Cannabinoid-Based Classification of Ghanaian Cannabis for Regulatory and Commercial Applications

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Abstract

Ghana's emerging cannabis legislation distinguishes industrial hemp from marijuana primarily by Δ^9-tetrahydrocannabinol (THC) content, using a threshold of 0.3% THC by dry weight. To support regulation, enforcement, and commercial development, this study characterized phytocannabinoid profiles in cannabis samples collected from three farms in two major producing regions of Ghana and in seized samples. Farm samples first tested positive for *Cannabis sativa* with the Duquenois-Levine reagent. The 4-aminophenol (4-AP) presumptive test then produced pink, blue, and inconclusive purple outcomes, which were confirmed by HPLC-DAD through quantification of cannabidiol (CBD) and THC. Among the 12 farm samples, substantial chemical variability was observed; 7 exhibited THC-dominant profiles consistent with drug-type chemotypes, whereas only a small proportion met the industrial hemp threshold. Analysis of seized material showed elevated cannabinol (CBN) in older samples, consistent with cannabinoid degradation during storage. Discriminant analysis based on THC, CBD, and CBN indicated that phytocannabinoid composition reflected plant type more strongly than geographical origin. Overall, most cannabis examined would not qualify as industrial hemp under the proposed legal threshold, highlighting the need for confirmatory instrumental analysis, chemotype-specific breeding, and evidence-based regulatory frameworks for medicinal cannabis and industrial hemp development in Ghana.

Introduction

The illicit cultivation of *Cannabis sativa* has long been established in Ghana and predates current discussions on its potential legal industrialization[1,2,3,4]. The plant has been widely misused because it contains THC, one of its major cannabinoids and its principal psychoactive constituent. More than one hundred cannabinoids have been identified based on various morphological features of the cannabis plant[15], but the most abundant are tetrahydrocannabinolic acid (THCA) and cannabidiolic acid (CBDA), both of which are derived from cannabigerolic acid (CBGA). CBGA is converted into THCA, CBDA, and cannabichromenic acid (CBCA) by the enzymes THCA synthase, CBDA synthase, and CBCA synthase, respectively[5]. Classification of *Cannabis sativa* as hemp or marijuana depends largely on the relative abundance of two phytocannabinoids, THC and CBD[6,16]. This distinction is central to determining whether the plant is suitable for industrial or medicinal use. Medicinal *Cannabis sativa* typically contains higher THC levels (0.3–38% dry weight), which contribute to its therapeutic effects, whereas industrial *Cannabis sativa* contains much lower THC concentrations (0-0.3% dry weight), making it suitable for non-psychoactive industrial applications[7,8,14]. Owing to the psychoactive effects of THC, cannabis has historically been tightly regulated and, in many jurisdictions, including Ghana, treated as a Schedule I controlled substance, although this position has begun to shift in some regions, including parts of the United States[7].

As Ghana moves toward decriminalizing hemp for medicinal and industrial purposes, distinguishing between *Cannabis sativa L.* containing less than 0.3% delta-9-tetrahydrocannabinol (THC), commonly

referred to as hemp, and *Cannabis sativa L.* containing more than 0.3% THC, commonly referred to as marijuana, has become increasingly important. This distinction is especially relevant in cannabis testing. The 2018 U.S. Farm Bill defines hemp, or industrial hemp, as *Cannabis sativa L.* and any part of the plant, including seeds and all derivatives, extracts, cannabinoids, isomers, acids, salts, and salts of isomers, provided that the Δ^9-tetrahydrocannabinol concentration does not exceed 0.3% on a dry-weight basis[9,17].

Marijuana and industrial hemp are distinct varieties of *Cannabis sativa L.* and can be differentiated only through quantitative analysis of total Δ^9-tetrahydrocannabinol (THC) concentration. In Ghana, law enforcement currently relies on the Duquenois-Levine test[10], which can identify plant material as cannabis based on the presence of THC, but there is no presumptive field test that can reliably distinguish hemp from marijuana by taking both THC and CBD into account. This limitation underscores the need for new presumptive testing methods, such as the 4-aminophenol test, that can be evaluated on cannabis cultivated in Ghana to reduce uncertainty and minimize false positives and false negatives.

Color tests are rapid preliminary screening methods used to narrow the possible identity of an unknown drug sample. Although they are not specific, they can quickly indicate whether a controlled substance may be present. The 4-aminophenol test is a presumptive color test for qualitative analysis of cannabis plant material and may help differentiate hemp from marijuana. Hädener *et al.* showed that the 4-AP test successfully distinguished CBD-rich from THC-rich *Cannabis sativa* L. samples. When THC concentration exceeds CBD concentration, the test produces a blue color, indicating a THC-rich/CBD-poor sample.[11] Conversely, when CBD concentration exceeds THC concentration, the test produces a pink color, indicating a THC-poor/CBD-rich sample. Given the legal THC limit of 0.3%, a pink result should indicate a CBD-rich sample with THC below 0.3%. Because the test provides only presumptive information about THC/CBD ratios, quantitative instrumental analysis is still required to determine the actual concentration of THC and other cannabinoids. In this study, samples of *Cannabis sativa* L. were collected from three undisclosed farms under law-enforcement supervision. Chemometrics has also been used to monitor the illicit production of drugs, including cannabis. It involves applying statistical and mathematical methods to chemical data. One major advantage of chemometric algorithms is their ability to tolerate overlapping peaks, meaning that models do not need to include the concentration of every chemical species present, and multiple analytes can be determined simultaneously. In studies of cannabis and marijuana samples, principal component analysis (PCA) and hierarchical cluster analysis (HCA) have been used to classify samples according to their chemical composition and sectoral similarities. These approaches make it possible to differentiate samples and to infer the use of diluents and/or adulterants added to increase drug yield.[12,13] The study aimed to evaluate the 4-AP reagent on cannabis cultivated in Ghana, assess whether cannabinoid levels fell within the scope of the reagent on the basis of the two major cannabinoids measured by HPLC, and determine whether breeding or crop-improvement strategies may be needed to promote hemp varieties for industrial and medicinal purposes. HPLC with diode-array detection provides accurate and reliable qualitative and quantitative determination of phytocannabinoids and is better suited to cannabinoid analysis than gas chromatography because it allows simultaneous measurement of both the acidic and neutral forms of each cannabinoid. Under

HPLC conditions, the acids remain in their original form, whereas under GC conditions, they decarboxylate to their neutral analogs because of high inlet and oven temperatures.[18]

Materials and methods

The following reagents and chemicals were used in this study: 4-aminophenol was purchased from Merck Ghana. Acetaldehyde, vanillin, and chloroform ($CHCl_3$) were also purchased from Merck Ghana. Ethanol and hydrochloric acid were purchased from Fisher Chemical (USA), and sodium hydroxide was purchased from VWR Scientific and EmScience Lab Chemicals (Germany). Deionized water was provided by the Ghana Standards Authority Forensic Laboratory. UNODC provided cannabinoid reference materials through the Narcotic Control Commission. Twelve samples were obtained from two regions in Ghana based on law-enforcement intelligence indicating high levels of illicit cannabis seizure activity. All samples were screened using the Duquenois-Levine and 4-aminophenol presumptive tests, and cannabinoid levels were subsequently determined by HPLC. All color-test reagents were prepared in the laboratory.

Preparation of Duquenois-Levine reagents

Duquenois reagent was prepared by mixing 4 g of vanillin with 2.5 mL of acetaldehyde in 200 mL of ethanol. The modified Duquenois reagent with Levine was prepared using an acetaldehyde/ethanol solution and a stoichiometric amount of vanillin (20 g). The acetaldehyde/ethanol solution was prepared by mixing 7.5 mL of acetaldehyde with 250 mL of ethanol.[10]

Testing of harvested Cannabis sativa samples with Duquenois-Levine reagents

The Duquenois-Levine test was performed by placing approximately 5 mg of each farm *Cannabis sativa* sample into 12 separate glass test tubes. Ten drops of Duquenois-Levine reagent were added to each tube, and the contents were shaken. Next, 10 drops of concentrated HCl were added, and the tubes were shaken again. Any color produced after the hydrochloric acid step was recorded. Twenty drops of chloroform were then added to each tube, after which the tubes were vortexed, allowed to settle, and observed for phase separation. Any color transferred into the organic layer was also recorded. *Cannabis sativa* produces a purple color after the addition of the Duquenois reagent and hydrochloric acid. Upon addition of chloroform, the purple color transfers to the organic layer, indicating a positive presumptive test for cannabinoids.

Preparation of 4-aminophenol reagents

The 4-aminophenol test consists of two separate reagents, designated reagent 1 and reagent 2. Reagent 1 was prepared by weighing 300 mg of 4-aminophenol powder (Merck) on a calibrated analytical balance in the Forensic Science Department. A total of 995 mL of 97% ethanol was placed in a 1 L volumetric flask, and the weighed 4-aminophenol powder was dissolved in the ethanol. The solution was then

brought to volume with 5 mL of 2 N hydrochloric acid. The final solution was transferred to a labeled amber glass bottle and stored in the refrigerator.

Reagent 2 was prepared by weighing 30 g of sodium hydroxide (NaOH) into a 500 mL beaker and dissolving it in 300 mL of deionized water. Next, 700 mL of 98% ethanol was poured into a 1 L volumetric flask, and the flask was brought to volume with the 300 mL deionized water/NaOH solution. The final solution was then transferred to a labeled glass bottle.[9]

Testing of harvested cannabis samples with 4-AP reagents

Approximately 5 mg of each farm *Cannabis sativa* sample was placed into 12 separate test tubes. Reagent 1 was added in sufficient volume to cover each sample in the tube, after which 2–4 drops of reagent 2 were added and mixed thoroughly. The mixtures were allowed to stand for 2 minutes to permit color development. Three outcomes were possible: pink, blue, or inconclusive. An inconclusive result was defined as any color other than pink or blue, most commonly purple. A pink result indicated a cannabis sample containing more CBD than THC, whereas a blue result indicated more THC than CBD. All cannabis samples were analyzed in triplicate without grinding.

HPLC-DAD instrumentation

A Waters HPLC system with photodiode array detection was used. THC and CBD concentrations, reported in ppm, were determined using the HPLC parameters listed in Table 1.[18]

Table 1
HPLC-DAD (Waters) operational parameters used

Parameters	**Conditions**
Type of column	250 x 4mm LiChrosper 60 RP-8 (5 µm)
Temperature of the column	35°C
Type of mobile phase	(80:20 v/v) ratio of Acetonitrile and water, at constant solvent concentration
Flow rate	1.1 mL/min
Detection	Diode array (DA)
Volume of sample injection	10.00 µL

Retention times for THC and CBD, established by comparison with the standards, were used for qualitative identification. The HPLC data were statistically analyzed using Excel and JMP 19.

Standard solution preparation

Stock solutions of Δ^9-THC and CBD were prepared from standard methanolic solutions containing 1 mg/mL of each analyte. These were used to prepare calibration standards (Standard A and Standard B) at concentrations of 200, 400, and 600 ppm to construct the calibration curves.

Results

Descriptive analysis of Cannabis sativa samples with the Duquenois-Levine reagent

Table 2 shows that all samples turned purple after the addition of the DL reagent, indicating a positive presumptive result for *Cannabis sativa* and confirming the presence of cannabinoids targeted by the test. Because the Duquenois-Levine test responds primarily to tetrahydrocannabinol (THC), it serves as a presumptive method for identifying *Cannabis sativa*. These results confirm that all samples collected from the clandestine farms were cannabis plant material. In Ghana, the Duquenois-Levine test is currently used as an initial screening tool before quantitative laboratory analysis is completed. Accordingly, the twelve samples obtained from three farms across two regions were first subjected to the DL test to verify their identity.

Table 2
Presumptive test on farm cannabis samples with Duquenois-Levine reagents

Sample location	Duquenois Levine Test Result
BAN(C_1)	Purple
BAN(C_2)	Purple
BAN(C_3)	Purple
BAN(C_b)	Purple
BAN(C_c)	Purple
BAN(C_d)	Purple
EAS(C_1)	Purple
EAS(C_2)	Purple
EAS(C_3)	Purple
EAS(C_4)	Purple
EAS(C_5)	Purple
EAS(C_6)	Purple

Descriptive analysis of Cannabis sativa samples with 4-aminophenol reagents

The same twelve cannabis samples were then analyzed using the 4-AP reagent, which produced three observed color outcomes, as shown in Table 3: blue, pink, and purple. Blue indicates a *Cannabis sativa* sample with THC above 0.3% by dry weight, pink indicates THC below 0.3%, and purple is considered inconclusive.[9] Results from the color test are shown in Figs. 1 and 2 below.

Table 3 below shows that 50% of the BAN samples produced blue results, while the remainder produced pink results. A similar distribution was observed among the EAS samples, except for EAS(C_5), which produced a purple result and was therefore classified as inconclusive. Overall, these findings suggest that a substantial proportion of *Cannabis sativa* plants grown in these two regions may contain THC above the 0.3% legal threshold. The regions were selected based on law-enforcement records identifying them as areas associated with clandestine cultivation and illicit trafficking of cannabis in Ghana.[20]

Table 3
Presumptive test on farm *Cannabis sativa* samples with 4-aminophenol reagents

Sample location	4-AP Test Result
BAN(C_1)	Pink
BAN(C_2)	Blue
BAN(C_3)	Pink
BAN(C_b)	Pink
BAN(C_c)	Blue
BAN(C_d)	Blue
EAS(C_1)	Blue
EAS(C_2)	Pink
EAS(C_3)	Blue
EAS(C_4)	Pink
EAS(C_5)	Purple
EAS(C_6)	Blue

Descriptive analysis of cannabinoids in farm Cannabis sativa samples in the two regions

All *Cannabis sativa* samples obtained from the clandestine farms in the two regions of Ghana contained the two major cannabinoids, CBD and Δ^9-THC, the plant's principal psychoactive compound. All cannabinoid concentrations were measured in triplicate, and the mean values are presented in Table 4.

Table 4
The THC and CBD concentrations in farm cannabis samples by LC instrumentation.

Sample code	%THC	%CBD
BAN(C_1)	0.2701	0.5900
BAN(C_2)	0.0748	0.0431
BAN(C_3)	1.0288	1.9535
Mean	**0.4579**	**0.8622**
SD	**0.5040**	**0.9839**
BAN(C_b)	1.2035	2.1039
BAN(C_c)	0.7400	0.1484
BAN(C_d)	0.6193	0.0696
Mean	**0.8543**	**0.7740**
SD	**0.3084**	**1.1524**
EAS(C_1)	0.8701	0.1093
EAS(C_2)	0.1165	2.7453
EAS(C_3)	0.5046	0.0510
EAS(C_4)	0.2143	1.0741
EAS(C_5)	0.0306	0.0329
EAS(C_6)	0.0952	0.0697
Mean	**0.3052**	**0.6804**
SD	**0.3232**	**1.0893**

Across all farm samples, %THC ranged from 0.0306 to 1.2035, with a mean of 0.4807 and a standard deviation of 0.4074. THC values showed positive skewness (0.5322). CBD ranged from 0.0329 to 2.7453, with a mean of 0.7492 and greater variability, reflected in a standard deviation of 0.9814 and skewness of 1.1599. Farm 2 showed the highest mean THC concentration, whereas Farm 1 showed the highest mean CBD concentration. Overall, all samples contained measurable levels of both CBD and THC, indicating substantial chemotypic variation across the sampled farms.

Descriptive analysis of phytocannabinoids in seized Cannabis sativa samples

The mean concentrations of the three cannabinoids are presented in Table 5. The samples consisted of *Cannabis sativa* plant material seized by law enforcement in Ghana between 2017 and 2020. Seizure frequency increased during this period, rising from one case in 2017 to nine cases in 2019. Only two seizures were available for 2020 because the material analyzed was drawn from law enforcement holdings in January 2020. Across the seized samples, mean CBD concentrations ranged from 0.6552 to 1.8280, whereas mean THC concentrations ranged from 0.7548 to 0.8473 for 2017–2019 and were 0.8218 in 2020. Mean CBN concentrations were substantially higher than both CBD and THC in the 2018–2020 samples, indicating marked variation in post-seizure or post-harvest cannabinoid composition.

Table 5
The concentrations of THC, CBD, and CBN in seized *Cannabis sativa* samples by LC instrumentation.

2017			
SAMPLE	**CBD**	**CBN**	**THC**
10/FS2/17	1.8089	0.3209	1.7564
2018			
15/FS2/18	1.2864	10.2745	0.4488
1/FS2/18	0.0636	6.0769	0.07
37/FS2/18	5.5385	9.0702	0.6278
16/FS2/18	2.0733	13.8535	0.6566
20/FS2/18	0.4016	0.3496	0.6759
38/FS2/18	1.6051	8.6604	2.0498
Range	0.0636–5.5385	0.3496–13.8535	0.0700–2.0498
Mean	1.8280	8.0475	0.7548
SD	1.9656	4.5438	0.6740
2019			
39/FS2/19	1.352	5.8438	0.4675
12/FS2/19	2.4059	8.9873	0.6048
9/FS2/19	0.4339	11.398	0.4472
23/FS2/19	1.4897	9.3917	1.2743
27/FS2/19	1.0333	16.9621	1.1384
44/FS2/19	3.189	10.3438	1.0961
17/FS2/19	0.7166	14.7817	1.831
13/FS2/19	1.3796	12.4809	0.6958
46/FS2/19	0.1559	0.1909	0.0709
Range	0.1559–3.1890	0.1909–16.9621	0.0709–1.8310
Mean	1.3507	10.0389	0.8473
SD	0.9542	4.9289	0.5345
2020			

2017			
SAMPLE	**CBD**	**CBN**	**THC**
10/FS2/20	0.8907	4.6945	0.1369
9/FS2/20	0.4196	24.8064	1.5066
Range	0.4196–0.8907	4.6945–24.8064	0.1369–1.5066
Mean	0.6552	14.7505	0.8218

Among the three cannabinoids measured, CBN showed the highest mean concentrations across the seized samples. The highest mean CBN concentration was observed in the 2020 samples (14.7505), followed by the 2019 samples (10.0389), and the lowest in the 2017 samples (0.3209). Fresh cannabis typically contains little or no CBN; this cannabinoid forms as THC degrades during storage, particularly under elevated temperatures.[19] The conversion of THC to CBN is illustrated in Fig. 3.

Under heat and related stress conditions, THCA undergoes decarboxylation to form THC, which can subsequently oxidize to CBN through loss of hydrogen atoms. CBN levels in *Cannabis sativa* may therefore reflect storage history, although the rate of conversion does not depend solely on the number of years a sample has been stored.

Phytocannabinoid Levels and Geographical Origin of the Cannabis Samples

Discriminant analysis (DA) was used to examine whether phytocannabinoid profiles were associated with the geographical origin of the cannabis samples, as in approaches previously applied to elemental data. The dataset was normalized using z-scores. The analysis was performed using the concentrations (ppm) of Δ^9-tetrahydrocannabinol, cannabidiol, and cannabinol, as shown in Fig. 4. The dataset included samples from Farms 1, 2, and 3, together with all seized samples from 2019 and 2020. Samples from 2017 and 2018 were excluded because the farm cannabis samples were collected only between 2019 and 2020. The objective was to assess whether any of the seized samples could be associated with one of the three farms.

The DA plot suggests that the samples seized in 2019 and 2020 are distinct from those collected at the three farms, indicating a high probability that the seized materials did not originate at any of those locations. This pattern is plausible because phytocannabinoid composition is influenced largely by plant type and cultivar. By contrast, Farms 1 and 2 showed overlap, likely because they were in the same region and may have contained similar cannabis varieties. During field sampling, it was also observed that some farmers operated multiple farms at different locations within the same region, which may further explain the correlations among these samples.

Discussion

The primary objective of this study was to evaluate whether presumptive color testing, supported by HPLC-DAD, could distinguish hemp from marijuana in cannabis cultivated in Ghana. The results show that the 4-aminophenol (4-AP) test provides useful preliminary information because its blue, pink, and purple outcomes broadly reflected differences in THC and CBD abundance observed by instrumental analysis. However, the farm samples also showed substantial chemical variability, confirming that presumptive color reactions alone are not sufficient for definitive classification. HPLC data demonstrated that only a small proportion of the farm samples met the legal threshold for hemp (THC ≤ 0.3%), whereas most exhibited cannabinoid profiles consistent with drug-type chemotypes. These findings directly address the study objective by showing that cannabis currently cultivated in the sampled regions is more often classified as marijuana than industrial hemp under the proposed regulatory standard.

The occurrence of an inconclusive purple 4-AP result in one farm sample further highlights the limitations of presumptive testing. In practical terms, this means that some samples cannot be reliably assigned to the hemp or marijuana category without confirmatory laboratory analysis. This limitation is important for Ghana, where the 0.3% THC threshold now has legal significance. If presumptive tests are used in the field without confirmatory follow-up, inconclusive or misleading results could lead to misclassification. The present findings therefore support the continued use of chromatographic confirmation whenever legal or regulatory decisions depend on cannabinoid concentration rather than simple cannabis identification.

The preliminary ranges summarized in Table 6 also help explain why false-negative outcomes remain a concern in cannabis screening. Samples with relatively high CBD but THC concentrations above 0.3% may still produce pink results, even though they would be classified legally as marijuana. This is consistent with published DEA observations and is relevant to the Ghanaian context because future industrial hemp regulation will require an accurate distinction between low-THC and above-threshold material. For this reason, refinement of the 4-AP approach, including the modified CBD-focused formulation explored in this study, may improve the discriminatory value of field testing, but such tests should still be interpreted as presumptive rather than definitive.

Table 6
Preliminary data for the 4-AP color test based on the DEA published ranges.

SAMPLE	%Δ^9 -THC	%CBD	RESULT
1	0.11	0.64	Pink
2	0.20	6.52	Pink
3	0.29	11.04	Pink
4	**0.36**	8.15	Pink (**false negative**)
5	**0.59**	15.62	Pink (**false negative**)
6	0.38	0.10	Blue
7	0.43	0.14	Blue
8	0.73	0.05	Blue
9	2.27	3.99	Purple
10	2.71	5.94	Purple
11	2.89	4.07	Purple

The modified CBD-focused formulation examined in this study suggests that additional reagent steps may improve the interpretation of samples with CBD-rich profiles. In particular, the observed color change under acidic conditions indicates that some samples initially classified as pink by the standard 4-AP procedure may still contain THC above the legal threshold. This observation is important because it points to a possible route for reducing false-negative screening outcomes in samples with mixed or CBD-dominant chemotypes. At the same time, the present data should be viewed as preliminary, and further validation with a larger sample size will be necessary before the modified procedure can be recommended for routine forensic or regulatory use.

The quantitative farm-sample results are also relevant to the broader question of how cannabis cultivated in Ghana may be directed toward industrial or medicinal use. Because legal classification depends on THC concentration, the observed THC/CBD ratios indicate that most sampled plants would not qualify as industrial hemp, despite several CBD-rich samples. This suggests that expansion of a lawful hemp sector in Ghana will require deliberate selection of cultivars with consistently low THC expression rather than reliance on seed-derived material from existing clandestine cultivation. At the same time, some samples displayed cannabinoid profiles that may be of interest for medicinal applications, particularly where mixed THC-CBD chemotypes are desirable. These findings support the study objective of assessing whether breeding or crop-improvement strategies will be needed to promote chemotypes appropriate for specific legal and commercial uses.

The analysis of the seized sample provides additional context for interpreting cannabinoid composition over time. CBN was the most prominent of the three measured cannabinoids in the seized material, and its higher levels in the 2018–2020 samples are consistent with post-harvest degradation of THC during storage. This pattern supports the view that cannabinoid profiles in seized cannabis may reflect both original chemotype and subsequent storage conditions. Accordingly, seized-sample chemistry should be interpreted with caution when inferring the intended use or source, as aging may alter the apparent balance among cannabinoids.

Finally, the discriminant-analysis results indicate that phytocannabinoid composition was more strongly associated with plant type than with geographical origin. The seized samples from 2019 and 2020 did not cluster with the farm samples, suggesting that the sampled farms were unlikely sources of those seizures. In contrast, the overlap between Farms 1 and 2 indicates that samples from nearby locations may share similar chemical characteristics, especially when similar seed stock or cultivation practices are used. This outcome addresses the study objective concerning geographical classification and suggests that phytocannabinoid data alone may have limited power for source attribution unless supported by additional chemical or agronomic markers.

Conclusion

In conclusion, Duquenois-Levine and 4-aminophenol color-test reagents can support rapid field identification of *Cannabis sativa L.* plant material. The 4-aminophenol reagent provides additional discriminatory value by helping distinguish hemp from marijuana based on relative CBD and THC levels, but the present results also show that presumptive color testing alone is insufficient for definitive legal classification. HPLC-DAD confirmation remains necessary, particularly when THC thresholds determine whether material qualifies as industrial hemp or marijuana. With further development of CBD-mod reagents, false-negative results involving CBD-rich *Cannabis sativa L.* samples may be reduced, thereby improving the practical utility of field screening.

Cannabis sativa has considerable potential for both industrial and medicinal applications because of its rich phytochemical composition. The concentrations of tetrahydrocannabinol and cannabidiol, the two major phytocannabinoids examined in this study, determine chemotype and therefore distinguish hemp from marijuana under cannabis legislation. The results indicate that most farm samples analyzed would not qualify as industrial hemp under the 0.3% THC threshold, highlighting the need for deliberate cultivar selection, chemotype-specific breeding, and controlled cultivation if Ghana is to develop a lawful hemp sector. Analysis of seized material also showed elevated CBN in older samples, emphasizing that storage-related degradation can alter cannabinoid profiles over time. Finally, phytocannabinoid variation appeared to reflect plant type more strongly than geographical origin, suggesting that source attribution based on cannabinoid data alone should be interpreted cautiously. Together, these findings are relevant to agricultural planning, medicinal cannabis development, forensic interpretation, and law enforcement monitoring of clandestine farms.

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Author Contribution

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Data Availability

All data supporting the findings of this study are available and can be provided upon request.

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Figures

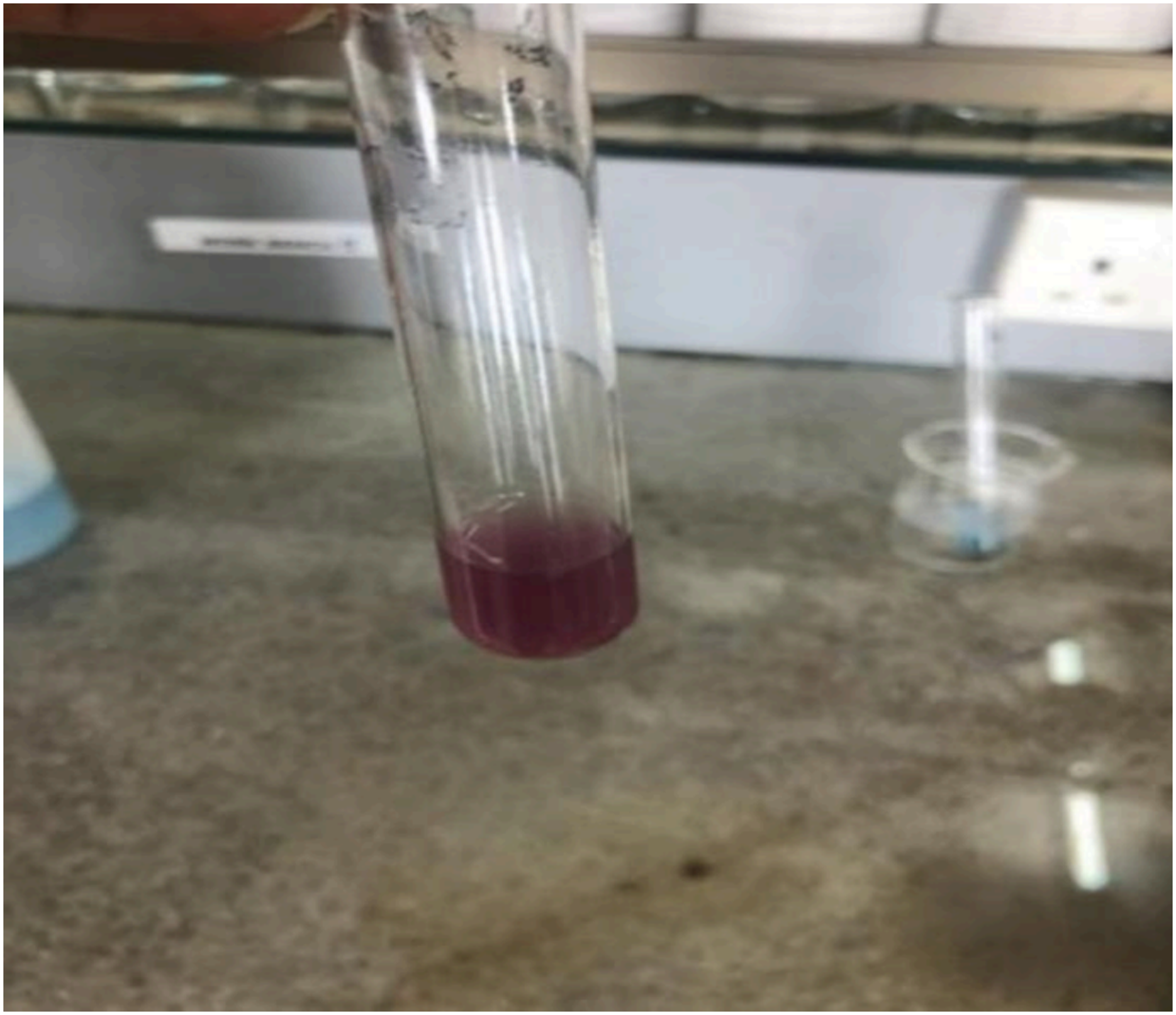

Figure 1

Positive 4-AP result for cannabis with THC below 0.3%, classified as hemp.

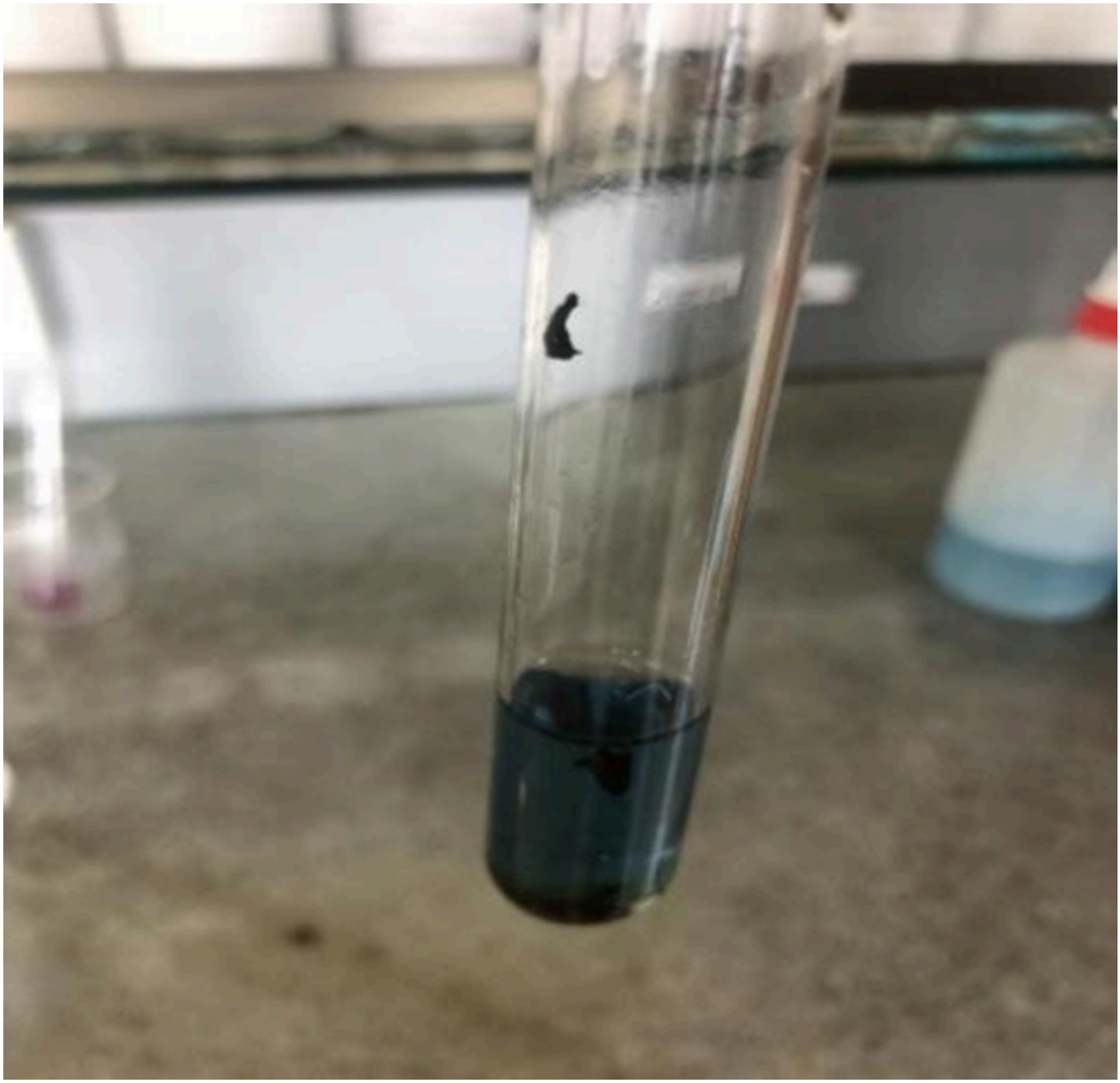

Figure 2

Positive 4-AP results for cannabis with THC above 0.3%, classified as marijuana.

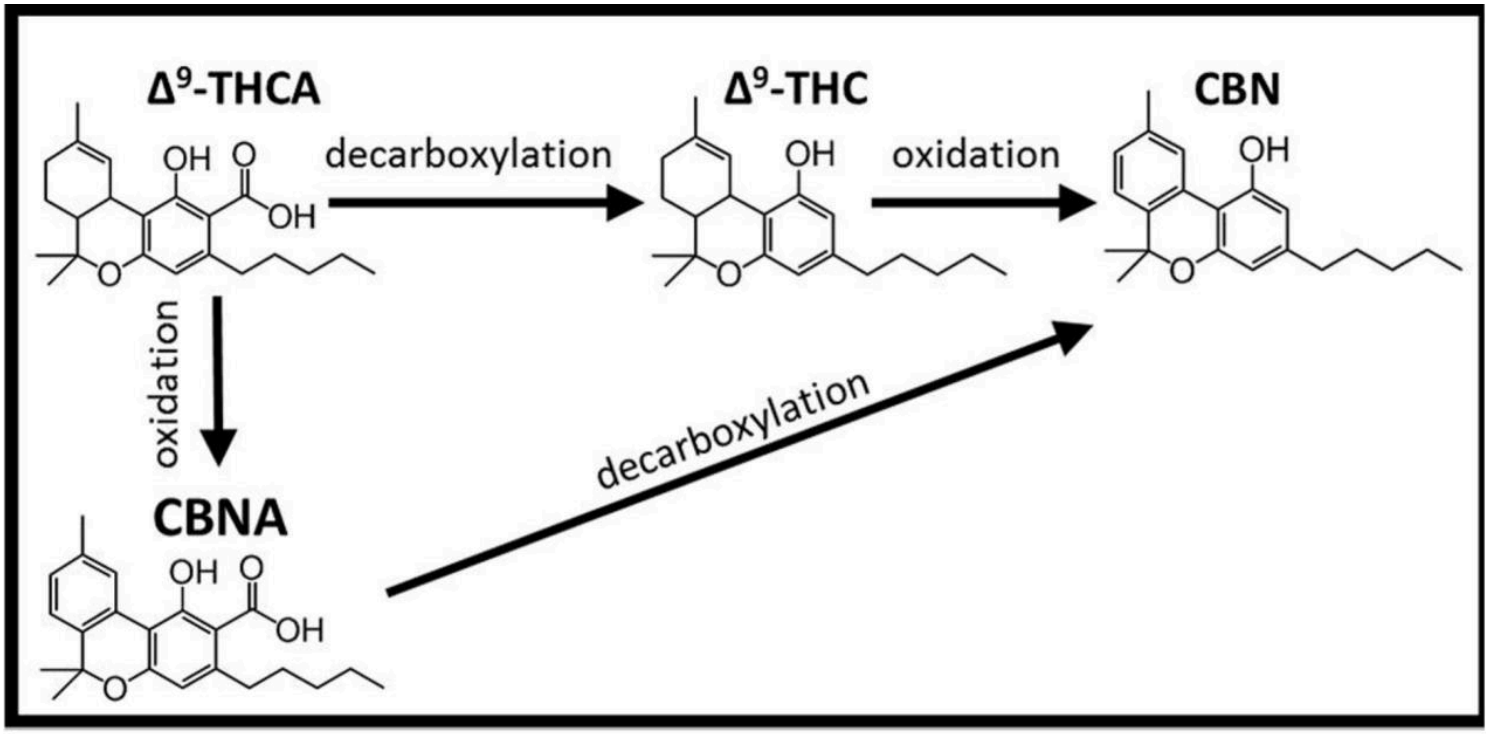

Figure 3

The conversion of THCA and THC to CBNA and CBN.

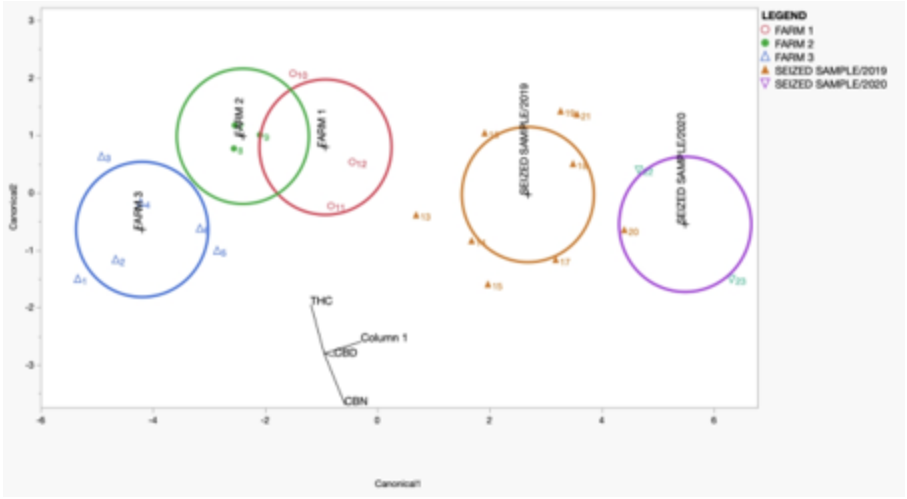

Figure 4

Canonical discriminant analysis plot based on three phytocannabinoids determined by HPLC in the Cannabis samples.

Supplementary Files

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- floatimage1.png