ORIGINAL ARTICLE

Nicotine, Propylene Glycol and Tobacco-specific Nitrosamines Content in Selected E-Liquids in Malaysia: The Case Support for Initiation of Standards or Guidelines

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ABSTRACT

Introduction: Electronic Cigarette (EC) usage has been gaining acceptance in Malaysia despite its lack of analytical evidence on the chemical constituents of its liquid formulations. This study aims to evaluate the chemical concentrations of nicotine, propylene glycol (PG) and selected Tobacco-Specific Nitrosamines (TSNAs); 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK) and N'-nitrosonornicotine (NNN) in e-liquids locally sourced from the Malaysian market. **Methods:** A total of 17 e-liquids from a variety of flavours and brands were purchased from local EC retailers in Klang Valley, Malaysia. Nicotine and PG concentrations were assessed using Gas Chromatography-Flame Ionization Detector (GC-FID) while NNK and NNN were quantified using Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS). The concentrations of nicotine and PG (mg/mL) were described in comparison with the levels indicated on the labels when present while levels of TSNAs were descriptively explained. **Results:** Nicotine was detected in all e-liquid samples, despite several samples being declared as nicotine-free. The average (standard deviation) level of nicotine, PG, NNN and NNK were 3.26 (1.04) mg/mL, 484.10 (98.24) mg/mL, 0.383(0.288) µg/L and 0.086 (0.057) µg/L, respectively. Labelling discrepancies (when indicated on the label) of nicotine and PG were between the range of 27%-73% and 3%-63%, respectively. **Conclusion:** The concentrations of nicotine and PG in local e-liquids were varied. There were evidences of labelling discrepancy in that local e-liquids. TSNAs were detected in all samples of e-liquids. This study brought forth strong evidence on the need for the implementation of regulation on e-liquid manufacturing and sales, particularly on the accuracy of labelling and licensing to protect the public health.

Keywords: E-liquid, Nicotine, TSNA, Tobacco, Electronic-nicotine delivery system

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INTRODUCTION

The use of electronic cigarettes (EC) have grown exponentially over the past few years and has been one of the most used innovation of tobacco products (1,2). EC works by delivering nicotine in aerosolised form. Once the sensor in the mouthpiece detects airflow, it activates a heating element that surrounds the cotton wick soaked with EC solution known as electronic-liquid (e-liquid) which often contains nicotine. This results in the vaporising of nicotine into aerosolised form that are later inhaled by the users (3,4).

Two major ingredients of e-liquid are propylene glycol (PG) and glycerine which are responsible in producing aerosols also act as a solvent for flavours and colours (5,6). Apart from that, e-liquid also contained flavouring additives (7) which have been associated with respiratory problems. For nicotine, its concentration in e-liquids have been found to range between 0.0001 mg/mL to 0.324 mg/mL (8). In the United Kingdom (UK), United States (US) and Poland, nicotine content is usually labelled by categories: low, medium or high concentrations (3,9). The European Food Safety Authority (EFSA) has established an Acute Reference Dose (ARfD) of 0.0008 mg/kg body weight according

to the Lowest Observed Adverse Effect Level (LOAEL) of 0.0035 mg/kg body weight for pharmacological effects after intravenous application of nicotine (10). While, the allowable maximum level of PG in the fine bakery wares and mixes are 1500 mg/kg as regulated in international standard for food additives (11). In terms of PG's toxicological profile, a minimal risk level (MRL) is 0.009 ppm (6), derived for intermediate-duration (15-364 days) of inhalation exposure.

TSNAs which known to be among the most potent compound found in tobacco products have also been reported to be present in e-liquids at variable levels (12,13). Compared to weaker carcinogenic TSNAs namely N'-nitrosoanabasine (NAT) and N-nitrosoanabasine (NAB), NNK and NNN are categorized as group 1 carcinogens (14). The latter are commonly found in e-liquids at average concentrations of 1.71 (1.69) µg/L for NNK and 4.06 (9.34) µg/L for NNN (13) while a median (interquartile range, IQR) concentration of 4.7 (3.2-6.8) µg/L and 1.3 (0.5-4.4) µg/L respectively, was reported by other study (12).

The use of EC among adult smokers in Malaysia was reported within the percentage of 10.4% to 15% (15,16). However, there are a lack of comprehensive surveys identifying the factors for the high EC usage. Previous studies have cited that EC was used as a harm reduction tool for smokers (17,18) but this applies to those with higher dependency to nicotine because there is the need for EC users to increase their initial nicotine intake up to 12 mg/mL before being able to successfully quit smoking (19,20). The need for the higher nicotine intake was due to low nicotine absorption from EC resulting in the ineffective delivery of nicotine to users. On the other hand, contrary finding was evident in a systematic meta-analysis study (21) where the use of EC was significantly correlated with lower quitting ratio. Due to the fact that nicotine is addictive, the increment of usage among youths who were previously non-smokers is a valid concern (21-23).

Globally, there are different EC regulations and policies adopted across different countries (23-25). In Malaysia, the sale, supply and storage of products containing nicotine are regulated under the Poison Act 1952 (26), restricting the sales of nicotine-containing EC to licensed pharmacies or medical officers only. There have been occurrences reported outside of Malaysia where e-liquids sold were found to contain detectable amounts of nicotine despite being labelled as nicotine-free (8,27,28). The labelling discrepancy may have been intentional to circumvent restriction mandated by law. In Malaysia, there is no set of specific standards for the manufacturing and packaging of e-liquids or EC. Unlike the production of conventional cigarettes (29), the manufacturing of e-liquids for the Malaysian market is not subjected to any specified standards pertaining to its contents and quality assurance of the product apart from the restriction in Poison Act.

There is a lack of published reports available focusing on chemical contents of local e-liquids in Malaysia despite the significant public health interest to EC and the controversial uncertainty regarding the harm due to its usage. Thus, this study aims to evaluate the chemical concentrations of nicotine, propylene glycol (PG) and selected Tobacco-Specific Nitrosamines (TSNAs); 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK) and N'-nitrosonornicotine (NNN) in e-liquids locally sourced from the Malaysian market. This study will provide crucial baseline information to narrow down the existing scientific gap and assist public health professionals and relevant administrative bodies in making decisions regarding the manufacturing, sales and usage of EC. The information obtained will enable further evaluation of risks related to EC usage to be carefully considered.

MATERIALS AND METHODS

E-liquid samples

A total of 17 locally manufactured e-liquids of various brands (30 mL bottle each) were purchased from three local vape retailers located within the Klang Valley, Malaysia. The e-liquids were then categorised according to its flavours as follows: fruity, coffee, tobacco, creamy rosewater syrup (a common flavour local to Malaysia), chocolate, creamy, menthol, vanilla and cola. The selections were based on the most favoured local e-liquids identified from questionnaire surveys on EC usage and patterns of use among 86 adult users in Klang Valley, Malaysia (30). The purchased samples were assigned with a unique coding, placed in individual zip-logged bags, kept from light source and were then stored at room temperature prior to analysis.

Reagents

Nicotine (L-nicotine, (≥99%) and 1,2-propanediols (≥99%) respectively) reference standards and dichloromethane (DCM) were purchased from Fisher Scientific Ltd. (New Jersey, USA). Isopropyl alcohol (i-propanol) was purchased from Systerm ChemAR (Malaysia). Reference standards of NNN (1mg/mL) (KIT0570) 95% and NNK (1mg/mL) (KIT0575) 98%, and isotope internals standards of NNN-d4 (0.1mg/mL) (KIT0765) 98% and NNK-d4 (1mg) (M325751) 98% were purchased from Toronto Research Chemicals (Canada). HPLC grade methanol (MeoH) was purchased from J.T. Baker (US).

Sample preparation and analysis procedures

The analysis of nicotine and PG were carried out based on the modification of a previously reported method (27). In brief, e-liquid samples were diluted with iso-propyl alcohol. Due to the wide difference in nicotine and PG contents in the e-liquids samples, two dilutions were prepared (5df and 250df, respectively) (28) prior to

the injection into the GC-FID. A method of liquid-liquid extraction for the determination of selected TSNAs level was modified from previous study (13). Firstly, 0.5 µL of e-liquid sample was pipetted into 20mL test tube and 4 mL deionized water was added. The solution was then extracted twice with 4 mL of dichloromethane by mechanical shaking for 10 minutes. The total organic phase was evaporated using rotary evaporator for 15 to 20 minutes. The remaining solution was then filtered using syringe filter (0.22 µm membrane pore size). About 380 µL of the sample was transferred into the autosampler vial and diluted with 100 µL of methanol. The addition of 20 µL of mix solution of internal standards (40 ppb) was added into the autosampler vial. The final volume of the sample was 0.5 mL and 25 µL prior automatically injected into the LC system. The repeatability (intra-day measurement) and reproducibility (inter-day measurement) test of all compounds were presented in Table I.

Instrumentation and apparatus

The concentration of nicotine and PG were analysed using an Agilent HP-624 GC-FID (Agilent Technologies, CA, USA). The chromatographic separation was accomplished using a J&W Scientific capillary column (DB-624, 30m, 0.25 mm i.d., 1.4µm film thickness, Part-No. 122-1334). For the quantification of nicotine and PG contents, a five-point calibration curve ranging from 0.2 mg/mL to 1 mg/mL was prepared for each analyte. Accela high speed Liquid Chromatography interface to Thermo Scientific Quantum Ultra triple stage quadrupole (QqQ) mass spectrometer (Thermo Scientific, CA, USA) was used to quantify the NNK and NNN. The analytes were separated using a 3.0 mmx50 mm Poroshell 120,

Table I: Intra- and inter-day laboratory accuracy and precision results for the analysis of nicotine, PG, and TSNAs (n=5)

Compound	Concentration	Intra-day measured value (Repeatability) (n=5)		
		Measured concentration (mg/mL)	Accuracy[1] (%)	Precision[2] (%RSD)
		0.5971±0.0075	99.516±1.249	1.25
	0.6mg/mL	Inter-day measured value (Reproducibility)		
Nicotine		Measured concentration (mg/mL)	Accuracy (%)	Precision (% RSD)
	1st day (n=5)	0.5971±0.0075	99.516±1.249	1.25
	2nd day (n=5)	0.5782±0.0146	96.361±2.430	2.52
	3rd day (n=5)	0.5724±0.0154	95.396±2.566	2.69
		Intra-day measured value (Repeatability)(n=5)		
		Measured concentration (mg/mL)	Accuracy (%)	Precision (% RSD)
	0.6mg/mL	0.5367±0.0184	89.449±3.066	3.427
PG		Inter-day measured value (Reproducibility)		
		Measured concentration (mg/mL)	Accuracy (%)	Precision (% RSD)
	1st day (n=5)	0.5367±0.0184	89.449±3.066	3.427
	2nd day (n=5)	0.5318±0.0164	88.640±2.739	3.08
	3rd day (n=5)	0.5104±0.0076	85.062±1.270	1.49
		Intra-day measured value (Repeatability)		
		Measured concentration (µg/L)	Accuracy (%)	Precision (% RSD)
	60µg/L	69.60±6.85	116.00±11.42	9.84
		Inter-day measured value (Reproducibility)		
		Measured concentration (µg/L)	Accuracy (%)	Precision (% RSD)
NNK	1st day (n=5)	69.60±6.85	116.00±11.42	9.84
	2nd day (n=5)	62.78±3.43	104.63±5.72	5.46
	3rd day (n=5)	63.59±4.09	105.98±6.82	6.43
		Intra-day measured value (Repeatability)		
		Measured concentration (µg/L)	Accuracy (%)	Precision (% RSD)
	60µg/L	67.89±4.06	113.15±6.77	5.98
		Inter-day measured value (Reproducibility)		
		Measured concentration (µg/L)	Accuracy (%)	Precision (% RSD)
	1st day (n=5)	67.89±4.06	113.15±6.77	5.98
	2nd day (n=5)	64.51±3.51	107.52±5.84	5.44
NNN	3rd day (n=5)	62.82±6.33	104.71±10.55	10.07

[a]Accuracy (%): $\frac{\text{measured concentration value}}{\text{true concentration value}} \times 100$ [b]Precision (%RSD): $\frac{\text{Standard deviation,SD}}{\text{Mean}} \times 100$

EC-C18 column with 2.7 µm pore size (Agilent, USA). Calibration curves were established for each compound containing eight points ranging from 0.5 to 100 µg/L for NNK and 1 to 100 µg/L for NNN. The limits of detection of NNK and NNN were 0.012µg/L and 0.021µg/L, respectively.

In the absence of certified reference materials, 0.6 mg/mL of nicotine and PG standard solutions were prepared and measured for repeatability (intra-day measurement) and reproducibility (inter-day measurement). Intra-day accuracy (%) and precision (% Relative Standard Deviation, % RSD) were evaluated for five injections of analyte standard solutions at concentrations of 0.6 mg/mL in one day. Inter-day accuracy (%) and precision (% Relative Standard Deviation, % RSD) were determined by their recoveries on three different days. The intra-day accuracy for nicotine was 99.5±1.25% and the precision was less than 10% (1.25% RSD) whereas , the accuracy percentage was reported between the range of 96.36% to 99.52% for inter-day analysis.The precision of the analysis was 1.25% to 2.69%. The accuracy of intra-day measurement for PG analysis showed a good accuracy and precision with 89.45±3.07% and 3.43% RSD.

The accuracy and precision of the TSNAs analysis were determined by performing intra-day and inter-day analysis of 60 µg/L NNK and NNN standards solutions; spiked with 40 µg/L internal standards. The intra-day analysis for five replicates of injections were resulted a good accuracy with an average of 124.57% and 115.78% for NNK and NNN respectively. While the range accuracy for three consecutive days of analysis (inter-day) were 104.63-124.57% for NNK and 104.71-113.15% for NNN. Table I summarizes the precision and accuracy for the determination of nicotine, PG, NNK and NNN.

RESULTS

Nicotine and Propylene Glycol

Descriptively, out of the 17 samples examined in this study, seven samples (41%) had no specified nicotine concentration on their labels. Eight samples (n=8) were labeled to contain 6 mg of nicotine. Another two bottles had nicotine-free declared on its label. For samples with labeled nicotine concentration, the actual measured concentrations were lower by 27% to 73% compared to declared-contents. Nicotine was also detected in two samples of e-liquids, despite being declared as nicotine-free. For e-liquids without any indication of nicotine content, the nicotine concentrations were found to range from 2.07-5.15 mg/mL with mean (standard deviation, s.d.) of 3.38 (1.24) mg/mL. The average (s.d) content of PG was 484.1(98.2) mg/mL and ranged between 316.7 mg/mL to 715.7 mg/mL. Only 12 of the samples indicated concentrations of PG on their labels (ranging from 34% to 60%). Distributions of PG and nicotine concentrations are as presented in Table II. The representative GC chromatograms of nicotine's standard

Table II: Concentration of nicotine, PG, NNN and NNK in local-manufactured e-liquids (N=17)

ID	Flavour	Nicotine				PG			NNN	NNK
		Bottle capacity (mL)	Content on label (mg/mL)	Measured Content (mg/mL)	Difference from label (%)[2]	Content on label (%)[4]	Measured Content (mg/mL)	Difference from label (%)	Measured Content (µg/L)	
EL1	Coffee	NS[1]	0	1.80	-	50	487.5	2.50	0.683	0.065
EL2	Tobacco	NS	0	3.48	-	35	397.7	13.6	0.415	0.084
EL3	Coffee	30	6	1.60	73.3	NS	448.5	-	0.193	0.031
EL4	Fruity	30	6	2.38	60.3	NS	585.9	-	0.179	0.074
EL5	Creamy rosewater syrup	30	6	3.26	45.67	30	316.7	5.56	0.166	0.070
EL6	Chocolate	32	6	3.62	39.67	34	555.4	63.3	0.868	0.151
EL7	Creamy	30	6	3.55	40.83	40	488.6	22.2	0.147	0.027
EL8	Creamy	30	6	3.65	39.17	30	409.7	36.6	0.979	0.113
EL9	Creamy	NS	6	3.99	33.50	60	472.1	21.3	0.316	0.073
EL10	Menthol	30	6	4.41	26.50	50	401.1	19.9	0.727	0.186
EL11	Fruity	30	NS[1]	2.07	NS	NS	515.5	-	0.133	0.072
EL12	Fruity	NS	NS	2.48	NS	NS	715.7	-	0.631	0.141
EL13	Fruity	NS	NS	2.67	NS	50	416.7	16.7	0.127	0.116
EL14	Menthol	NS	NS	2.45	NS	50	469.7	6.06	0.188	0.019
EL15	Creamy	30	NS	4.38	NS	60	645.5	7.45	0.042	0.016
EL16	Vanilla	30	NS	4.47	NS	50	419.5	16.1	0.355	0.025
EL17	Cola	30	NS	5.15	NS	NS	483.9	-	0.369	0.196
			Average[3]	3.26 (1.04)			484.1 (98.2)		0.383 (0.288)	0.086 (0.057)

[1] NS: Not stated; [2] %Difference from label: , [3] Mean (Standard deviation); [4] conversion of % to mg/mL: author has rounded the actual PG density of 1.04g/cm^3 to 1.0g/cm^3

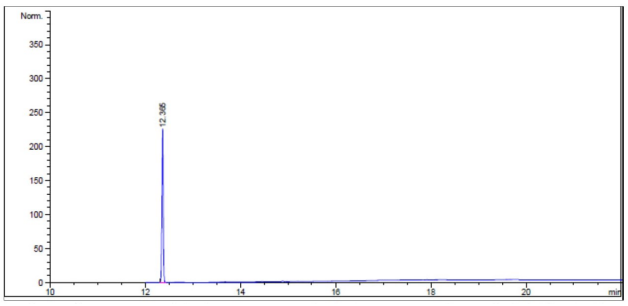

Figure 1: Representative of GC chromatogram of nicotine standard solution (5df) (0.6mg/mL)

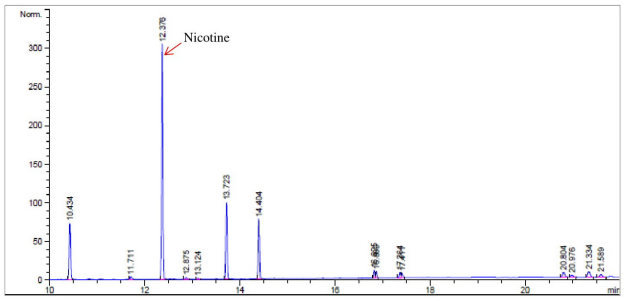

Figure 2: Representative of GC chromatograms of sample "EL9" for nicotine analysis (5df)

and e-liquid sample are shown in Figure 1 and Figure 2, respectively.

Tobacco-specific nitrosamines (TSNAs)

All samples had detectable levels of NNN and NNK. The mean (s.d) concentration of NNN was 0.383 (0.288) µg/L while for NNK, the average was 0.085 (0.057) µg/L. The highest level of NNN (0.980 µg/L) and NNK (0.196 µg/L) was found in sample "EL8" and "EL17", respectively. The lowest level of NNN (0.042 µg/L) and NNK (0.016µg/L) were present in the same sample; sample "EL15". The measured content of NNN and NNK are included in Table II. Examples of LC-MS/MS chromatograms of the selected TSNAs are shown in Figure 3 and Figure 4.

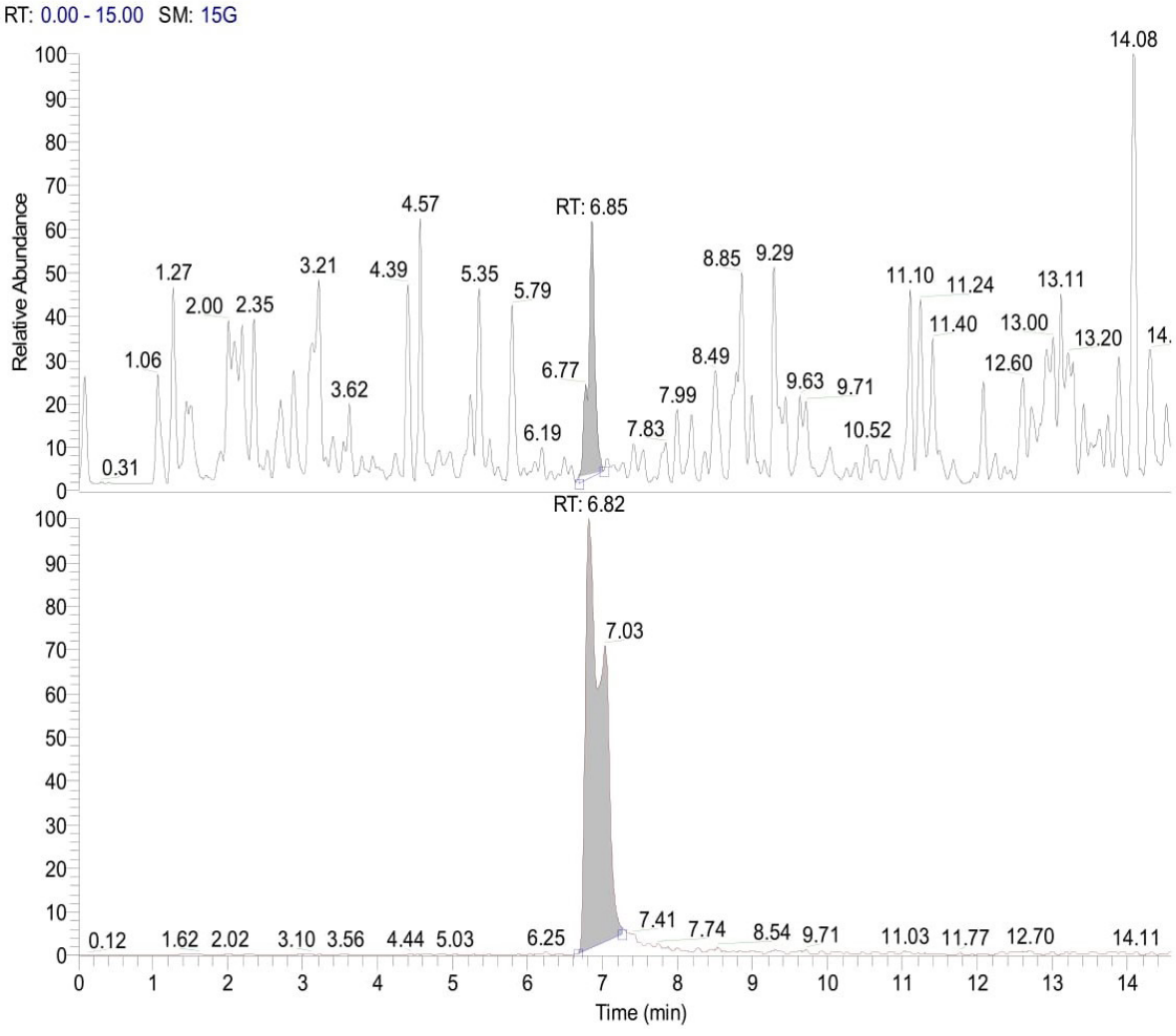

Figure 3: Representative of LCMS/MS chromatograms of sample "EL17" for NNK analysis

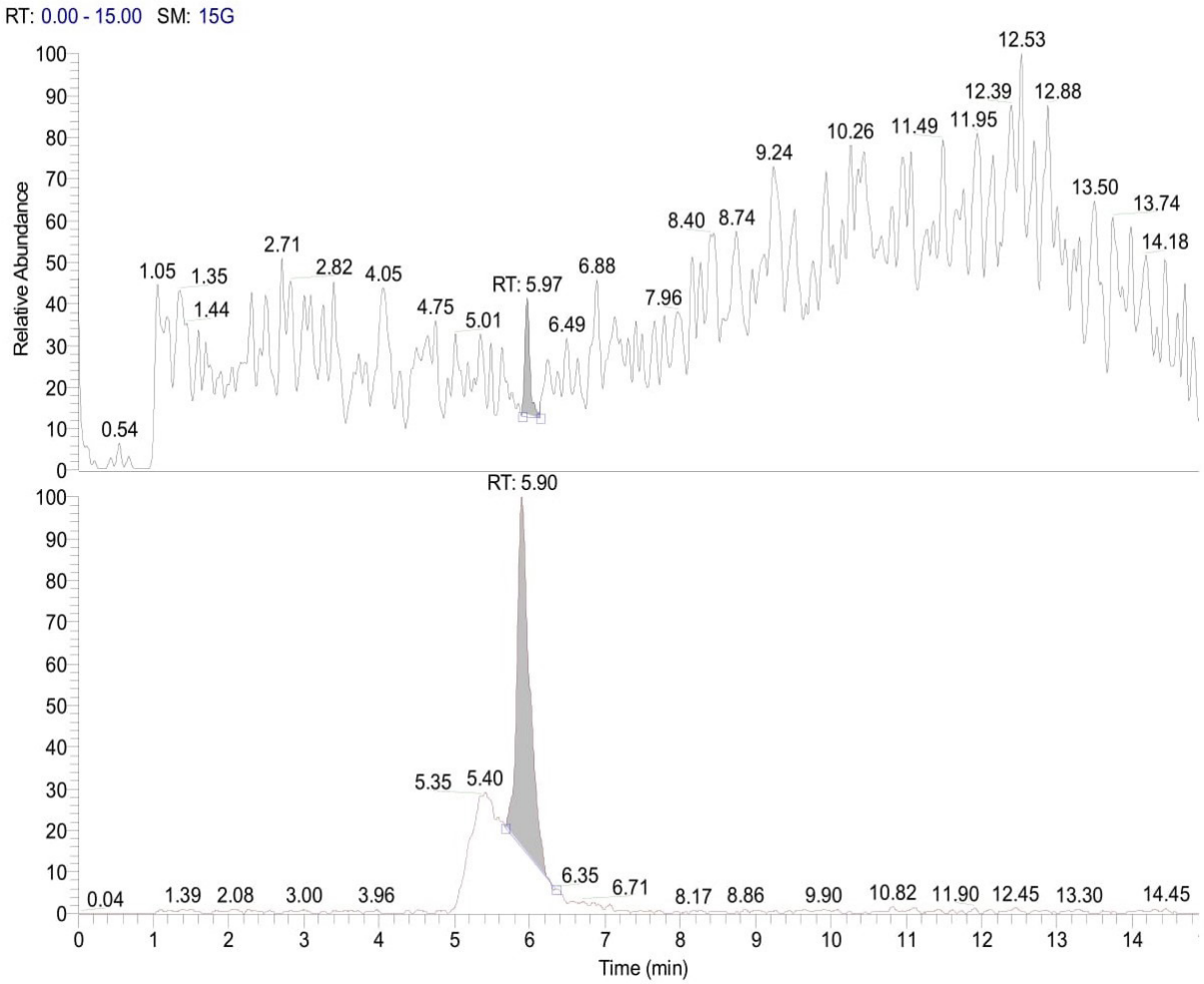

Figure 4: Representative of LCMS/MS chromatograms of sample "EL14" for NNN analysis

DISCUSSION

This study was able to objectively measure the concentrations of nicotine, PG and selected TSNAs in 17 locally-sourced e-liquid purchased in the Klang Valley, Malaysia. There are no other local studies thus far which have reported the levels of chemical constituents of locally made e-liquids, even though the trend of use is on the rise.

This study found inconsistencies between the levels of nicotine declared on the labels of e-liquid bottles from the actual concentrations measured. Most of the e-liquids had lower actual nicotine concentrations compared to the levels declared, which is similar to findings previously described elsewhere (3,31,32). It is suggested that the lower nicotine concentrations may be due to the degradation of nicotine over time into other nicotine-related substances. One study reported that degradation may account up to 4.4% of the total nicotine content in e-liquids (33). This study also found that e-liquids which were declared as nicotine-free were found to contain nicotine. To explain this, it may be that the detected nicotine in nicotine-free e-liquids may have been carried over from other ingredients which occur during the manufacturing process as reported in a previous study (8). If the nicotine were in fact being unintentionally carried over, the levels measured will likely be in minute concentrations; however in this study, the levels were similar to the samples declared to contain nicotine; in other words, there were minimal differences in terms of the distribution of nicotine, meaning most likely that the e-liquids were intentionally spiked with specific concentrations of nicotine. This finding may suggest that nicotine concentration in local e-liquids were purposely undeclared or incorrectly labelled in order to circumvent the sale restriction as indicated in the existing legislation.

The main concern on incorrect labelling of nicotine is the increased likelihood of EC users to be involuntarily exposed to higher levels of nicotine. There is the possibility that nicotine addiction among novice EC users is induced which is against the tobacco control policy of this country and nicotine addiction among dual-users in worsened (34). In such scenario, the potential of EC to be used as a tool for smoking cessation needs to be carefully considered.

The issue of inconsistency in the labelling of e-liquids

may also be due to the unavailability of guideline, unlike in other developed countries at present. The Ministry of Health has announced they are inclined towards prohibiting EC as stipulated by the World Health Organisation Framework Convention on Tobacco Control (WHO FCTC) (35) but this would require an amendment of the legislation. Thus, the manufacturing and sales of e-liquids in the local market continues without any clear restrictions. In certain countries, manufacturers need to closely adhere to the permissible levels of nicotine in e-liquids. There is a need for similar stipulation in the regulation; or at minimum, in the industrial code of practice for the manufacturers and retailers to comply with.

Taking into considerations the guidelines available elsewhere (24,36), the construction of similar outline can be seen as a good initial approach to be adapted in controlling and managing the production of local-manufactured e-liquids. This is to prevent any unwanted health consequences from intentional EC usage among vulnerable populations such as young adolescents and women or unintentional e-liquid exposure among children such as accidental ingestion (37). Thus, safety aspects such as childproof bottles and warning lables need to be considered in the production of e-liquids.

Compared to a previous study in Italy (27) (530.7±11.3 to 538.7±15.3 mg/mL), e-liquids in this study had a lower average of PG. In spite of the non-toxic characteristics of PG (6), several studies have shown that the heating process of this humectant has been proven to produce carcinogenic carbonyl compounds such as formaldehyde, acetaldehyde and acrolein in EC vapours (3,38). The composition of e-liquids containing more PG combined with the high EC battery voltage suggested to contribute to a higher amount of carbonyl compounds in EC vapour as PG is more prone to thermal decomposition than vegetable glycerine (VG), another base solution for e-liquids (38).

The acute and chronic exposures to PG have shown to cause eye and respiratory irritation and may also affect the central nervous system (6). The risk of exposures to PG can be further described using Health Risk Assessment method as have been previously published (39). The calculation of risk can be made using the information on vaping topography of a particular population; combined with concentration of PG determined analytically such as in this study. The potential Average Daily Dose (ADD) of PG can be used for estimating the hazard quotient (HQ) which indicates whether PG exposure could possibly pose appreciable non-carcinogenic health risk to the users. In addition, there are other significant factors that influenced the estimated risks such as the frequency of EC usage and the volume of e-liquid ingested either after deposition of vapour droplet into the upper aero-digestive tract during normal vaping or accidental ingestion (40,41). Even though PG has been known to be safe, over consumption and individual pattern of EC usage would exacerbate its repercussions to the users.

This study measured TNSAs which are carcinogenic compounds produced from the process of nicotine extractions from tobacco leaves (4). Insufficient storage during manufacturing process have caused the nitrosation of nornicotine originated from nicotine that occurs in the e-liquid solution (42) and therefore, enhancing NNN content in e-liquids. For this study, the measured NNN and NNK levels were found to be lower than the level reported in a previous study; (14) 1.71(1.69) µg/L for NNK and 4.06(9.34) µg/L for NNN. Several studies have reported low or undetectable levels of TSNAs (39,40). Despite of low detected level of TSNA, the conversion of nitrate contained in the e-liquid into nitrite in saliva (43) would result in the endogenous production of TSNA (44). Thus, the potential carcinogenic health risks will be worsened by the additional mechanism taking place in the human body which may result in higher exposures to TSNA compounds.

In summary, this study is among the first published data on the analysis of chemical contents in selected brands of locally-manufactured e-liquids which is currently scarce in Malaysia. The evidence found in this study may help to reduce the knowledge gap regarding chemical constituents of e-liquids and can be used by public health researchers to perform risk estimation due to exposures to the chemicals. This study may help provide input to the authorities in assisting them to make decisions pertaining to the regulating of EC in Malaysia as the analysis covered the most used EC brands (34) by the local EC users.

There are several limitations in this study; 1) only one batch of e-liquids sample was purchased for each brand, thus any variation due to different production batches was unable to be determined, 2) this study had specifically selected e-liquid samples with 6 mg of nicotine in its content (when nicotine is declared on its label), the lowest in the available range, to reflect the common selection of adult smokers reported in a previous study used as a reference (30). In retail shops, there are options for e-liquids containing 10 or 12 mg of nicotine for selection, as such there may be the need to also include other range of nicotine concentration in future studies.

CONCLUSION

This study found that the concentrations of nicotine and PG in local e-liquids were varied. There were evidence of labelling discrepancy and e-liquids declared as nicotine-free had in fact contain nicotine. Despite its low levels, carcinogenic TSNAs were detected in all samples of e-liquids. These findings have brought forth evidence on the crucial need for the implementation

of regulation on e-liquid manufacturing and sales particularly on the accuracy of labelling and licensing to protect the public health. Compulsory declaration of the contents by the manufacturer should be enforced to avoid endless cost-ineffective sampling by enforcement agencies. Any contradiction to such self-declared labels should be deemed as non-compliance under the law for deceptive labeling. Another worrying issue is that there is possibility of other dangerous drugs or alcohol to be misused by the act of vaping. Thus, e-cigarette devices should also be deemed as "utensils" under the original and revised version of the Dangerous Drugs Act 1952. In supporting the Endgame of tobacco in Malaysia in 2045, there is an urgency for the government to come out with a legislation related to EC and strengthening its existing enforcements to prevent detrimental health effects arising from EC usage.

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