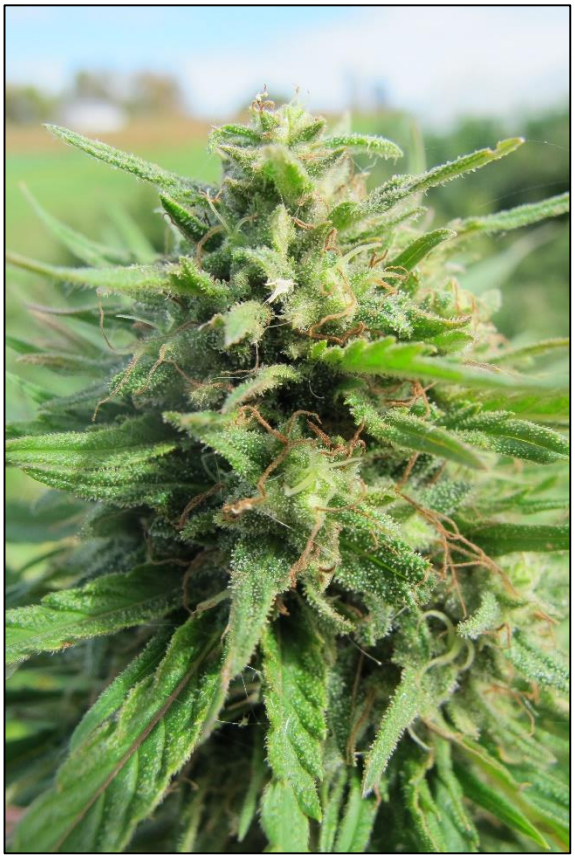
NORTHWEST CROPS & SOILS PROGRAM

2020-2021 Hemp Flower Storage Trial



Dr. Heather Darby, UVM Extension Agronomist
John Bruce and Rory Malone
UVM Extension Crops and Soils Technicians
(802) 524-6501

Visit us on the web: http://www.uvm.edu/nwcrops

THE UNIVERSITY OF VERMONT EXTENSION

2020-2021 HEMP FLOWER STORAGE TRIAL

Dr. Heather Darby, University of Vermont Extension
heather.darby[at]uvm.edu

Hemp is a non-psychoactive variety of *cannabis sativa L*. Hemp is a crop of historical importance in the U.S. and re-emerging worldwide as a popular crop, as it is sought out as a renewable and sustainable resource for a wide variety of products. Hemp that is grown for fiber, grain oil, or as an intended health supplement contains less than 0.3% tetrahydrocannabinol (THC). When hemp is grown to produce cannabidiol (CBD), it is grown more intensively, similar to vegetable production, and can be grown indoors or in the field. As hemp production for CBD products is rapidly increasing in the northeast, research on the impact of storage on quality is needed, as farmers may have to store harvested hemp flowers for months before transporting it to a processor or store. Information on the effect of temperature on product quality can aid growers in selecting the best storage method. In this trial, UVM Extension's Northwest Crop and Soils Team examined the impact of storage temperature and time on CBD, THC, and terpene concentrations of hemp flower.

MATERIALS AND METHODS

The trial was initiated 20-Nov 2020 at the E.E. Cummings Crop Quality Testing Lab (Burlington, VT). Hemp flower grown for cannabidiol (CBD) was placed in 60 plastic bags, with 30 g of dried flower (var. Lifter) in each bag. Plastic sample bags were placed in brown paper bags, then in colored plastic storage bins, to prevent photodegradation. The experimental design was a completely randomized design with four replications. There were four-storage length treatments, which were the dates hemp flower was removed from storage and sent for cannabinoid and terpene analysis in order to determine changes in concentration over time. These dates were 90 days of storage (20-Feb 2021), 120 days (20-Mar 2021), 150 days (20-Apr 2021), and 180 days (20-May 2021). There were three temperature treatments, which were the ambient temperature in the E. E. Cummings Crop Testing Lab (approximately 19°C, 66.2°F), storage in a refrigerator (approximately 5°C, 41°F) and storage in a freezer (approximately -19°C, -2.2°F).

Table 1. Trial design for the cannabidiol hemp storage trial, Burlington, VT, 2020.

Storage Location	UVM Extension E.E. Cummings Crop Testing Lab, Burlington, VT
Hemp flower harvest date	1-Oct 2020
Trial start date/baseline sampling	20-Nov 2020
Variety	Lifter
Replicates	5
Storage time treatments	90 days, 120 days, 150 days, 180 days
Storage temperature treatments	Refrigerator, freezer, ambient

Air temperature in each storage type was monitored with a thermometer to make sure that there were not fluctuations in temperature within a storage type. At each storage sample time, hemp flower samples were pulled from each storage type and sent to ProVerde Laboratories (Portland, ME) for cannabinoid analysis. Cannabinoids profiles can be used as an indicator of quality of hemp flower grown for cannabinoid production. Cannabinoids such as cannabidiol are desired for their purported medicinal benefits. Cannabidiol (CBD), cannabidiolic acid (CBDA), cannabigerol (CBG), cannabigerolic acid (CBGA),

tetrahydrocannabinolic acid (THCA), cannabichromene (CBC), and cannabichromic acid (CBCA) were measured. CBGA is a precursor to three major cannabinoids; THCA, CBDA, and CBCA. CBC and CBG are not included in statistical analysis in this report. The CBDA compound becomes CBD, and so on, when a carboxyl group is removed from the acid during decarboxylation. This occurs when the flower is heated to high temperatures in an oven or during combustion or slowly over time. Drying, temperature, length of storage, and other storage factors can all have the potential to impact cannabinoid profiles.

Samples were analyzed for cannabinoids via liquid chromatography, with an Ultra-Performance Convergence Chromatography System (UPC2) from Waters Corp., which utilizes carbon dioxide as the primary mobile phase component. The terpene profile was measured by head-space gas chromatography. A combination of flame ionization detection and/or mass spectrometric detection with mass spectral confirmation against the National Institute of Standards and Technology (NIST) Mass Spectral Database, Revision 2017, were used.

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 2008). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at $p<0.10$. Variations in genetics, soil, weather, and other growing conditions can result in variations in yield and quality. Statistical analysis makes it possible to determine whether a difference between treatments is significant or whether it is due to natural variations in the plant or field. At the bottom of each table, a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown. This means that when the difference between two treatments within a column is equal to or greater to the LSD value for the column, there is a real difference between the treatments 90% of the time. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with similar lettering. In this case below, the difference between two treatments within a column is equal to or greater than the least significant difference (LSD). Treatment B and treatment C have share the same letter “a” next to their yield value to indicate that these results are statistically similar. The difference between treatment C and treatment B is equal to 1.5, which is less than the LSD value of 2.0. This means that these treatments did not differ in yield. The difference between treatment C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these treatments were significantly different from one another. The letter ‘b’ next to treatment A’s yield value shows that this value is significantly different from treatment B and treatment C, which have the letter ‘a’ next to their value.

Treatment	Yield
A	6.0 b
B	7.5 a
C	**9.0 a**
LSD	2.0

RESULTS

Impact of Storage Time

Within this trial there were significant differences observed across the time interval treatments for THCA, CBD, CBDA, Total CBD, and CBD: THC ratio (Table 2). Between treatments, highest values for CBD were observed at the 90-day storage period when compared to the other storage treatments at 16.4% total potential CBD, also leading to the highest ratio of CBD to THC at 30.7. Decarboxylated components THC and CBD were highest at the 180-day storage period. This could perhaps be indicative of slow conversions from THCA and CBDA over time compared to more common, rapid decarboxylation which occurs at higher temperatures than those within this study. None of the observed compounds showed linear decreasing or increasing trends for concentrations over time, however these highest observed values for D9-THC and CBD occurred at the 180-day period at 0.053% and 0.532% respectively and were statistically similar to the 150-day treatment. THCA, in addition to total potential THC, remained consistent over time with no statistically significant differences observed across time storage treatments, despite the slight fluctuations observed in D9-THC.

Table 2. Cannabinoid analysis results by storage time, 2021.

Treatment	D9-THC	THCA	CBD	CBDA	Total CBD†	Total THC‡	CBD : THC
	%	%	%	%	%	%	
90-day	0.048 b¥	0.556	0.418 b	**18.3 a**	16.4 a	0.536	**30.7 a**
120-day	0.040 c	0.555	0.417 b	16.0 c	14.5 c	0.527	27.5 c
150-day	0.051 ab	0.538	0.494 a	15.8 c	14.4 c	0.523	27.5 c
180-day	**0.053 a**	0.545	**0.532 a**	17.2 b	15.7 b	0.531	29.4 b
LSD (p=0.10)	0.005	NS€	0.058	0.0652	0.583	NS	0.190
Trial Mean	0.048	0.549	0.465	16.8	15.2	0.529	28.8

† Total potential CBD = (0.877 x CBDA) + CBD.

‡ Total potential THC = (0.877 x THCA) + Δ-9 THC.

¥ Treatments within a column with the same letter are statistically similar. Top performers are in **bold.**

€NS – There was no statistical difference between treatments in a particular column (p=0.10).

Impact of Storage Type

Except for total potential CBD and total potential THC, each of the measured parameters for cannabinoids showed statistically significant differences across storage temperature treatments (Table 3). Samples stored at ambient temperatures over the trial period had significantly higher D9-THC (0.080%) and CBD (0.782%) concentrations when compared to those stored at freezer and refrigerator temperatures. Conversely, THCA and CBDA concentrations were highest in the freezer storage treatment at 0.573% and 17.3% respectively, and were statistically similar to the freezer treatment. The ratio of CBD:THC was significantly higher at those warmer temperatures for refrigerator and ambient storage conditions when compared to freezer conditions whereas total potential CBD and total potential THC were not significantly different across treatments.

Table 3. Cannabinoid analysis results by storage temperature, 2021.

Treatment	D9-THC	THCA	CBD	CBDA	Total CBD†	Total THC‡	CBD : THC
	%	%	%	%	%	%	
Ambient	**0.080 a¥**	0.504 b	**0.782 a**	16.2 b	15.0	0.521	28.8 a
Freezer	0.032 b	0.569 a	0.296 b	17.0 a	15.2	0.531	28.5 b
Refrigerator	0.032 b	**0.573 a**	0.317 b	**17.3 a**	15.5	0.535	**28.9 a**
LSD (0.10)	0.004	0.0182	0.0501	0.564	NS€	NS	0.164
Trial Mean	0.048	0.549	0.465	16.8	15.2	0.529	28.8

† Total potential CBD = (0.877 x CBDA) + CBD.

‡ Total potential THC = (0.877 x THCA) + Δ-9 THC.

¥ Treatments within a column with the same letter are statistically similar. Top performers are in **bold.**

€NS – There was no statistical difference between treatments in a particular column (p=0.10).

Interactions

There were a few significant interactions between storage temperature and time in storage. The interaction for CBD ($p = 0.0011$), D9-THC, and total potential CBD:THC ratio ($p < 0.0001$) were similar. Samples stored at ambient temperature regardless of their length in storage had higher concentrations of CBD and D9-THC compared to the other treatments. Comparatively, those samples stored in the freezer had higher CBD and D9-THC concentrations at 90 days in storage compared to those stored in the refrigerator. However, as storage length increased the samples stored in the refrigerator had slightly higher levels of CBD and D9-THC. This may be as a result of a slow conversion of CBDA and THCA over time in the coldest treatment.

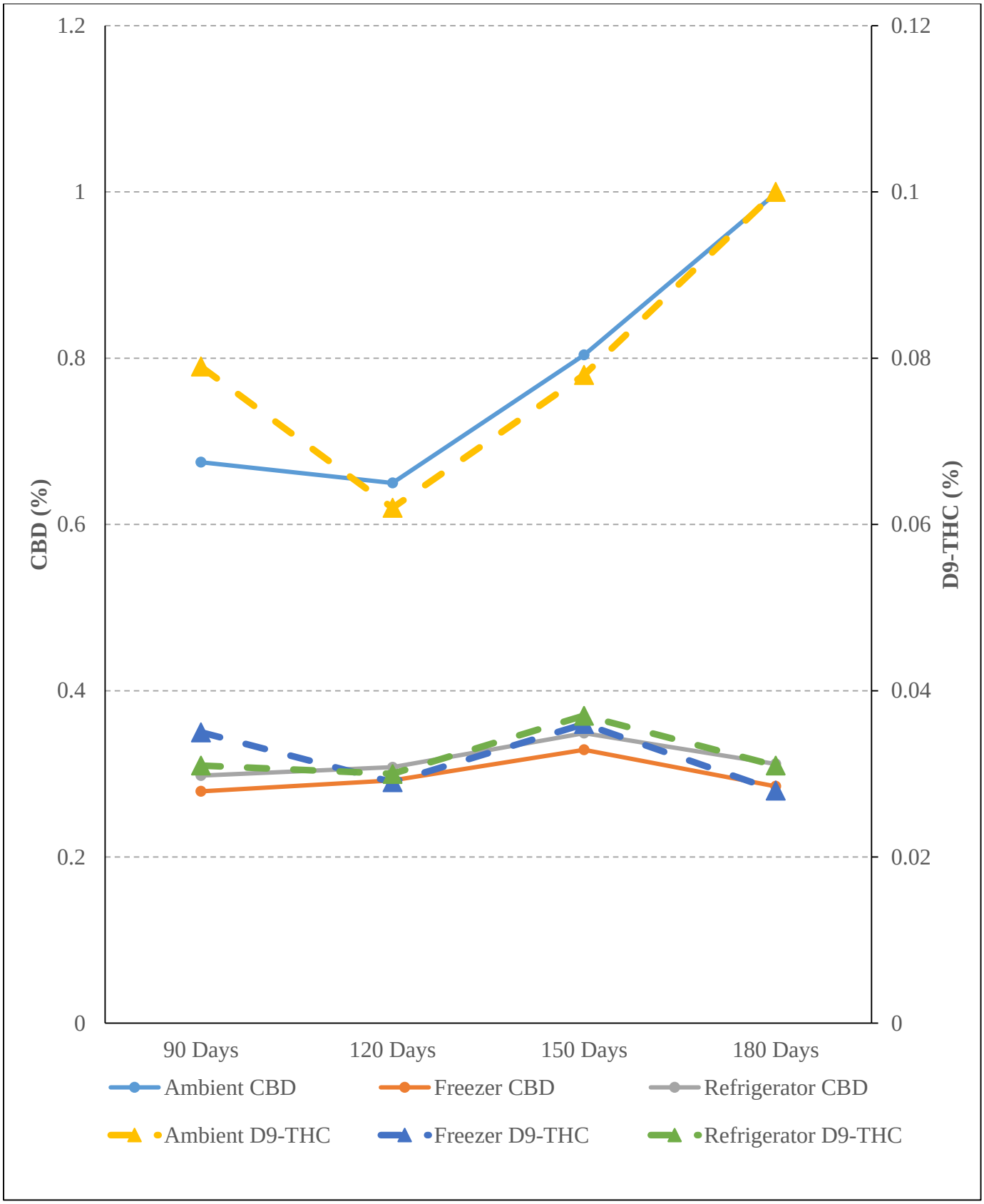


Figure 1. CBD and D9-THC percentages by storage temperature over time, 2021.

DISCUSSION

These results show an increase of CBD and THC concentrations over time as CBDA and THCA decarboxylate over time with warmer temperatures. When the greatest conversions would occur in temperatures in excess of 230°F, this process will occur naturally over time. Comparatively, total concentrations of either major cannabinoid did not appear to change significantly through temperature treatments, but lower values were observed over time. During this 180-day trial period, there appeared to be ~1-2% fluctuations in total potential CBD over time. With greater lengths of storage, there could be increased potential for loss over time through a variety of additional factors. This could be potentially further impacted by packaging material, storage moisture, and light to name a few. Storage conditions are also important to monitor for further spoilage through mold, largely impacted by these various conditions. Storage temperature did have an effect on some cannabinoids, with CBD and THC being highest in the ambient temperature storage treatment. CBD increased over time in the ambient temperature treatment over time more so than the other temperatures, which could mean that the lower temperatures slow the degradation of CBDA. It is important to remember that these data represent only one year of research. Further research is needed to determine the impacts of storage time and temperatures on cannabinoids. Furthermore, this trial did not look into terpene concentrations which would likely have greater fluctuations over time, especially when looking at temperatures as many of these highly volatile compounds begin to degrade in temperatures around 70°F and above.

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Program would like to give a special thanks to Roger Rainville and the staff at Borderview Research Farm for their help with the trials. This project was supported by and was funded through our partnership with Hatch Act Multistate Research Fund and Vermont IPM Extension Implementation Program. This work was funded by the Northeastern IPM Center through Grant #2018-70006-2882 from the National Institute of Food and Agriculture, Crop Protection and Pest Management, Regional Coordination Program. This information is presented with the understanding that no product discrimination is intended and neither endorsement of any product mentioned, nor criticism of unnamed products, is implied.

UVM Extension helps individuals and communities put research-based knowledge to work.

THE UNIVERSITY OF VERMONT EXTENSION