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Original Research Article

Forensic analysis of illicit liquors in Himachal Pradesh: Assessing toxicity and composition for public health safety

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ABSTRACT

Illicit liquors, also known as illegal, hooch, or bootleg liquors, refer to alcoholic beverages that are produced, distributed, or retailed in defiance of legal regulations and licensing requirements. These beverages are typically produced in clandestine operations, often circumventing taxation, quality control standards, and safety protocols mandated by authorities. The manufacture and consumption of illicit liquors present formidable hazards and complexities. Poisoning incidents linked to illicit liquors can result from contamination with hazardous substances, primarily methanol, alongside compounds such as esters, ketones, aldehydes, and acids, which can inflict deleterious effects on the human body, potentially culminating in fatality. The present study was conducted to perform forensic analysis of illicit liquors in different districts of Himachal Pradesh. In this research, 25 samples of illicit alcohol were meticulously collected from five distinct districts in Himachal Pradesh, namely Kangra, Una, Chamba, Mandi, and Bilaspur. The results of the color test revealed that ethanol might be present, but no other harmful compounds like methanol, or metals like copper and iron were detected. Furfural was found in samples S19, S22, and S23. Following that, samples were tested using an alcolyzer, which detected variations in alcohol percentage and density. Some samples had a higher alcohol percentage, indicating greater toxicity.To further corroborate these findings and identify additional constituents within illicit liquors, the samples underwent scrutiny employing Fourier-transform infrared spectroscopy (FTIR). Prospective research endeavours could expand upon this foundation by augmenting the sample size and employing advanced techniques like gas chromatography-mass spectrometry (GC-MS) for comprehensive quantitative analysis of the diverse components present in illicit liquors.

1. Introduction

The term 'Beverage' finds its origin in the Latin word 'bever,' which signifies a break from labor, encompassing any liquid refreshments designed to quench thirst. These beverages are expertly crafted for human consumption, serving purposes such as refreshment, stimulation, hydration, or pure enjoyment. Common varieties of beverages include water, tea, coffee, milk, soda, juice, and wine, among others. Broadly, beverages fall into two primary categories: Alcoholic and non-alcoholic. Alcoholic beverages, characterized by the presence of ethanol, are meticulously produced through the fermentation of grains, sugars, or fruits. Notable examples encompass Brandy and Vodka. Conversely, non-alcoholic beverages, often referred to as Virgin drinks, contain less than 0.5% alcohol by volume, with little to no ethanol content. This category encompasses beverages such as tea,

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coffee, soda pop, sparkling water, root beer, and energy drinks.[1,2] 'Licit liquors' denote beverages that adhere to established legal regulations and licensing requirements in their production, distribution, and sale. They play a pivotal role in fostering economic growth, preserving cultural heritage, and promoting responsible drinking practices. Additionally, they contribute significantly to government revenue and support local industries.[3]

In contrast, 'Illicit liquors,' also known as illegal or bootleg liquors, are manufactured, distributed, or sold in blatant disregard for legal regulations and licensing stipulations. The production and consumption of illicit liquors present formidable risks and complexities. Notorious for their potential health hazards, these illicit concoctions often harbour toxic substances such as methanol, heavy metals (e.g., lead, arsenic), furfural, and acetaldehyde. Consumption of these beverages can lead to severe health consequences, including alcohol poisoning, organ damage, and, tragically, death. The illicit liquor trade involves a web of criminal activities, including smuggling, organized crime, and tax evasion, undermining legal systems, destabilizing regulated markets, and bolstering underground economies. Methanol, a volatile liquid with a colorless appearance, possesses a distinct odour reminiscent of alcohol, accompanied by a burning taste.[4–6]

Methanol, an insidious toxic alcohol, undergoes its primary metabolic transformations predominantly within the liver, orchestrated by enzymatic reactions of paramount significance. The pivotal enzyme alcohol dehydrogenase (ADH) orchestrates the conversion of methanol into the perilous compound formaldehyde, concomitantly yielding NADH as a byproduct. The ensuing sequence is fraught with peril, as formaldehyde, notorious for its high toxicity, expeditiously metamorphoses into formic acid under the catalytic influence of formaldehyde dehydrogenase (FDH), further amplifying the accumulation of NADH. Subsequently, formic acid embarks on a transformational journey, culminating in its breakdown into innocuous constituents: carbon dioxide and water. This transformation is achieved through a series of enzymatic reactions, the most notable being formate dehydrogenase. The resultant carbon dioxide is expelled via respiration, while water is excreted through the urinary system.[7] However, the accumulation of these malevolent compounds within the body's internal milieu can set the stage for a cascade of grievous health repercussions, foremost among them being metabolic acidosis, which can unleash a host of afflictions. These include optic nerve damage, potentially catastrophic organ dysfunction, and a perilous cascade of physiological malfunctions.[8] It is crucial to underscore that the specific composition and impurities inherent to each illicit liquor product can yield distinct health risks. Furthermore, these risks are profoundly elevated in comparison to their legally produced and meticulously regulated alcoholic counterparts.

The forensic importance of illicit liquors is underscored by their critical role in investigations and analyses, serving as essential tools for uncovering illicit activities and furnishing pivotal evidence in legal proceedings. Several key facets emphasize the forensic significance of illicit liquors, encompassing the following:Identification of Illicit Production, Detection of Adulteration, Toxicological Effects, Source Tracing, Expert Testimony etc. The forensic significance of illicit liquors extends beyond mere analysis; it serves as a cornerstone in the fight against illegal activities, safeguarding public health and safety while simultaneously exposing and prosecuting those engaged in unlawful liquor-related endeavours. Poisonings stemming from these illicit concoctions, rife with hazardous compounds, pose grave threats to human well-being, including the potential for fatal outcomes. Thus, forensic investigations play a pivotal role in unravelling the intricate web of illicit liquor production and consumption.[9]

In forensic investigation, the detection of methanol presence emerges as a pivotal determinant in elucidating the root cause behind fatalities and illnesses. Furthermore, it unravels the intricate connections between the production and distribution of illicit liquors and a web of organized criminal activities, encompassing heinous acts such as homicide and smuggling. Beyond these fundamental revelations, forensic scientists adeptly unravel the composition of illicit liquors, effectively deciphering their origins, manufacturing processes, and the spectrum of ingredients they conceal. This critical insight equips forensic investigators to establish cogent connections between diverse criminal undertakings, constructing compelling cases against suspects.[10] Over the past five years, the enforcement authorities have apprehended a staggering 3.46 lakh individuals, effectively thwarting illegal liquor activities. During this period, a staggering 150 lakh liters of both country-made and Indian-made foreign liquor were seized, constituting a substantial disruption of illicit liquor networks. A sobering statistic emerges from the annals of 2021, with 708 documented incidents of illicit liquor consumption leading to a tragic toll of 782 lives lost across the nation. The epicenter of these tragedies was most notably marked in Uttar Pradesh with 137 fatalities, followed closely by Punjab with 127, Madhya Pradesh with 108, and Karnataka with 104, underscoring the grave magnitude of the issue at hand.

In 1928, Reidhunt, M.D., conducted a study on the toxicity of illicit liquor, analysing one hundred samples obtained from police departments in 1927. The samples from July had a high alcohol concentration, and methanol was detected in all samples. Rawat 2012 used headspace gas chromatography (HS-GC) to analyse body fluids in cases of illicit liquor poisoning, detecting methyl alcohol in homemade liquor known as Gudanji.[12] In 2016, Hasan

Table 1: State/UT wise deaths due to consumption of Illicit spurious liquor during 2018- 2020.[11]

S. No.	State / UT	2018	2019	2020
1	Andhra Pradesh	42	27	18
2	Arunachal Pradesh	0	0	0
3	Assam	2	98	0
4	Bihar	0	9	6
5	Chhattisgarh	77	115	67
6	Goa	0	0	0
7	Gujarat	1	3	10
8	Haryana	162	0	10
9	Himachal Pradesh	43	56	43
10	Jharkhand	56	115	139
11	Karnataka	218	268	99
12	Kerala	11	7	3
13	Madhya Pradesh	410	190	214
14	Maharashtra	0	0	0
15	Manipur	0	1	0
16	Meghalaya	4	3	15
17	Mizoram	2	0	1
18	Nagaland	0	0	0
19	Odisha	6	0	18
20	Punjab	159	191	133
21	Rajasthan	64	88	31
22	Sikkim	2	3	8
23	Tamil Nadu	0	0	20
24	Telangana	0	0	0
25	Tripura	3	2	3
26	Uttar Pradesh	78	41	50
27	Uttarakhand	0	47	5
28	West Bengal	12	0	0
29	A & N Islands	0	0	20

Gokce and colleagues investigated the hepatotoxicity of illegal homemade alcohols, focusing on "Bogma Raki," which contained trans anethol. Punia et al. 2017 conducted an analysis of 27 different illicit liquors from northern India using headspace gas chromatography mass spectrometry (HS-GC-MS), revealing variations in ethanol content, and identifying various components in the samples.[13] In another study by Priya et al. (2019), an analysis of illicit liquor from Himachal Pradesh was carried out using color tests and Fourier transform infrared spectroscopy (FTIR).[4] Thakur et al. (2019) explored the cultural significance of traditional fermented beverages in Himachal Pradesh, India, emphasizing their role in rituals and daily life.[14]

Yadav et al. (2020) conducted a forensic examination of cheap liquor in Karnataka, revealing high unrecorded alcohol consumption rates, particularly among males, leading to dangerous health consequences.[15] Caroline Magut (2020) studied illicit alcohol consumption among youth in Kenya, highlighting the prevalence of harmful liquor like Changaa and its adverse social and health effects.[16] Nikoo et al. (2020) focused on the adulteration of liquor, emphasizing the presence of impurities and additives that can lead to severe health problems, including methanol-related blindness and death.[17] Lastly, Rohit et al. (2021) conducted an elemental analysis of country-made and standard illicit liquor samples, identifying toxic elements in the former that can harm the human body.[18] Certainly, in their 2021 study, Janhvi et al. examined the preparation of alcoholic beverages by tribal communities in the Indian Himalayan Region (IHR), emphasizing their cultural and economic significance, as well as the diversity in ingredients and methods used.[3] On the other hand, Rohit et al. (2022) conducted a forensic analysis of illicit liquor, using various methods to detect adulterants such as ethanol, methanol, aldehydes, urea, copper, and ammonia in seized country-made liquor samples.[18] These studies shed light on the toxicity and composition of illicit liquors, highlighting the risks associated with their consumption. Therefore, the present study has been designed to compare the illicit liquors in different districts of Himachal Pradesh.

2. Materials and Methods

2.1. *Sample collection*

Simple deliberate sampling method was used for collection of samples. Twenty-five samples of illicit liquor were collected from five districts of Himachal Pradesh. The five districts were Kangra, Una, Chamba, Mandi, Bilaspur of Himachal Pradesh.

Table 2: Samples collected from different districts of Himachal Pradesh

S. No	Samples	District
1.	S1 to S5	Kangra
2.	S6 to S10	Una
3.	S11 to S15	Chamba
4.	S16 to S20	Mandi
5.	S20 to S25	Bilaspur

2.2. *Collection method*

All the 25 samples were collected in glass bottles and vials.

2.3. *Methodology*

After collection, samples were analysed using preliminary test or colour test. After that, samples have been analysed and examined through Alcolyzer and FTIR (Fourier transform infrared spectroscopy).

2.3.1. *Colour test*

The various colour tests have been performed to detect the presence of various compounds such as ethanol, methanol etc.

2.3.1.1. Test for ethanol.

Figure 1: Glass bottles containing illicit liquors

Figure 2: Vials containing Illicit liquors

1. **Iodoform test:** 1ml of sample has been taken in a test tube and add 1ml of 5%NaOH and then add solution of iodine (20gm potassium iodide +10gm iodine in 100ml of distil water) dropwise until dark brown color appeared. Diluted NaOH solution has been added to remove excess of iodine. Addition of equal amount of water has been done and kept for 10 min. At last yellow color crystalline precipitates shows the presence of ethanol.[19]
2. **Dichromate test:** 1ml of sample taken in test tube and 0.2ml of 2%potassium dichromate added and addition of concentrated H2SO4. Yellow color of dichromate change to blue or green color that shows presence of ethanol.

2.3.1.2. Test for methanol. **Schiff's reagent test:** In a test tube, 4.5 ml of the sample and 0.5 ml of ethanol are added. After adding 2 ml of a 3% potassium permanganate solution and 2 ml of phosphoric acid, the mixture is allowed to sit for 10 minutes. Then, 1 ml of concentrated Sulphuric Acid and 1 ml of 10% Oxalic Acid are added. At room temperature, the contents are allowed to cool. Schiff's reagent, 5 ml, is added, and the mixture is maintained for 30 minutes.

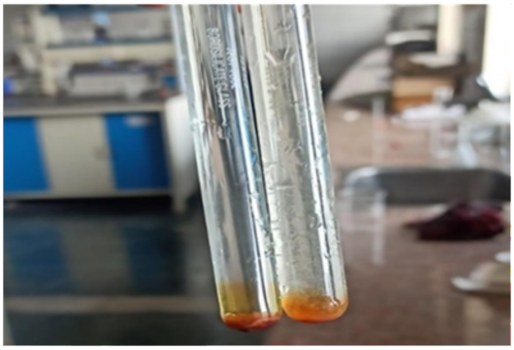

Figure 3: Sample in test tubes gives brown colour showing the positive results for ethanol

Figure 4: Sample in test tube gives blue colour showing the positive result for the ethanolcolour[20]

The presence of Methanol is detected by the appearance of purple colour.[20]

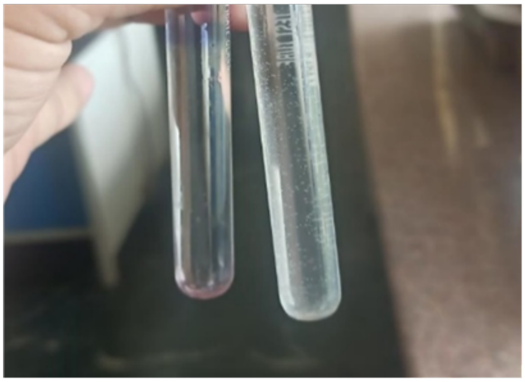

Figure 5: Showing negative result for Schiffs reagent test

2.3.1.3. Test for copper and iron. 5ml of sample was taken in test tube.1 drop of nitric acid was added. Then 1ml of 0.025M potassium ferrocyanide was added. No color appears shows the absence of copper and iron.

2.3.1.4. Test for furfural. 5ml of sample is taken in a test tube and then add 0.2ml of aniline. The addition of 0.4ml of glacial acetic acid. No color appears indicates the absence of furfural.

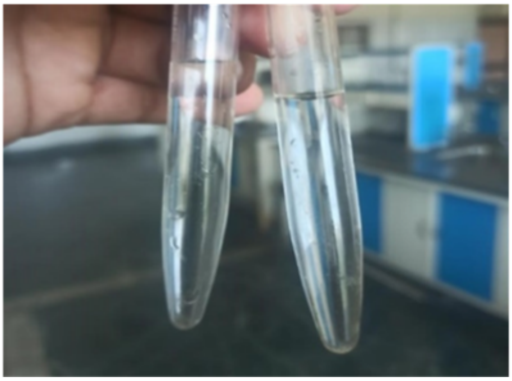

Figure 6: Showing negative result for Copper and Iron test

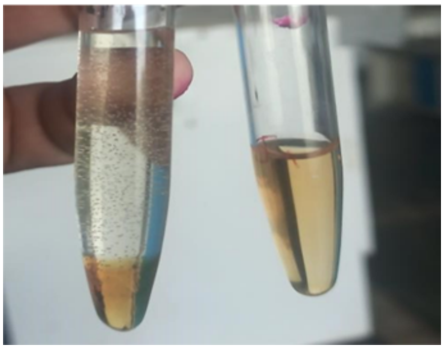

Figure 7: Showing the positive result for furfural test

2.4. Alcolyzer

It is an instrument which is used to determine the concentration and density of alcohol. It gives accurate readings, and determines alcohol content of all liquors like beer, wine, ciders, etc. It is easy to use and takes approx. 5 min. to take for analysing one sample. In this study, samples were analysed by using DMA 4500M model alcolyzer.

2.5. FTIR

It stands for Fourier transform infrared spectroscopy. In FTIR, infrared radiation passed through sample then some radiation gets absorbed by the sample and some gets transmitted.FTIR is an analytical technique, utilized by material analysts to identify organic compounds.[21] In this study, twenty-five samples were analysed by Perkin Elmer Spectrum two with ATR and pellet accessories The wavenumber of spectra ranges from 4000-600cm-1 and percentage of transmittance ranges from 0 -150%.

Figure 8: Alcolyzer (DMA 4500M)

3. Results and Discussion

3.1. Color tests

Preliminary test or color tests have been performed to check the presence of Ethanol, Methanol, Iron and Copper and Furfural in the illicit liquor samples. From the observations, Iodoform and dichromate test showed positive result for all the twenty-five samples that indicates the presence of ethanol. Whereas Schiff's Reagent Test and tests for copper, iron and showed negative result that indicates the absence of methanol, and furfural is present in some sample S19, S22, S23. The results have been tabulated in Table 3.

3.2. Alcolyzer

A total of 25 samples were collected from various districts of Himachal Pradesh. Samples S1 to S5 were obtained from Kangra, samples S6 to S10 from Una, samples S11 to S15 from Chamba, samples S15 to S20 from Mandi, and samples S20 to S25 from Bilaspur. All the samples have been analysed using Alcolyzer. After analysing, it has been observed thatthe alcohol content in samples S1 to S5 ranged approximately from 19% to 20%, while their density ranged from 0.97519 g/cm3 to 0.97589 g/cm3. Samples S6 to S10 exhibited alcohol percentages between 11% and 22%, with densities ranging from 0.97196 g/cm3 to 0.98099 g/cm3. Samples S11 to S15 showed alcohol concentrations ranging from 9% to 19% and densities ranging from 0.97 g/cm3 to 0.98 g/cm3. In the case of samples S15 to S20, the alcohol content ranged from 6% to 17%, accompanied by densities ranging from 0.97 g/cm3 to 0.99 g/cm3. Lastly, samples S21 to S25 demonstrated alcohol percentages between 17% and 24%, with a consistent density of 0.97 g/cm3. It is noteworthy that out of all the twenty-five samples, samples S21 to S25 exhibited higher alcohol content, while samples S11 to S15 had comparatively higher density. The results have been tabulated in Table 4.

Table 3: Shows results of color test for illicit liquors

Sample no-	Iodoform Test	Dichromate Test	Schiff's Reagent Test	Test for Cu, Fe	Test for Furfural
S1	+ve	+ve	-ve	-ve	-ve
S2	+ve	+ve	-ve	-ve	-ve
S3	+ve	+ve	-ve	-ve	-ve
S4	+ve	+ve	-ve	-ve	-ve
S5	+ve	+ve	-ve	-ve	-ve
S6	+ve	+ve	-ve	-ve	-ve
S7	+ve	+ve	-ve	-ve	-ve
S8	+ve	+ve	-ve	-ve	-ve
S9	+ve	+ve	-ve	-ve	-ve
S10	+ve	+ve	-ve	-ve	-ve
S11	+ve	+ve	-ve	-ve	-ve
S12	+ve	+ve	-ve	-ve	-ve
S13	+ve	+ve	-ve	-ve	-ve
S14	+ve	+ve	-ve	-ve	-ve
S15	+ve	+ve	-ve	-ve	-ve
S16	+ve	+ve	-ve	-ve	-ve
S17	+ve	+ve	-ve	-ve	-ve
S18	+ve	+ve	-ve	-ve	-ve
S19	+ve	+ve	-ve	-ve	+ve
S20	+ve	+ve	-ve	-ve	-ve
S21	+ve	+ve	-ve	-ve	-ve
S22	+ve	+ve	-ve	-ve	+ve
S23	+ve	+ve	-ve	-ve	+ve
S24	+ve	+ve	-ve	-ve	-ve
S25	+ve	+ve	-ve	-ve	-ve

Table 4: Shows the alcohol (% v/v), density and British proof values of illicit liquors samples observed through alcolyzer

Samples	Alcohol (% v/v)	Density	British proof
S1	18%	0.97589g/cm3	32.98 Proof
S2	19.43%	0.97511g/cm3	34.04 Proof
S3	19.34%	0.97519g/cm3	33.89 Proof
S4	19.94%	0.97456g/cm3	34.94 Proof
S5	18.40%	0.97627g/cm3	32.24 Proof
S6	14.18%	0.98099g/cm3	24.85 Proof
S7	11.61%	0.98392g/cm3	20.34 Proof
S8	22.71%	0.97196g/cm3	39.79 Proof
S9	14.81%	0.98029g/cm3	25.95 Proof
S10	14.91%	0.98010g/cm3	26.13 Proof
S11	19.08%	0.97571g/cm3	33.43 Proof
S12	13.12%	0.98219g/cm3	23.00 Proof
S13	13.65%	0.98188g/cm3	23.91 Proof
S14	9.24%	0.98673g/cm3	16.20 Proof
S15	10.60%	0.98504g/cm3	18.58 Proof
S16	11.36%	0.98414g/cm3	19.90 Proof
S17	17.78%	0.97724g/cm3	31.15 Proof
S18	16.57%	0.97282g/cm3	29.04 Proof
S19	17.88%	0.97679g/cm3	31.34 Proof
S20	6.41%	0.99039g/cm3	11.22 Proof
S21	17.37%	0.97739g/cm3	30.34 Proof
S22	17.96%	0.97673g/cm3	31.47 Proof
S23	19.69%	0.97489g/cm3	34.51 Proof
S24	18.63%	0.97607g/cm3	32.65 Proof
S25	24.00%	0.97022g/cm3	42.06 Proof

3.3. FTIR

The samples of Illicit liquors were examined using Fourier transform infrared spectrophotometer. Various spectra of the samples have been generated and thus interpreted respectively. For the study, total fifteen samples of illicit liquors from different districts of Himachal Pradesh, three each from Kangra (S1, S2, S3), three samples from Una (S6, S7, S8), three sample from Chamba (S11, S12, S13), three samples from Mandi (S16, S17, S18), three samples from Bilaspur (S21, S22, S23) were analysed using ATR-FTIR.

Following results were obtained after the analysis of samples.

Spectra of sample S1 shows the band form at 3336.40cm-1 that indicates the presence of (O-H) group,2133.78cm-1 shows the presence N=C=N stretching and compound is carbodiimide, 1640.06cm-1 shows the presence of C=C stretching and compound is conjugated alkene, 1085.06cm-1 C-O stretching and compound is primary alcohol, 877.51cm-1 shows C=C bending compound is alkene compound. 632.27cm-1 shows the presence of C-Br stretching compound is halo compound, 1044.41cm-1 that shows CO-O-CO compound is anhydride.

Spectra of sample 2 shows the bandform at 3326.04cm-1 that indicates the presence of(O-H) group, 2121.23cm-1 shows the presence of N=C=N stretching that indicate the presence of carbodiimide, 1640.25cm-1shows the C=C stretching and compound is conjugated alkene, 1085.02cm-1 shows the presence of C-Ostretching that indicates the compound is primary alcohol, 1044.40cm-1 shows the presence of CO-O-CO that indicates the compound is anhydride, 643.50cm-1 shows the presence of C-Br stretching that indicates the compound is halo compounds.

Spectra of sample S3 shows the band form at 3328.52cm-1 that indicates the presence of (O-H) group.2135.70cm-1 that shows the presence of N=C=N that indicates the presence of carbodiimide, 1640.24cm-1 C=C that indicates the presence of compound is conjugated alkene, 1085.03cm-1 that shows the presence of C-O stretching that indicates the presence of primary alcohol, l642.22cm-1 that shows the presence of C-Br that indicates the presence of halo compounds, 1044.40cm-1 shows the presence of CO-O-CO that indicates the compound is anhydride.

Spectra of sample S4, shows the bandform at 3308.18cm-1 that indicates the presence of(O-H) group, 2120.79cm-1 shows the presence N=C=N stretching and compound is carbodiimide, 1640.35cm-1 shows the presence of C=C stretching and compound is conjugated alkene, 1084.97cm-1 C-O stretching and compound is primary alcohol, 877.51cm-1 C=C stretching compound is alkene, 651.43cm-1 shows the presence of C-Br compound is halo compound, 1044.38cm-1 that shows CO-O-CO compound is anhydride.

Spectra of sample S5, shows the bandform at 3325.52cm-1 that indicates the presence of(O-H) group, 2138.11cm-1 shows the presence N=C=N stretching and compound is carbodiimide, 1640.06cm-1 shows the presence of C=C stretching and compound is conjugated alkene, 1085.01cm-1 C-O stretching and compound is primary alcohol, 877.47cm-1 C=C compound is alkene, 641.38cm-1 shows the presence of C-Br compound is halo compound, 1044.41cm-1 that shows CO-O-CO compound is anhydride**.**

Spectra of sample S6, shows the bandform at 3308.52cm-1 that indicates the presence of(O-H) group, 2128.05cm-1 shows the presence N=C=N stretching and compound is carbodiimide, 1639.226cm-1 shows the presence of C=C stretching and compound is conjugated alkene, 1084.95cm-1 C-O stretching and compound is primary alcohol, 877.63cm-1 C=C compound is alkene, 632.27cm-1 shows the presence of C-Br compound is halo compound, 1044.62cm-1 that shows CO-O-CO compound is anhydride.

Spectra of sample S7 shows the bandform at 3328.50cm-1that indicates the presence of(O-H) group, 2135.55cm-1 shows the presence N=C=N stretching and compound is carbodiimide, 1638.74cm-1 shows the presence of C=C stretching and compound is conjugated alkene, 877.65cm-1 C=C stretching compound is alkene, 642.74cm-1 shows the presence of C-Br compound is halo compound, 1044.73cm-1 that shows CO-O-CO compound is anhydride.

Spectra of sample S8, shows the bandform at 3331.06cm-1 that indicates the presence of(O-H) group,, 2982.92cm-1 shows the presence C-H stretching and compound is alkene, 2122.20cm-1 shows the presence of N=C=N stretching and compound is carbodiimide, 1641.03cm-1 that shows C=C stretching and compound is conjugated alkene,1084.85cm-1 C-O stretching and compound is primary alcohol, 877.43cm-1 C=C bending compound is alkene, 641.39cm-1 shows the presence of C-Br compound is halo compound,1044.32cm-1 that shows CO-O-CO compound is anhydride.

Spectra of sample S9, shows the bandform at 3327.29cm-1 that indicates the presence of(O-H) group, 2121.70cm-1 shows the presence N=C=N stretching of N-H stretching and compound is carbodiimide, 1639.04cm-1 shows the presence of C=C stretching and compound is conjugated alkene, 877.55cm-1 C=C compound is alkene, 640.27cm-1 shows the presence of C-Br compound is halo compound, 1044.68cm-1 that shows CO-O-CO compound is anhydride.

Spectra of sample S10, shows the bandform at 3332.55cm-1 that indicates the presence of(O-H) group, 2982.59cm-1shows the presence C-H stretching and compound is alkane,1641.33cm-1 shows the presence of C=C stretching and compound is conjugated alkene,1416.34cm-1 shows the presence of O-H stretching that indicates the presence of carboxylic acid, 1084.72cm-1 C-O stretching and compound is primary alcohol,877.44cm-1 C=C compound is alkene, 651.75cm-1 compound is halo compound, 1044.28cm shows the presence of C-Br-1 that shows CO-O-CO compound is anhydride.

Spectra of sample S11, shows the band form at 3326.78cm-1 that indicates the presence of (O-H) group, 2136.28cm-1 shows the presence N=C=N stretching and compound is carbodiimide, 1638.69cm-1 shows the presence of C=C stretching and compound is conjugated alkene, 877.55cm1 C=C compound is alkene shows CO-O-CO compound, 640.68cm-1shows the presence of C-Br compounds halo compound, 1044.41cm-1 that is anhydride.

Spectra of sample S12 shows the bandform at 3328.12cm-1 that indicates the presence of(O-H) group,2983.97cm-1 shows the C-H stretching and compound is alkane,2117.01cm-1 shows the presence C≡C stretching and compound is alkyne, 1639.96cm-1 shows the presence of C=Cstretching and compound is conjugated alkene,1083.42cm-1C-O stretching and compound is primary alcohol, 877.53cm-1C=C compound, is alkene, 641.87cm-1 shows the presence of C-Br compound is halo compound,1044.65cm-1 that shows CO-O-CO compound is anhydride.

Spectra of sample S13, shows the bandform at 3325.97cm-1 that indicates the presence of (O-H) group, 2115.00cm-1 shows the presence C≡C stretching and compound is alkyne, 1639.01cm-1 shows the presence of C=C stretching and compound is conjugated alkene, 877.60cm-1 C=C compound is alkene, 629.33cm-1 shows the presence of C-Br compound is halo compound, 1044.88cm-1 that shows CO-O-CO compound is anhydride.

Spectra of sample S14, shows the band form at 3328.26cm-1 that indicates the presence of(O-H) group, 2116.31cm-1 shows the presence C≡C stretching and compound is alkynes, 1638.30cm-1 shows the presence of c=c stretching and compound is conjugated alkene, 623.52cm-1 shows the presence of C-Br compound is halo compound, 1045.16cm-1 that shows CO-O-CO compound is anhydride.

Spectra of sample S15, shows the band form at 3309.00cm-1 that indicates the presence of(O-H) group, 2120.69cm-1 shows the presence C≡C stretching and compound is alkyne, 1638.cm-1 shows the presence of C=C stretching and compound is conjugated alkene, 631.47cm-1 shows the presence of C-Br compound is halo compound, 1045.09cm-1 that shows CO-O-CO compound is anhydride. The spectra of the samples show slight changes in all five districts. The spectrum shows that the presence of alcohol along with the other components found like: hydrocarbons, acid anhydrides, and halo compounds etc.

It has been noticed that there are slight changes in the peak value of spectra generated from FTIR. The spectras of all the samples shows the presence of alcohol along with other compounds such as acid anhydrides, halo compounds and alkenes. In the previous studies, the presence of compounds like acid anhydride, hydrocarbons, sulfonyls etc. have been reported.

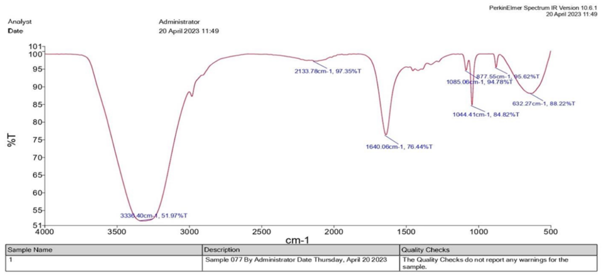

Figure 9: Spectra of sample-S1; Kangra

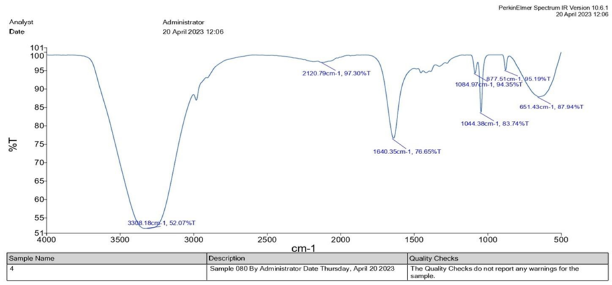

Figure 10: Spectra of sample-S4; Una

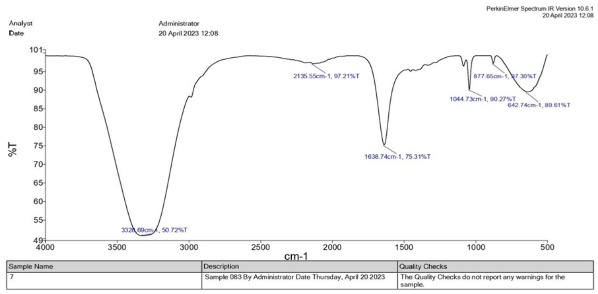

Figure 11: Spectra of sample-S7: Chamba

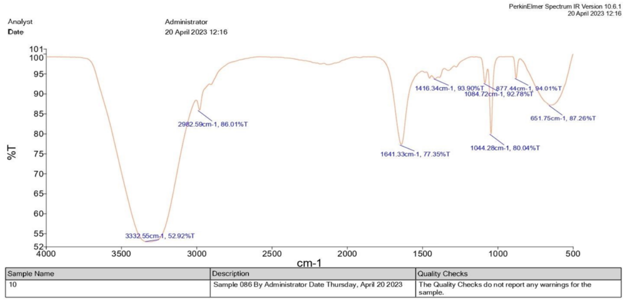

Figure 12:

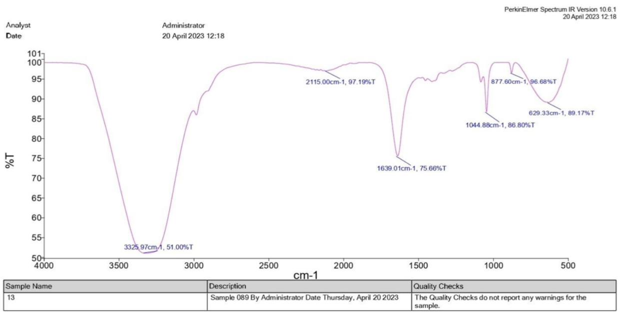

Figure 13: Spectra of sample-13: Bilaspur

4. Conclusion

The primary aim of this study was to assess and juxtapose illicit alcoholic beverages, with a multifaceted approach. Initially, the research embarked on a preliminary examination, commencing with color tests. As per the outcomes of these color tests, indications emerged that ethanol may be present, although no trace of other substances like methanol or metallic contaminants such as copper and iron was detected. Noteworthy is the identification of furfural within select samples, specifically S19, S22, and S23. Furfural, an organic compound, features a furan ring that has undergone substitution with a hydroxyl methyl group. Despite its inherent colourlessness, older samples exhibit an amber hue. This compound imparts an unpalatable taste and emits a faint, albeit discernible, burning odour. Inhalation of furfural can lead to respiratory irritation, manifesting as coughing and potential breathing difficulties. At higher exposure levels, the consequences escalate to pulmonary oedema, a medical crisis characterized by profound breathlessness. Excessive exposure can induce sensations of light-headedness, dizziness, and even loss of consciousness.Subsequent to the color tests, the samples underwent scrutiny via an alcolyzer, revealing notable variations in both alcohol density and percentage. Furthermore, the study encompassed Fourier-transform infrared spectroscopy (FTIR) analysis of the illicit liquor specimens. The findings underscored the consistent presence of alcohol across all samples, alongside the unearthing of additional perilous substances, including acid anhydrides, hydrocarbons, halo compounds, and more.In forthcoming research endeavors, it is imperative to augment the sample size significantly. This expansion will encompass a broader geographical spectrum, encompassing diverse states and regions. To elevate the scientific rigor of these investigations, the adoption of more advanced and sophisticated methodologies is imperative. These methodologies will serve as potent tools for the meticulous quantification of the diverse components inhabiting illicit liquors, thus affording a more nuanced and comprehensive understanding of their intricate composition and associated implications.

5. Source of Funding

None.

6. Conflict of Interest

None.

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