from 14.8 to 55.1 mg g^{-1}. Higher levels of reducing sugars in tobacco reduce the harshness of the smoke.

3.3. Relationship of Tar to Carbon-monoxide in bidi mainstream smoke

Correlation between tar and CO was studied was found to be highly positive and significant

(Pearson Correlation Coefficient R value: 0.9536, P-Value < .00001 (p<0.01), Table.3). Further the relationship of Tar content and Carbon monoxide in bidi mainstream smoke was established using linear regression analysis. A model was developed to indicate the relationship and to predict the CO levels through the equation (Fig.2).

Linear regression Model: Tar (mg g^{-1}) = 8.9169 + 1.439 * Carbon monoxide (mg g^{-1}).

A significant linear relationship between Tar content and Carbon monoxide content in the smoke of bidis was found (R^2: 0.941) (Table.4, Fig.1) It is inferred that bidi tobacco smoke with higher tar levels contribute to higher CO levels. It is concluded that tar, nicotine and carbon monoxide contents in smoke of bidi samples were relatively high compared to FCV tobacco smoking products. Higher tar contents in bidi samples correlated with higher CO levels indicated that *bidi tobacco*-based bidis having low tar and CO are preferable as it is well known that tar and carbon monoxide are not good for human health and the environment. As smoking habit in India is high in the form of bidi and consumption of this form of tobacco for smoking is increasing in other parts of the world, it is henceforth become an important researchable and health care subject to develop bidis and bidi tobacco types with low tar and CO which help in reducing these levels in mainstream smoke of *bidi*.

Table 2: Physical, smoke and leaf quality parameters (mean) of different bidi lines.

Bidi tobacco lines code	Bidi weight (g)	BidiLength (mm)	Tar or NFDPM (mg g^{-1})	Smoke Nicotine (mg g^{-1})	Carbon monoxide	Leaf Nicotine (mg g^{-1})	Leaf Reducing sugars (mg g^{-1})	Moisture (mg g^{-1})
A 119	0.5730	71	64.84	5.27	38.74	29.7	33.18	21.66
ABD 114	0.5176	72	85.49	6.30	52.07	23.0	31.00	21.12
ABD 115	0.5309	72	72.91	4.84	46.54	19.0	29.90	17.89
ABD 116	0.5000	72	78.70	4.92	50.96	20.7	23.90	26.26
ABD 117	0.4904	72	87.38	4.28	54.63	21.0	24.40	32.12
ABD 119	0.4697	70	82.53	7.26	44.01	24.2	16.50	24.35
ABD 124	0.5144	70	73.91	6.30	42.20	31.6	14.80	26.54
ABD 131	0.6315	67	40.60	4.96	25.78	43.2	42.10	24.21
ABD 132	0.6373	65	51.70	5.57	26.28	42.3	55.10	28.16
NBD 119	0.5794	71	46.65	5.78	30.30	55.0	27.27	20.71
NBD 260	0.5380	67	64.96	6.02	37.71	51.7	31.30	18.55
NBD 289	0.4454	73	79.70	5.34	47.69	53.1	38.80	41.92
NBD 290	0.4126	73	92.05	6.23	61.06	39.6	38.90	43.38
Nandyal Pogaku - 1	0.5200	73	67.85	1.98	44.19	34.8	32.00	30.08
Mean	***0.530***	***70.57***	***70.66***	***5.36***	***43.01***	***34.92***	***31.37***	***26.92***
CV (%) :	***12.197***	***3.59***	***22.11***	***23.15***	***24.37***	***36.44***	***33.24***	***28.08***
SD (ó) :	***0.0641***	***2.53***	***15.62***	***1.24***	***10.48***	***12.72***	***10.43***	***7.56***

Table 3: Analysis of variance (Tar).

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	1	1449.290	1449.290	79.348	**0.000**
Error	5	91.325	18.265		
Corrected Total	6	1540.615			

Computed against model Y=Mean(Y)

Table 4: Model parameters (Tar).

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Intercept	8.917	5.817	1.533	0.186	-6.037	23.871
CO	1.439	0.123	11.671	**<0.0001**	1.122	1.755

R^2 value: 0.941, Adjusted R^2 : 0.929, MSE : 18.265, RMSE: 4.274

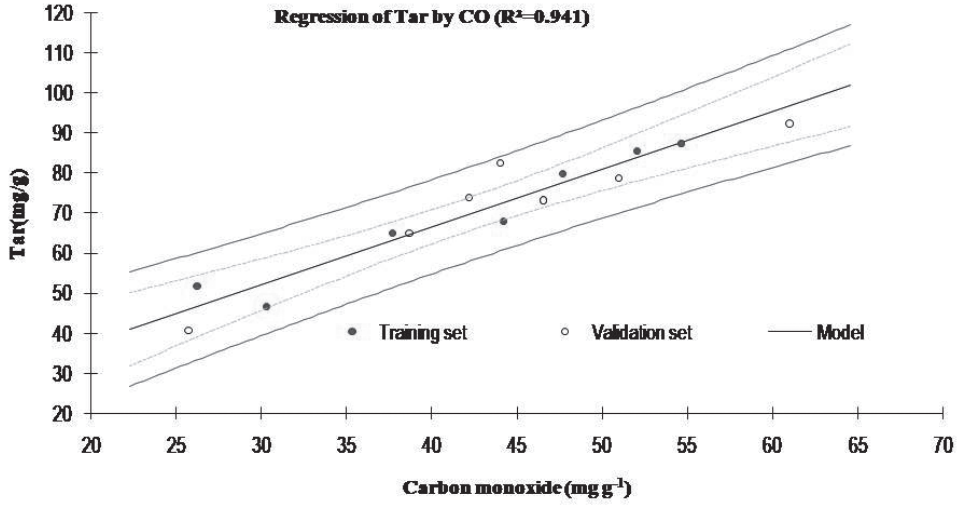

Fig.1: Relationship between Tar and Carbon monoxide present in bidi smoke.

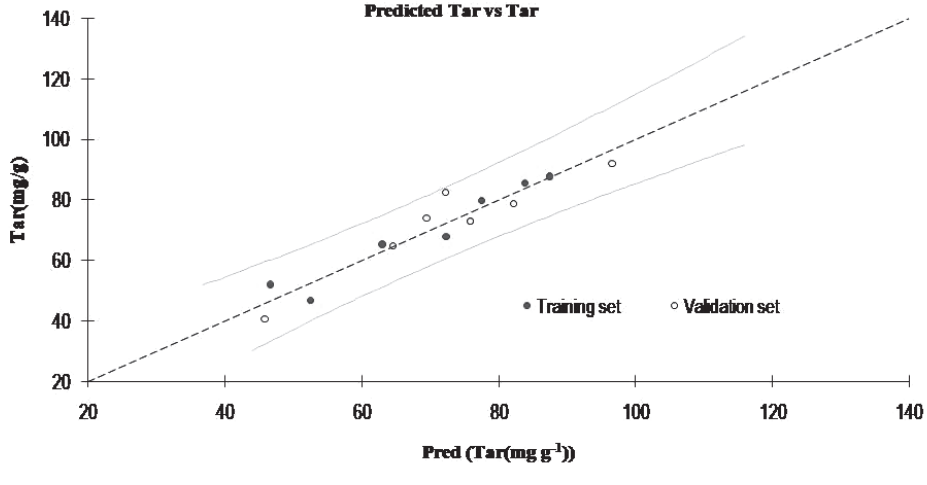

Fig.2: Predicted Tar vs Tar content in Bidi smoke

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