Chemical characterisation of a disposable e-vapour product reveals marked reductions in toxicant levels when compared to cigarettes

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1. INTRODUCTION

A new generation of disposable vapour products have been launched, which are characterised as being single use, pre-filled, pre-charged. Disposable vapour products have gained popularity with adult smokers as an alternative to smoking and are a growing category of E-Vapour Products (EVP). With the popularity of these products, there is a nascent and growing body of evidence for the contribution of disposables to harm reduction. The aim of this research was to characterise and compare EVP aerosol and tobacco smoke for 53 toxicants to demonstrate the harm reduction potential of EVP compared to cigarettes. The analytes that were reviewed have been identified by public health authorities as chemicals associated with causing diseases in smokers and have been published on lists such as WHO TobReg9 and FDA. These analytes included carbonyls, phenolics, tobacco specific nitrosamines, polyaromatic amines, polycyclic aromatic hydrocarbons and heavy metals.

2. METHODOLOGY

2.1 Test Products:

- 1R6F Reference Cigarette (University of Kentucky).
- Disposable EVP (blu bar™ Kiwi Passionfruit) (Imperial Brands PLC).

2.2 Smoke/Aerosol Generation:

- ISO:20778:2018 (55ml puff volume, one puff every 30 seconds, 2 second puff duration, bell shaped puff profile) puffing regime was used for cigarette smoke generation.
- ISO:20768:2018 (55ml puff volume, one puff every 30 seconds and 3 second puff duration, rectangle shaped) regimen was used for EVP.
- For 1R6F between 8.3 and 10.5 puffs were taken in replicates of 3.
- For the disposable EVP 50 puffs were taken for each block, with 3 blocks taken (150 puffs total).

2.3 Analytical Methods:

- EVP aerosol collected mass (**ACM**)/ 1R6F total particulate matter (**TPM**) was trapped on a Cambridge filter pad using a rotary machine. The mass of the filter pad including the holder of the smoking machine was determined before and after use. The mass of the collected particulate phase per stick is the ACM/ TPM.
- Tobacco Specific N-nitrosamines (**TSNAs**) - the collected ACM/ TPM of the aerosol/ smoke produced using was collected on Cambridge filter pads, and extracted with water/methanol. This was analysed using liquid chromatography (LC) and tandem mass spectrometry (MS/MS).
- **Gas phase** - the vapour phase of the aerosol/ smoke produced was collected in a Tedlar bag located after the Cambridge filter pad. The sample (vapour phase) is separated by gas chromatography (GC) and detected by mass spectrometry (MS).
- **Nicotine** – the particle phase of the aerosol/ smoke was trapped on a Cambridge filter pad. The filter was extracted with 2-Propanol. Analysis is carried out using GC-flame ionization detection (FID).
- **Heavy Metals** – the whole unfiltered aerosol/smoke was collected by two impingers in series, filled with a solution of nitric acid. Extracts were then analysed by induction coupled plasma (ICP)-MS.
- **Benzo(a)pyrene (BAP)** – the aerosol/ smoke produced is collected on a Cambridge filter pad which was then extracted by cyclohexane. Part of the extract is concentrated and cleaned using solid phase extraction (SPE) with n-hexane as eluent. The eluate is concentrated and diluted by cyclohexane. This solution is analysed by GC-MS.
- **Carbonyls** – the whole aerosol and the gas phase directly through two in row impingers containing DNPH (2,4-Dinitriphenylhydrazine) solution in acetonitrile to trap all carbonyls as hydrazones. The solution was stabilised and analysed using reversed phase high phase liquid chromatography (HPLC)-diode-array detector DAD.
- **Aromatic Amines** - following smoking, Cambridge filter pad is extracted by 5% hydrochloric acid, neutralized and the aromatic amines are extracted using n-hexane. The extract is treated with PFPA (Pentafluoropropionic acid anhydride) followed by a SPE and quantified by GC-MS.
- **Phenols -** following smoking, the Cambridge filter pad is extracted by 1% acetic acid in water. An aliquot is filtrated, diluted and analysed using reversed phase ultra high phase liquid chromatograph (UHPLC) fluorescence detector.
- **Semi-Volatiles** - following smoking, the Cambridge filter and the whole aerosol/smoke trapped with an impinger -Methanol at -70°C (dry-ice/isopropanol) are together extracted and injected in a specific GC-MS system.
- **Ammonia** - the smoke condensate is trapped using electrostatic trapping in addition to an impinger containing diluted sulfuric acid. Ammonium is transformed in a coloured complex and analysed using a continuous flow analyser.

3. RESULTS

The average ACM for the blu bar was 5.7mg/puff, whereas the 1R6F cigarette delivered 4.2mg/puff TPM. Figure 1 shows the chemical proportions of the 1R6F TPM, with nicotine and water making 34% of the overall constituents and the rest being carbon monoxide and other chemicals. Whereas Figure 2 shows that in blu bar, ACM is mainly composed of propylene glycol, glycerol and water, accounting for 95% of the collected mass. This illustrates, broadly, the chemical simplicity of EVP compared to cigarettes.

The nicotine yield for the blu bar product was 90.6µg/puff, whereas for 1R6F cigarettes it was higher at 206.2µg/puff.

Figure 1: Shows the proportions of constituents within 1R6F cigarette.

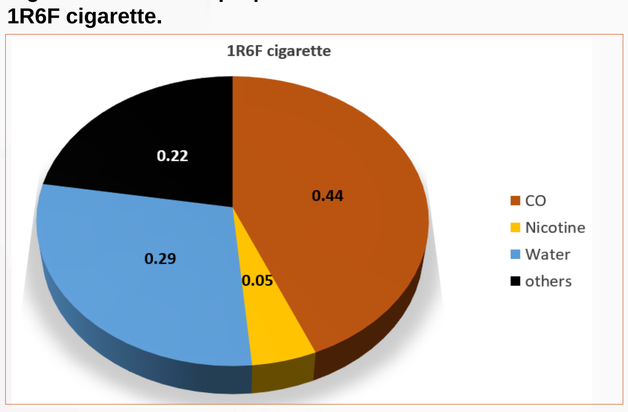
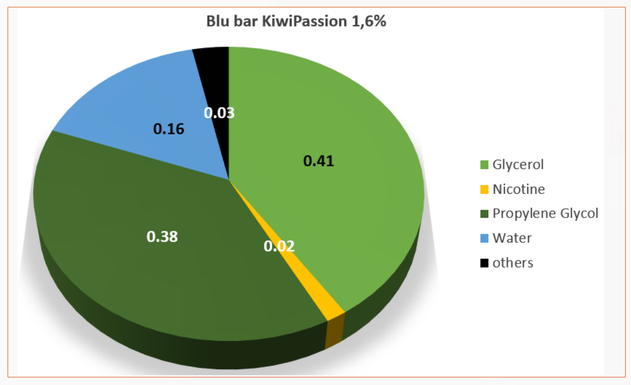


Figure 2: Shows the proportions of constituents within blu bar.



When collated into analyte lists suggested by public health authorities, there were toxicant decreases of 97.9 - 99.8% in the blu bar aerosol when compared to 1R6F smoke. See Figure 3.

Of the toxicants tested in the blu bar aerosol, 46 out of the 53 analytes were below their respective limits of quantification.

A summary of the 7 analytes that were quantifiable in the blu bar aerosol were compared to cigarette smoke levels and is shown in Figure 4. These analytes were present at levels markedly lower (95.6-99.8% reduction) than what was measured in 1R6F smoke.

Figure 3: Comparison of HPHC levels between blu bar and 1R6F against regulatory HPHC lists.

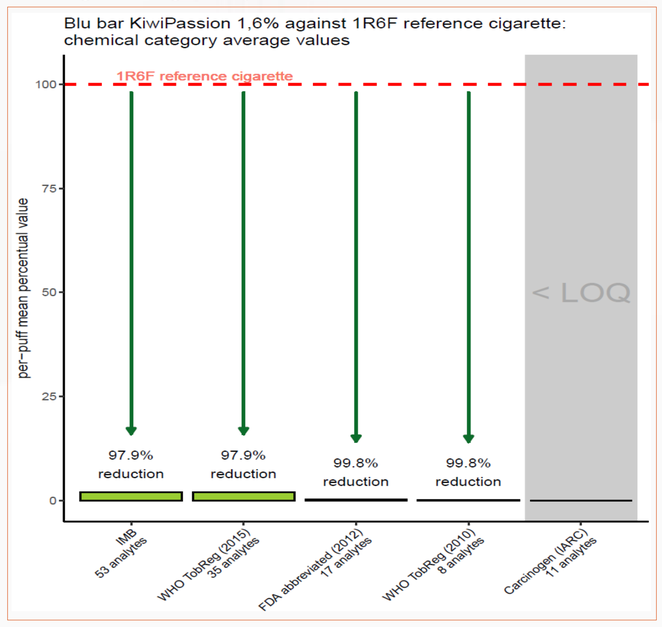
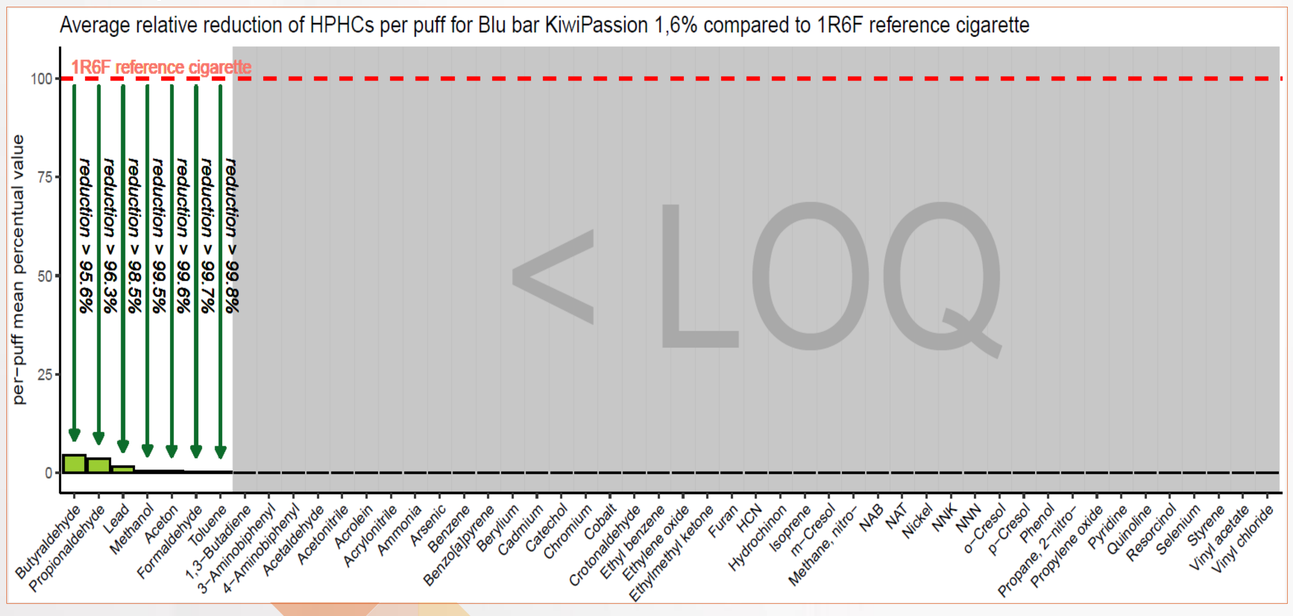


Figure 4: HPHC levels in blu bar and the relative reduction compared to 1R6F.



4. CONCLUSIONS

- **Nicotine Delivery:** The blu bar delivered an average of 90.6µg/puff of nicotine, whereas the cigarette delivered a nicotine level of 206.2µg/puff.
- **Substantially reduced numbers and levels of toxicants:** In contrast to the 1R6F cigarette, most toxicants analysed for in the disposable vape aerosol product were below the limit of quantification (n=46/53). Formaldehyde, propionaldehyde, butyraldehyde, methanol, acetone, toluene and lead, were quantified in the aerosol of the disposable vape product, but at substantially reduced levels when compared to cigarette smoke (reductions of 95.6-99.9%).
- **Contribution to harm reduction:** These results indicate that blu bar has the potential to contribute to tobacco harm reduction by delivering nicotine and flavours with substantial reductions in toxicants compared to cigarette smoke under the test conditions. This highlights the potential role of disposable EVP in tobacco harm reduction, given their potentially reduced risk for adult smokers.

REFERENCES

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