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ADMET analysis of phyto-components of *Syzygium cumini* seeds and *Allium cepa* peels

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Abstract

Background: The inedible wastes generated from vegetables and fruits are one of the sources of environmental pollution if not utilized or disposed-off in a proper way. Research is focused on the utilization of these wastes as potential resources rather than undesirable and unwanted products in order to avoid contamination of natural resources. *Syzygium cumini* (black plum) seeds and *Allium cepa* (onion) peels were studied. These wastes were fermented and phyto-components of these wastes were determined by gas chromatography mass spectrometry (GCMS). The phyto-components were examined for their pharmacokinetics properties like drug-likeness and toxicity. The open source softwares, DruLiTo and VEGA QSAR, were used to perform the aforementioned study.

Result: GCMS: Twenty phyto-components were identified by performing GCMS analysis of the methanol extracts of fermented *Syzygium cumini* seeds and fermented *Allium cepa* peels.
DruLiTo: Four phyto-components each from the methanol extracts of *Syzygium cumini* seeds and *Allium cepa* peels followed all the drug-likeness rules.
VEGA QSAR: Six phyto-components of methanol extract of fermented *Syzygium cumini* seeds were identified as non-mutagenic whereas nine phyto-components of methanol extract of fermented *Allium cepa* peels were non-mutagenic.
Collectively two phyto-components of methanol extracts of *Syzygium cumini* seeds and four phyto-components of methanol extracts of *Allium cepa* possess the pharmacokinetic properties.

Conclusion: The phyto-components predicted to be drug-like and non-mutagenic can be further studied as ligands for bacterial and cancerous targets by the means of in-silico docking approach/techniques. The exploration carries supportive data for future examinations that can lead to their therapeutic use.

Keywords: Pharmacokinetics, Drug-likeness, Toxicology, *Syzygium cumini*, *Allium cepa*, Gas chromatography mass spectrometry, DruLiTo, VEGA QSAR

Background

Since ancient time, *Syzygium cumini* seeds are used to treat several diseases. Extracts of *Syzygium cumini* seed contains flavonoids, alkaloids, glycosides, triterpenoids, steroids, saponins, and tannins [1]. *Allium cepa* peel possesses alkaloids, tannins, flavanoids, phenolic flavanoids, carbohydrates, steroids, cardiac glycosides and phlobatannins. Fermented *Allium cepa* peel extracts are reported to possess antioxidant potential [2].

Currently, pharmaceutical industry faces large attrition rates of preclinical and clinical candidates due to toxicity or lag of optimal pharmacokinetics properties, resulting in high costs and increased timelines for the drug discovery process [3].

To be a functional as a drug, the molecule must reach its target in the body in adequate concentration and stay there in a bioactive form until the expected biological

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events occur. Poor pharmacokinetic properties are one of the main reasons for terminating the development of drug candidates. Computed physicochemical properties associated with compounds that have good oral bioavailability, less or no toxicity and optimum values of physicochemical properties are key parameters for the drug discovery [4, 5]. Drug development involves valuation of absorption, distribution, metabolism, excretion (ADME) and toxicity (Tox) earlier in the discovery process, at a stage when more number of compounds are taken into consideration [6].

ADME/Tox was performed virtually to know the pharmacokinetic or drug-likeness property and mutagenicity of components obtained from the gas chromatography mass spectrometry analysis by open source software DruLiTo and VEGA QSAR [7, 8].

DruLiTo is an open source virtual Drug Likeness Tool available from http://www.niper.gov.in/pi_dev_tools/DruLiToWeb/DruLiTo_index.html [9]. DruLito calculates the basic pharmacokinetic properties like the molecular weight (Mw), partition coefficient (logP), octanol-water partition coefficient (AlogP), H-bond acceptor (HBA), H-bond donor (HBD), total polar surface area (TPSA), atom molar refractivity (AMR), number of rotatable bonds (nRB), rotatable bond count (RC), number of rigid bonds (nRigidB) and number of hydrogen bonds (nHB) [9]. Calculations with DruLiTo are dependent on various drug-likeness rules, namely Lipinski's rule, Veber's rule, the BBB rule and quantitative estimate of the drug-likeness (QED). Taking these rules and restrictions into account, DruLito allows one to determine substances that fulfil required parameters and enables their application in further research [6].

The toxicity of molecules was predicted by VEGA QSAR. VEGA QSAR is a freely available in silico model provided by VEGAHUB and can be downloaded from www.vegahub.eu/portfolio-item/vega-qsar [8]. Predictive toxicology is using models to predict biological endpoints for toxicity, without making real experiments. "Structure-Activity Relationship" (SAR) is based on the concept that the biological activity of a chemical can be linked to its molecular structure. When quantified, this relationship is known as "QSAR". A QSAR model makes use of existing experimental toxicity data for a series of chemicals to build a model that relates experimentally observed toxicity with molecular descriptors in order to predict the toxicity of further chemicals. VEGA is an open source software that offers many models for study of properties such as persistence, LogP, carcinogenicity, mutagenicity, skin sensitization. The input can be given in different standard formats used in the chemical domain, including SMILES and SDF (Structure Data Format) files [10]. Regarding mutagenicity, 85% reproducibility is reported while conducting in-vivo test [8].

Amongst the four VEGA models for mutagenicity, the CAESAR 2.1.13 model is more accurate, sensitive and specific [11]. Mutagenicity (Ames test) model (CAESAR) 2.1.13 provides a qualitative prediction of mutagenicity on *Salmonella typhimurium* [12].

Methods

Inedible food waste

Syzygium cumini and Allium cepa were bought from local fruit and vegetable market, Surat, Gujarat, India. Their authentication was carried out by botanist Dr. Bimal S. Desai. The voucher specimens were deposited at herbarium of Navsari Agriculture University, Navsari (*Syzygium cumini*—Voucher no. HSK/BPBSCI/JAMUN/2017-18/01-04; *Allium cepa*—Voucher no. HSK/BPBSCI/ONION/2017-18/01-04). The seeds of *Syzygium cumini* and peels of *Allium cepa* were washed several times with tap water and were shade dried until constant weight was obtained. After drying the seeds and peels were powered using electric blender and stored until further use.

Fermentation

The method [13] is used with slight modification. Erlenmeyer flask (250 mL), containing 10-g *Syzygium cumini* seeds powder and 100-mL water, was sterilized at 121 °C for 1 h. After sterilization, the flask was allowed to cool to room temperature and inoculated with *Saccharomyces cerevisiae.* The inoculated flasks were statically incubated at 30 °C for 5 days. Same protocol was followed for fermentation of *Allium cepa* peels.

Extraction

After fermentation, 100 mL of methanol was added to the flask and extraction was performed at room temperature in shaking condition for 24 h. The extraction mixture was filtered through a Whatman No. 1 filter paper [13] and allowed to evaporate in preweighed glassware. After evaporation, the extracted material is dissolved in methanol to obtain a desired concentration.

Gas chromatography mass spectroscopy

The gas chromatography mass spectroscopy (GCMS) was performed by Agilent 7890 coupled to JeolAccuTOF GCV, USA.

Make of GC: Agilent 7890; FID detector.

Make of MS: Model – JeolAccuTOF GCV, USA; EI/CI source; time of flight analyser; Mass range: 10–2000 amu, mass resolution: 6000.

Operation conditions:

Ionization mode: EI+; Ionization volt: 70 eV

Column specification: length—30 m, thickness—0.25 μm, internal diameter—25 mm

Helium was used as carrier gas at a flow rate of 1 mL/min.

The temperature raised from 70 °C up to 280 °C with the rate of 8 °C per min rise in temperature.

The analysis was carried out at Sophisticated Analytical Instrument Facility, Indian Institute of Technology, Bombay. The outcomes of mass spectra were compared with those stored in spectrometer database of National Institute of Standards and Technology Mass Spectral Database (NIST-MS). The Kovats retention index of each compound was also confirmed.

The Structure Data Format and canonical SMILES of the compounds identified by GCMS were downloaded from PUBCHEM.

ADME/Tox analysis

The compounds identified by GCMS were virtually scrutinized for their drug-like property (ADME) and mutagenicity (Tox) by using open source tool DruLiTo and software VEGA QSAR.

DruLiTo

Four filters of DruLiTo namely Lipinski's rule, Veber rule, BBB rule and Quantitative Estimate of Drug-likeness (QED) were used to study ADME profile [7] of compounds obtained from the GCMS results of fermented methanol extracts of *Syzygium cumini* seeds and *Allium cepa* peels.

Structure Data Format (SDF) of compounds was used as input.

The threshold values of the filters were kept default and are described below:

Lipinski's rule:

Molecular weight	≤ 500
LogP	≤ 5
H- bond donor	≤ 5
H- bond acceptor	≤ 10

Veber rule:

Rotable bond	≤ 10
Polar surface area	≤ 140

BBB rule:

Molecular weight	≤ 400
H-bond	≤ 8
Number of acids	≤ 0

QED:

Weighted QED	≥ 0.5
Unweighted QED	≥ 0.5

VEGA QSAR

VEGA QSAR was used for the qualitative prediction of mutagenicity (Ames test – CAESAR 2.1.13) of the compounds identified by GCMS, where canonical SMILES were used as input.

Results

Gas chromatography mass spectrometry

GCMS analysis of methanol extracts of fermented *Syzygium cumini* seeds and fermented *Allium cepa* peels was carried out at IIT SAIF, Bombay. Ten compounds from each extract were identified. The chromatograms are given in Figs. 1 and 2. The compounds identified are listed in Tables 1 and 2.

ADME/Tox analysis

ADME/Tox analysis of phyto-components identified by GCMS analysis was carried out by DruLiTo and VEGA QSAR.

DruLiTo

The molecular characteristics of phyto-components of extracts of fermented *Syzygium cumini* seeds and fermented *Allium cepa* peels determined by DruLiTo are shown in Tables 3 and 4 respectively.

Various drug-likeness rules like Lipinski's rule, Veber rule, BBB likeness rule and Quantitative estimate (QED) of drug-likeness are employed. Each rule functions according to a set threshold value for abovementioned characteristics. The results are noted in Tables 5 and 6.

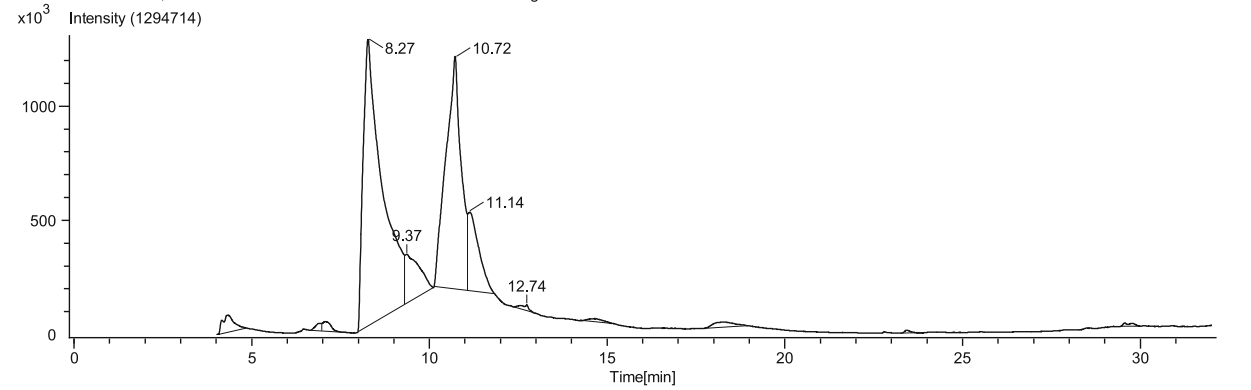
The result of Table 5 shows that four compounds with codes SC1, SC3, SC7 and SC10 follow all the drug-likeness rules.

It is apparent from Table 6 that the compounds with codes AC1, AC2, AC6 and AC8 follow all the drug-likeness rules.

VEGA QSAR

VEGA QSAR helped to virtually study the mutagenic behaviour of the compounds identified by GCMS. The results obtained are the predicted values which may help in reducing the wet lab efforts. If the compound has already been studied, the results is denoted as "experimentally proven" and for rest of compound it is denoted as "prediction". Ames test – CAESAR 2.1.13 model was used to qualitatively predict mutagenicity of test compounds. The results are noted in Tables 7 and 8.

Out of ten compounds from methanol extract of fermented *Syzygium cumini* seeds, six compounds were identified as non-mutagenic. Of these six non-mutagenic compounds, two are experimentally proven to be non-mutagenic viz. SC4 and SC5.



Peak Number	Time [min]	Type	Peak Width(FWH [min]	Area [Intens. * sec]	Height	Description	Start Point		End Point	
							Time[min]	Height	Time[min]	Height
1	4.31	BB	0.4206	1710566.63	75411.64		4.07	960	4.85	27911
2	6.90	BV	0.1919	363118.38	32711.60		6.67	18874	6.97	15661
3	7.07	VB	0.2724	712789.29	41807.08		6.97	15661	7.72	7593
4	8.27	BV	0.5385	46137070.91	1256361.86		7.99	12738	9.30	132886
5	9.37	VB	0.6135	5762494.85	212443.41		9.30	132886	10.10	205465
6	10.72	BV	0.4994	30220619.99	1019065.46		10.13	210721	11.07	192561
7	11.14	VB	0.3376	7597844.29	344633.14		11.07	192561	11.83	177750
8	12.74	BB	0.4476	353073.11	25494.43		12.33	122434	12.93	95980
9	14.66	BB	0.4915	406851.22	14445.23		14.26	61391	15.15	47689
10	18.29	BB	0.7641	887567.09	21655.30		17.67	26417	18.92	39051
11	23.42	BB	0.1727	138650.49	12515.38		23.26	6046	23.90	7371
12	29.56	BB	0.3592	254412.70	14220.43		29.45	35210	30.00	36934

Fig. 1 GCMS chromatogram of methanol extract of fermented *Syzygium cumini* seeds

The results noted in Table 8 show that nine compounds of methanol extract of fermented *Allium cepa* peels are non-mutagenic; amongst them, AC2, AC3, AC4 and AC6 are experimentally proven to be non-mutagenic.

Collectively on analysing the results of ADME/Tox, it was observed that there are compounds which justify drug-likeness rules but are mutagenic and vice versa. But there are compounds which fulfil both criteria. SC3, SC7, AC1, AC2, AC6 and AC8 are the molecules that obey the ADME/Tox analysis prediction. AC2 and AC6 are experimentally proven to be non-mutagenic.

Discussion

Amongst the parameters of DruLiTo, LogP is a key parameter that determines the environmental fate and hydrophobicity of test moiety. Hydrophobicity of the molecule is responsible for its absorption, bioavailability, interaction with a receptor, metabolism and toxicity [14]. If the molecule has AlogP value less than five, then it is prioritized as drug-like molecule. Restrictions for using the HBA, HBD, logP and Mw were postulated by Lipinski et al. [15]; fulfilment of Lipinski's rule approves of molecule being orally administrable. TPSA parameter is used to know the behaviour of polar atoms in a molecule that predicts the absorption and transportation of test molecule [16].

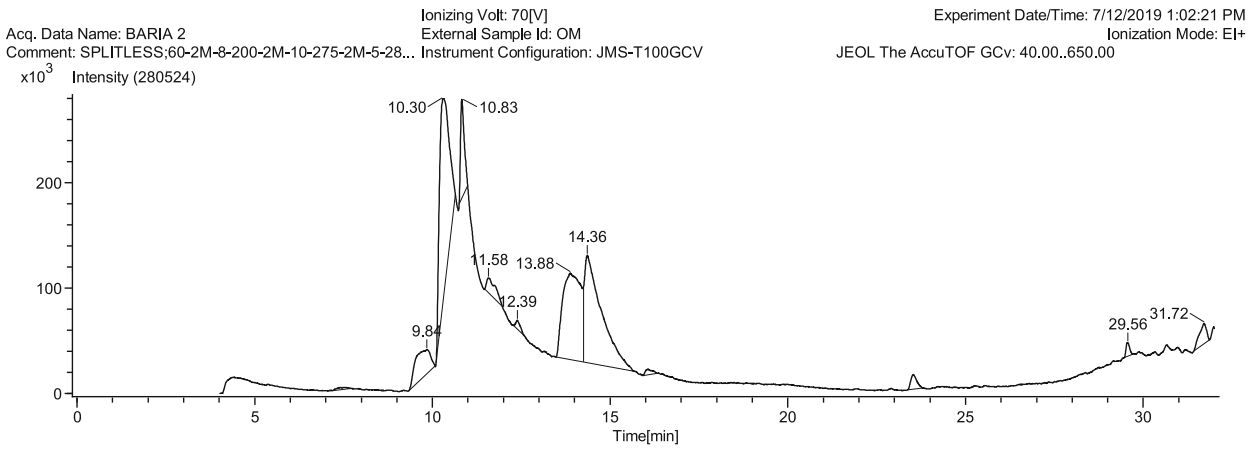
Twenty components were identified from gas chromatography mass spectrometry of methanol extracts of fermented *Syzygium cumini* seeds and fermented *Allium cepa* peels. Virtual prediction of these components for their drug-like property (tool used: DruLiTo) and mutagenicity (software used: VEGA QSAR) conveys that:

(a) There are four components from each extract that possess drug-like property based on their molecular characteristics.
(b) Six components of fermented *Syzygium cumini* seed methanol extract and nine components of fermented *Allium cepa* peel methanol extract are non-mutagenic. Six of these fifteen components are experimentally proven to be non-mutagenic.

Some of the compounds, which were identified by GCMS, are at present used for medicinal and therapeutic purposes. Their uses are mentioned below.

SC2—Oxetane, 2, 4-dimethyl-, trans-

Taxol possessing oxetane ring is used in cancer therapy. Oxetanocin A was first isolated from *Bacillus megaterium* and inhibits in vivo replication of HIV. Oxetanes being more polar are used as replacement



Peak Number	Time [min]	Type	Peak Width(FWH [min]	Area [Intens. * sec]	Height	Description	Start Point		End Point	
							Time[min]	Height	Time[min]	Height
1	7.51	BB	0.3832	41862.02	1794.44		7.19	2767	7.73	4590
2	9.84	BB	0.5013	763366.08	22892.17		9.33	2306	10.10	26974
3	10.30	BB	0.4580	3574269.69	193148.12		10.10	29004	10.65	188551
4	10.83	BB	0.1258	684130.63	93744.07		10.75	179445	10.99	197386
5	11.58	BB	0.1937	277202.55	14349.96		11.47	99090	11.97	82531
6	12.39	BB	0.1403	73857.17	8400.39		12.27	64910	12.60	54343
7	13.88	BV	0.6438	2932151.30	82236.06		13.45	34867	14.25	29831
8	14.36	VB	0.4819	3450690.21	101991.32		14.25	29831	15.70	20724
9	16.06	BB	0.2840	68036.98	5309.50		15.93	17085	16.32	19195
10	23.54	BB	0.1909	162150.07	13719.15		23.38	3502	23.81	5263
11	29.56	BB	0.1132	89298.91	13142.46		29.43	33562	29.75	37724
12	31.72	BB	0.2177	276650.46	18978.30		31.43	40280	31.88	51308

Fig. 2 GCMS chromatogram of methanol extract of fermented *Allium cepa* peels

groups to block metabolically vulnerable methylene sites. And also they are stable and not prone to enzymatic attack. Oxetane improves the binding affinity of 1,25-dihydroxyvitamin D3 analogues for bovine thymus D3 receptors [17].

SC3—Ethanamine,2-methoxy-

On condensation of ethanamine,2-methoxy- with salicylaldehyde derivatives, the derivatives obtained possess antioxidant and anticancer activity against gastric cancer cell lines [18].

Table 1 Compounds identified in the GCMS analysis of methanol extract of fermented *Syzygium cumini* seeds

RT	Code	Name of compound	Molecular formula	Mol. Wt. (g/mol)	Kovats RI Non polar (iu)
4.31	SC1	5-Acetamido-4,7-dioxo-4,7-dihydrobenzofurazan	$C_8H_5N_3O_4$	207.14	1981
6.90	SC2	Oxetane, 2,4-dimethyl-, trans-	$C_5H_{10}O$	86.13	591
7.07	SC3	Ethanamine, 2-methoxy-	C_3H_9NO	75.11	638
8.27	SC4	(S)-2-Hydroxypropanoic acid	$C_3H_6O_3$	90.08	838
9.37					
10.72	SC5	Glycerin	$C_3H_8O_3$	92.09	967
11.14					
12.74	SC6	1-Dimethyl(pentafluorophenyl)silyloxycyclopentane	$C_{13}H_{15}F_5OSi$	310.33	1293
14.66	SC7	Hydroperoxide, 1-methylpentyl	$C_6H_{14}O_2$	118.17	914
18.29	SC8	Benzene-1,2,3-triol	$C_6H_6O_3$	126.11	1342
23.42	SC9	Phthalic acid, heptyl pentyl ester	$C_{20}H_{30}O_4$	334.4	2434
29.56	SC10	9,9-Dimethoxybicyclo[3.3.1]nona-2,4-dione	$C_{11}H_{16}O_4$	212.24	1610

RT retention time, *SC Syzygium cumini*, *Mol. Wt.* molecular weight, *RI* retention index, *iu* International unit

Table 2 Compounds identified in the GCMS analysis of methanol extract of fermented *Allium cepa* peels

RT	Code	Name of compound	Molecular formula	Mol. Wt. (g/mol)	Kovats RI Non polar (iu)
7.51	AC1	Selenolo[2,3-b]pyridine, 3-methyl-	C_8H_7NSe	196.12	Not available
9.84	AC2	2,3-Butanediol	$C_4H_{10}O_2$	90.12	743
10.30	AC3	Glycerin	$C_3H_8O_3$	92.09	967
10.83	AC4	Monoethanolamine	C_2H_7NO	61.08	706
11.58	AC5	3,4-Dihydroxy-tetrahydrofuran (trans)	$C_4H_8O_3$	104.1	965
12.39	AC3	Glycerin	$C_3H_8O_3$	92.09	967
13.88	AC6	1,2-Benzenediol	$C_6H_6O_2$	110.11	1122
14.36					
16.06	AC7	Cyclohexan-1,4,5-triol-3-one-1-carboxylic acid	$C_7H_{10}O_6$	190.15	1835
23.54	AC8	Ethaneperoxoic acid, 1-cyano-1-[2-(2-phenyl-1,3-dioxolan-2-yl)ethyl]pentyl ester	$C_{19}H_{25}NO_5$	347.4	2584
29.56	AC9	9,12,15-Octadecatrienoic acid, 2-[(trimethylsilyl)oxy]-1-[[(trimethylsilyl)oxy]methyl]ethyl ester, (Z,Z,Z)-	$C_{27}H_{52}O_4Si_2$	496.9	2804
31.72	AC10	6,9,12-Octadecatrienoic acid, phenylmethyl ester, (Z,Z,Z)-	$C_{25}H_{36}O_2$	368.6	2774

RT retention time, *AC Allium cepa*, *Mol. Wt.* molecular weight, *RI* retention index, *iu* International unit

SC5—Glycerin

Glycerin has tonic, wound healing, immune boosting, protective, antiseptic, antibacterial, hypo allergic and soothing properties [19].

SC8—Benzene-1,2,3-triol

This compound is used as topical agent to treat psoriasis, leprosy, eczema, and destroy lupus. It is also used as eye drops in chronic cases of conjunctivitis [20].

AC2—2,3-Butanediol

The 2,3-Butanediol is commonly known as dimethyl ethylene glycol. The polyethylene glycols are used as laxatives. They are attached to various protein medications, to allow slower clearance of the carried proteins from the blood. Gene therapy vectors like viruses can be coated with these gylcols in order to shield them from immune system [21, 22].

AC4—Monoethanolamine

The monoethanolamine is used for therapeutic neurolysis of nerves or ganglia to provide relief in chronic pain caused in certain conditions such as inoperable cancers and trigeminal neuralgia [23].

AC6—1,2-Benzenediol

1,2-Benzenediol is commonly known as catechol, which is used as precursor to pesticides, flavours and fragrances. It is employed in medicine as expectorant [24].

Table 3 Characteristics of compounds identified from GCMS analysis of fermented *Syzygium cumini* seeds methanol extracts

Code of compound	Characteristics of compounds (methanol extract-fermented *Syzygium cumini* seeds)							
	MW	LogP	HBA	HBD	TPSA	nRB	nAG	nHB
SC1	207.03	0.266	4	1	97.19	2	0	5
SC2	86.07	1.088	1	0	9.23	0	0	1
SC3	75.07	− 0.756	2	1	35.25	2	0	3
SC4	90.03	− 0.591	3	2	57.53	1	1	5
SC5	92.05	− 1.88	3	3	60.69	2	0	6
SC6	310.08	3.677	1	0	9.23	3	0	1
SC7	118.1	1.93	2	1	29.46	4	0	3
SC8	126.03	1.431	3	3	60.69	0	0	6
SC9	334.21	5.922	4	0	52.6	14	0	4
SC10	212.1	− 0.296	4	0	52.6	2	0	4

Table 4 Characteristics of compounds identified from GCMS analysis of fermented *Allium cepa* peel methanolic extracts

Code of compound	Characteristics of compounds (methanol extract-fermented *Allium cepa* peels)							
	MW	LogP	HBA	HBD	TPSA	nRB	nAG	nHB
AC1	196.97	0.902	1	0	12.36	0	0	1
AC2	90.07	− 0.288	2	2	40.46	1	0	4
AC3	92.05	− 1.88	3	3	60.69	2	0	6
AC4	61.05	− 1.275	2	2	46.25	1	0	4
AC5	104.05	− 1.105	3	2	49.69	0	0	5
AC6	110.04	1.083	2	2	40.46	0	0	4
AC7	190.05	− 2.122	6	4	115.06	1	1	10
AC8	347.17	2.363	6	0	77.78	10	0	6
AC9	496.34	10.748	4	4	44.76	21	0	4
AC10	368.27	8.951	2	0	26.3	16	0	2

Table 5 Drug-likeness property of compounds of fermented *Syzygium cumini* seed methanolic extract

Code of compound	Name of filters				
	Lipinski's rule of five	Veber's rule	BBB likeness rule	Unweighted QED	Weighted QED
SC1	1	1	1	1	1
SC2	1	1	1	0	0
SC3	1	1	1	1	1
SC4	1	1	0	1	1
SC5	1	1	1	1	0
SC6	1	1	1	0	0
SC7	1	1	1	1	1
SC8	1	1	1	1	0
SC9	0	0	1	0	0
SC10	1	1	1	1	1

1 compound follows the rule, *0* compound does not follow the rule

Table 6 Drug-likeness property of compounds of fermented *Allium cepa* peels methanolic extract

Code of compound	Name of filters				
	Lipinski's rule of five	Veber's rule	BBB likeness rule	Unweighted QED	Weighted QED
AC1	1	1	1	1	1
AC2	1	1	1	1	1
AC3	1	1	1	1	0
AC4	1	1	1	1	0
AC5	1	1	1	1	0
AC6	1	1	1	1	1
AC7	1	1	0	0	0
AC8	1	1	1	1	1
AC9	0	0	0	0	0
AC10	0	0	1	0	0

1 compound follows the rule, *0* compound does not follow the rule

Table 7 Mutagenic property of compounds of fermented *Syzygium cumini* seed methanolic extract

Code of compound	Characteristics of compounds Mutagenic/non-mutagenic	Remarks
SC1	Mutagenic	Prediction
SC2	Mutagenic	Prediction
SC3	Non-mutagenic	Prediction
SC4	Non-mutagenic	Experimental result
SC5	Non-mutagenic	Experimental result
SC6	Non-mutagenic	Prediction
SC7	Non-mutagenic	Prediction
SC8	Mutagenic	Experimental result
SC9	Non-mutagenic	Prediction
SC10	Mutagenic	Prediction

AC7—Cyclohexan-1,4,5-triol-3-one-1-carboxylic acid

This compound is precursor to tyrosine, 3-phenylalanine, tryptophan, vitamin K and folate [25].

Conclusion

From the collective analysis of predicted drug-like property and mutagenicity of the components of these two fermented waste extracts, it is deduced that:

Ethanamine, 2-methoxy- and hydroperoxide, 1-methylpentyl from methanolic extract of fermented *Syzygium cumini* seeds and Selenolo[2,3-b]pyridine, 3-methyl-, 2,3-butanediol, 1,2-benzenediol and ethaneperoxoic acid, 1-cyano-1-[2-(2-phenyl-1,3-dioxolan-2-yl)ethyl] pentyl ester from fermented methanol extract of *Allium cepa* peels exhibit drug-like properties and are also non-mutagenic. These compounds predicted to be drug-like and non-mutagenic can be further studied as ligands for bacterial and cancerous targets by the means of in silico docking techniques. The findings can lead to their use in diseases like multi-drug resistant bacterial diseases, oxidative stress and cancer.

Table 8 Mutagenic property of compounds of fermented *Allium cepa* peel methanolic extract

Code of compound	Characteristics of compounds Mutagenic/non-mutagenic	Remarks
AC1	Non-mutagenic	Prediction
AC2	Non-mutagenic	Experimental result
AC3	Non-mutagenic	Experimental result
AC4	Non-mutagenic	Experimental result
AC5	Mutagenic	Prediction
AC6	Non-mutagenic	Experimental result
AC7	Non-mutagenic	Prediction
AC8	Non-mutagenic	Prediction
AC9	Non-mutagenic	Prediction
AC10	Non-mutagenic	Prediction

Abbreviations

AC: *Allium cepa*; ADMET: Absorption, distribution, metabolism, excretion, toxicity; g: Gram; GCMS: Gas chromatography mass spectrometry; HBA: Hydrogen bond acceptor; HBD: Hydrogen bond donor; IIT: Indian Institute of Technology; mL: Millilitre; MW/Mol. Wt.: Molecular weight; nAG: Number of acidic group; nHB: Number of hydrogen bonds; NIST-MS: National Institute of Standards and Technology Mass Spectral Database; nRB: Number of rotable bonds; QSAR: Quantified Structure-Activity Relationship; QED: Quantitative Estimate of Drug-likeness; RT: Retention time; SAIF: Sophisticated Analytical Instrument Facility; SC: *Syzygium cumini*; SDF: Structure Data Format; TPSA: Total polar surface area; °C: Degree Celsius

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Plant authentication

The fruit and vegetable used in study were authenticated by botanist Dr. Bimal S. Desai, Aspee College of Horticulture and Forestry, Navsari Agriculture University, Navsari, Gujarat, India. The voucher specimens were deposited at herbarium of Navsari Agriculture University, Navsari (*Syzygium cumini* - Voucher no. HSK/BPBSCI/JAMUN/2017-18/01-04; *Allium cepa* - Voucher no. HSK/BPBSCI/ONION/2017-18/01-04).

Authors' contributions

KHS carried out the research under the guidance of MFP. All authors read and approved the final manuscript.

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All data provided in the manuscript are available upon request.

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