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**Short Term Stability Study
The Influence of INTEGRA Boost on
Cannabis Storage**

Final Report

April 2016

CONFIDENTIAL



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1 Introduction

The dried and cured flowers of the female *Cannabis sativa* plant are used for both medicinal and recreational purposes. The main class of active compounds in Cannabis are the cannabinoids. Upon storage these compounds can degrade and lose their activity. Patients and other consumers usually purchase a quantity of flowers that will last them multiple weeks and therefore will need to store the product in a way that does not impact the quality of the product in a negative way. The degradation of cannabinoids and change in moisture content of the cannabis are two parameters that can negatively influence quality. Cannabis with too low of a moisture content produces a harsher smoke and lower quality experience for the user.

In this study we investigated the influence of INTEGRA Boost on cannabis during storage for 4 weeks. This study investigated three storage conditions:

- No humidity control
- 55% INTEGRA Boost
- 62% INTEGRA Boost

The cannabis was stored in 1 litre air tight media bottles and opened for 1 minute a day most days a week.. The frequent opening was performed to simulate the way an end user would utilize the stored material. Once a week the bottles were sampled and analysed for cannabinoid and moisture content.

The study will results in a better understanding of the stability of cannabinoids with respect to humidity, and establish guidelines for proper storage of cannabis in order to maximize shelf-life for the consumers benefit.



2 Materials and methods

The cannabis flowers were provided by Desiccare. Sticks and stems were removed and the material was broken up into homogenous pieces of 3-5 mm. This material was divided over 3 glass 1 liter Pyrex wide mouth bottles (VWR, article number 89090-054). Each bottle contained 15 g of plant material as well as a temperature and humidity data logger (Inkbird THC-4).

The control bottle did not have a humidity pack inside of it. The remaining two bottles had either a 55% INTEGRA Boost or 62% INTEGRA Boost humidity control device.

Sample	Humidity
Control	No humidity pack
A	55% INTEGRA Boost
B	62% INTEGRA Boost

Table 1. Humidity control of storage containers.

The containers were stored at ambient conditions in a Styrofoam cooler in the laboratory.

All containers were opened most days for 1 minute to simulate daily usage by a consumer. This 1 minute of opening allowed the air in the jar to equilibrate with ambient conditions. After closing the Pyrex bottles, relative humidity levels were restored by the humidity control packs.

At each time point the following analysis were performed

- Loss on drying in a vacuum oven
- Cannabinoids with UHPLC-UV/Vis

Samples for cannabinoid and moisture analysis were performed in triplicate.



3 Results

3.1 Monitoring of Relative Humidity and Temperature

A temperature and humidity logger was placed in the 1 litre media bottles to monitor the conditions inside during storage. Figure 1 shows the graph for the temperature in the various containers. Figure 2 shows the graph for the relative humidity in the various containers.

The following observations can be made:

- As expected, all temperatures follow a similar pattern.
- The humidity inside the bottles was significantly different between the control, 55% INTEGRA Boost and 62% INTEGRA Boost.
- The measuring days can be noticed in the humidity data as upwards or downwards spikes. This is because the jar got opened for a prolonged time during sampling which causes the humidity logger to log the ambient humidity.
- Bottles with INTEGRA Boost recovered to a stable humidity level after sampling whereas the control bottle steadily lost humidity.

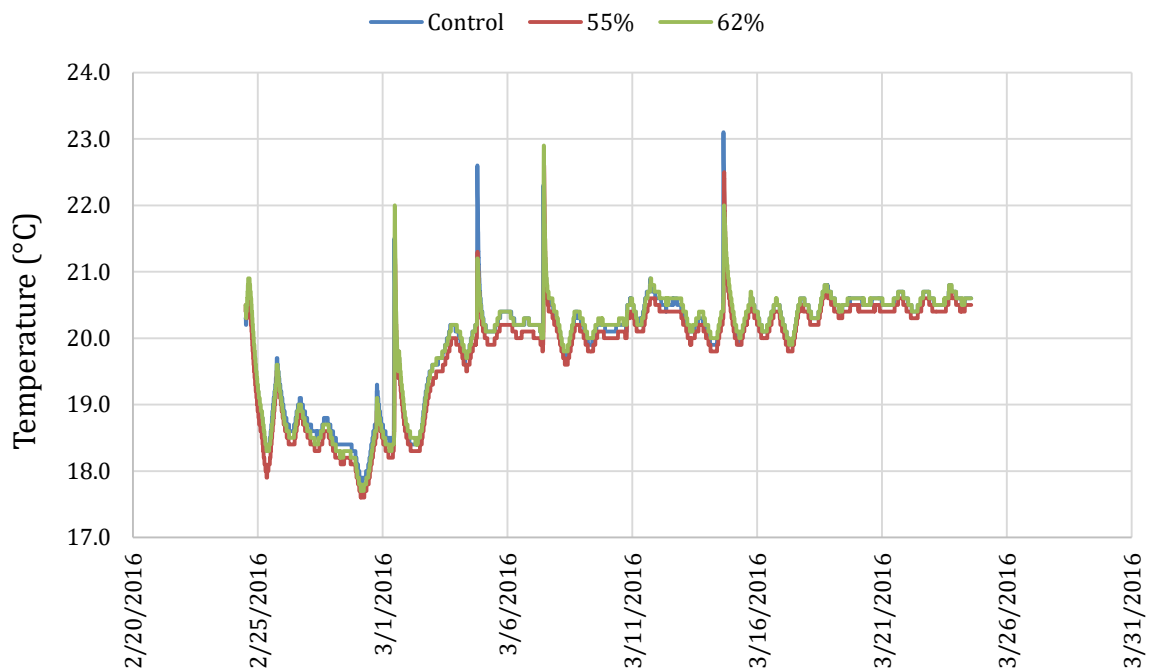


Figure 1. Temperature data for the various storage containers

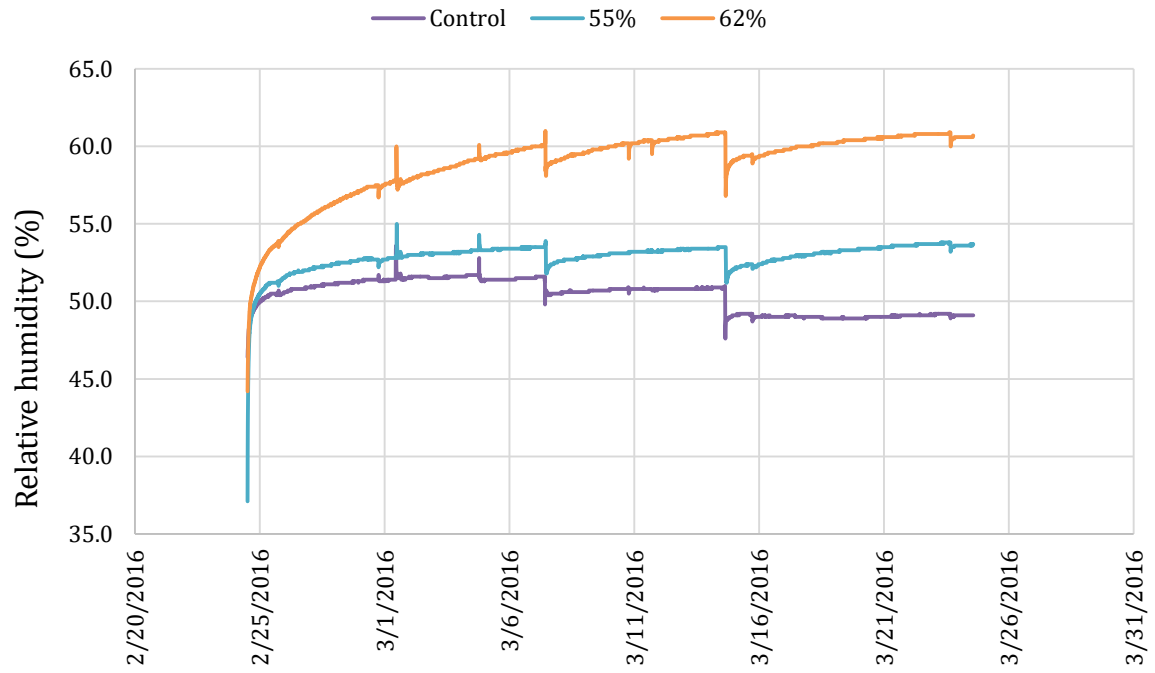


Figure 2. Relative humidity data for the various storage containers



3.2 Results for Loss on Drying

At measurement days, 500 mg of cannabis was dried in a vacuum oven until it reached a stable mass. This was performed in triplicate for each of the storage conditions. The loss in mass during this procedure is a measure for moisture content.

Figure 3 shows the average of the triplicate measurement as well as the 95% confidence interval (error bars) based upon the replicate data. Where the confidence intervals overlap, there is no significant difference. In those cases, the natural variability of the plant material would explain the difference.

The following observations can be made:

- All three storage conditions show a significant increase in loss on drying between the first and second data point. This indicates that the starting material was very dry and readily absorbed moisture during the first 6 days of storage.
- When looking at the last three measurement dates a significant difference can be observed for the moisture content of the materials. The cannabis stored in the control bottle has the least moisture and the 62% INTEGRA Boost has the most.

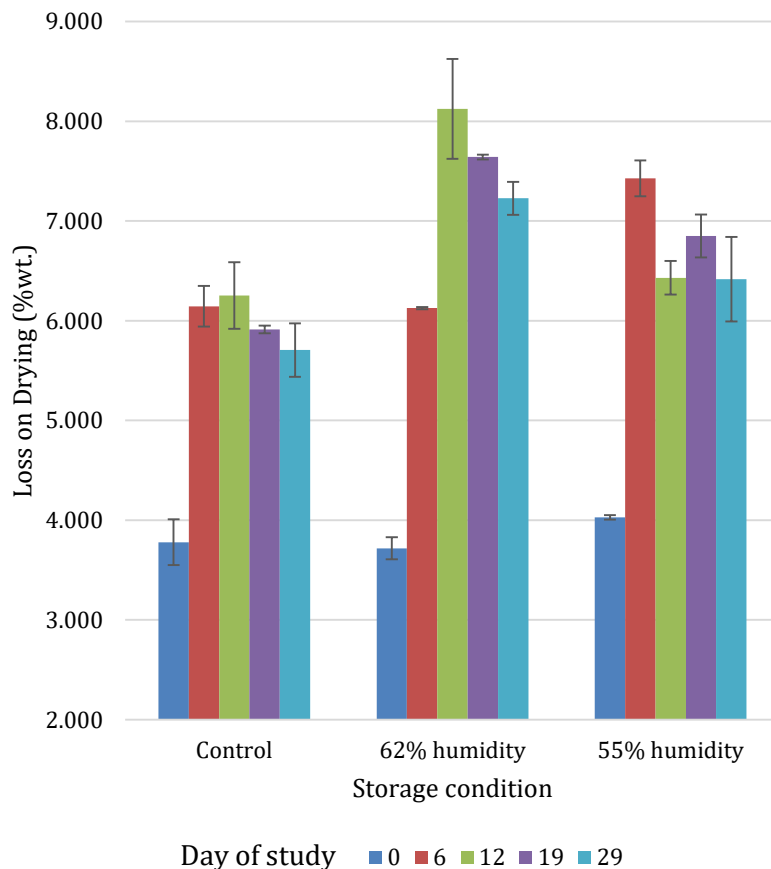


Figure 3. Data for loss on drying



3.3 Results for Cannabinoids

At every time point a triplicate measurement of cannabinoids was performed. The main cannabinoids present are THCA and THC. No CBN or CBD was found in any of the samples and for this reason they are not presented. Full data for all samples can be found in Appendix 2.

Figures 4 through 9 show the average result of the three replicates at each time point as well as the 95% confidence interval. The 95% confidence interval is calculated from the triplicate samples and is a measure of the natural variability of the plant matter. Where the error bars overlap, there is no statistical difference between the averages.

The following observations can be made:

- In all samples THCA was the main cannabinoid at approximately 17% by mass. All other cannabinoids were present at trace quantities (<0.4%).
- None of the samples had a quantifiable amount of CBN. CBN is the predominant degradation product of THC.
- The levels of all the cannabinoids remained stable during the 29 days of this experiment. There is no evidence to support degradation of the cannabinoids after 29 days of storage with frequent opening.

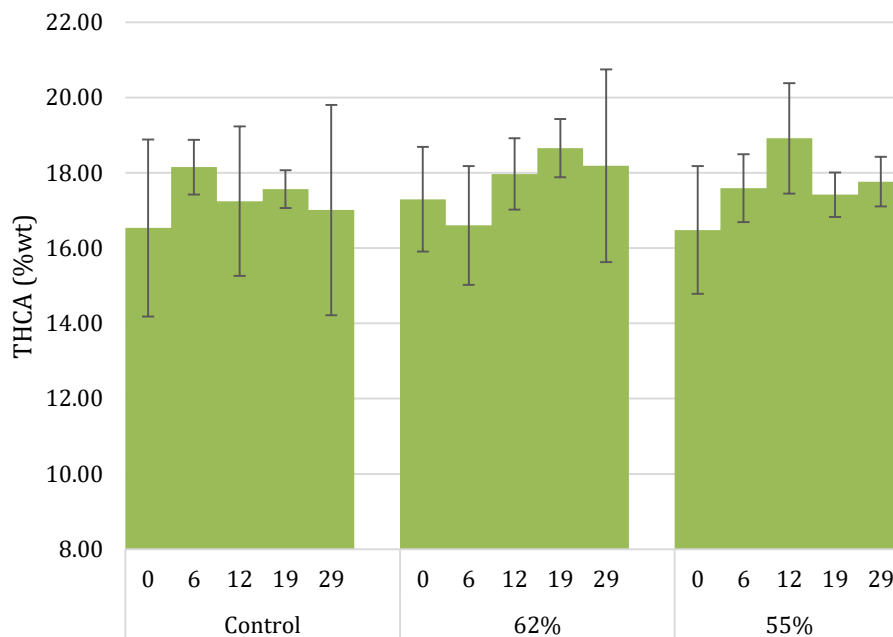


Figure 4. THCA results for the short term study

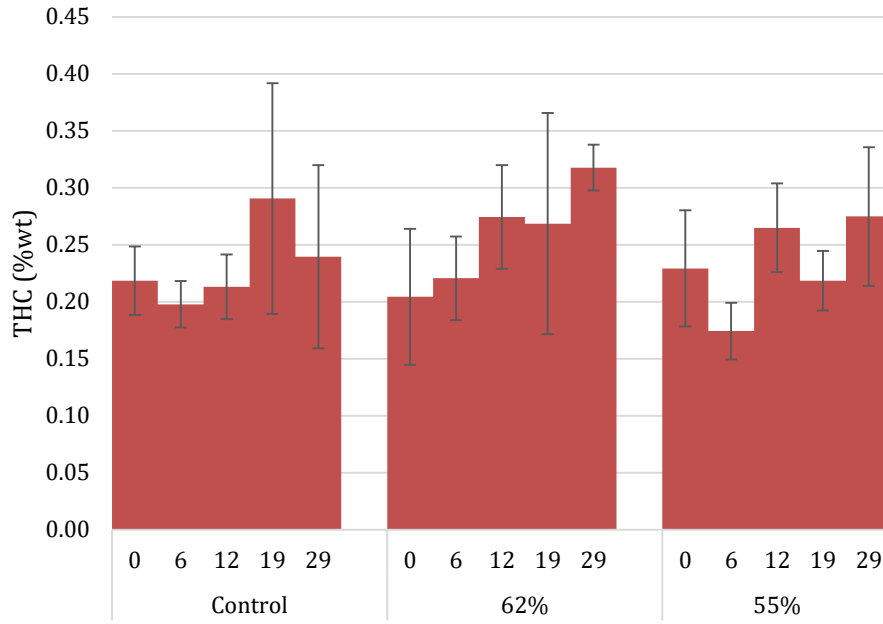


Figure 5. THC results for the short term study

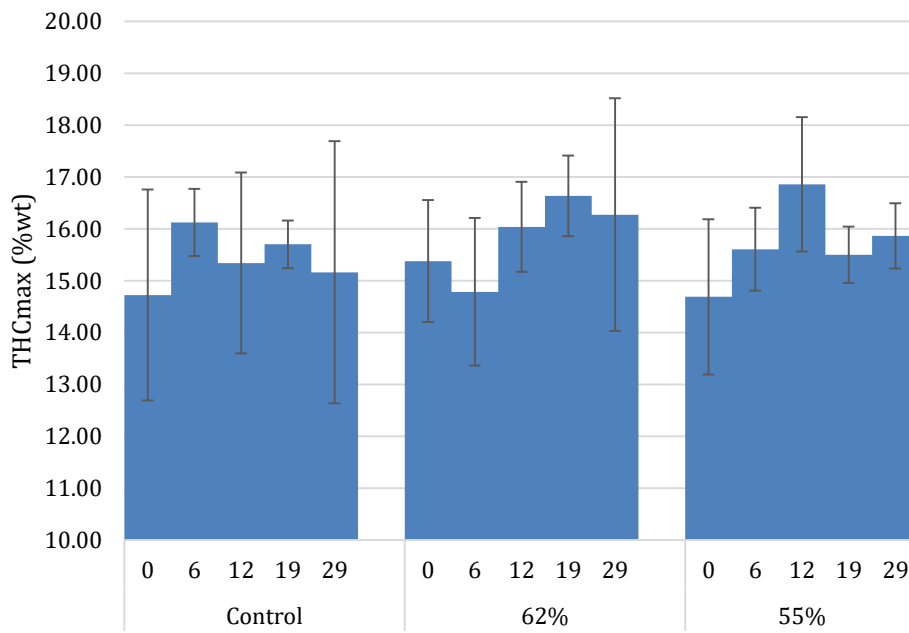


Figure 6. THCmax results for the short term study

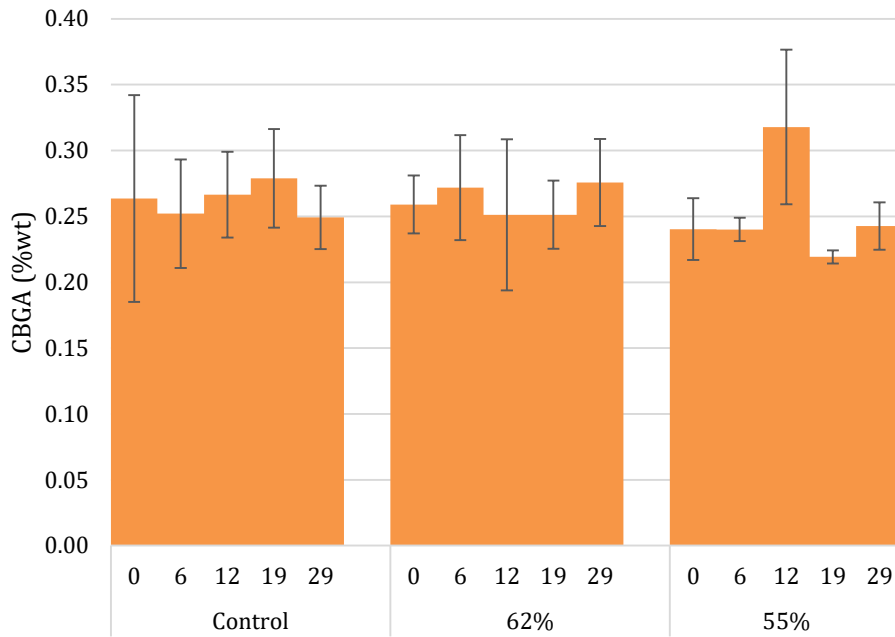


Figure 7. CBGA results for the short term study

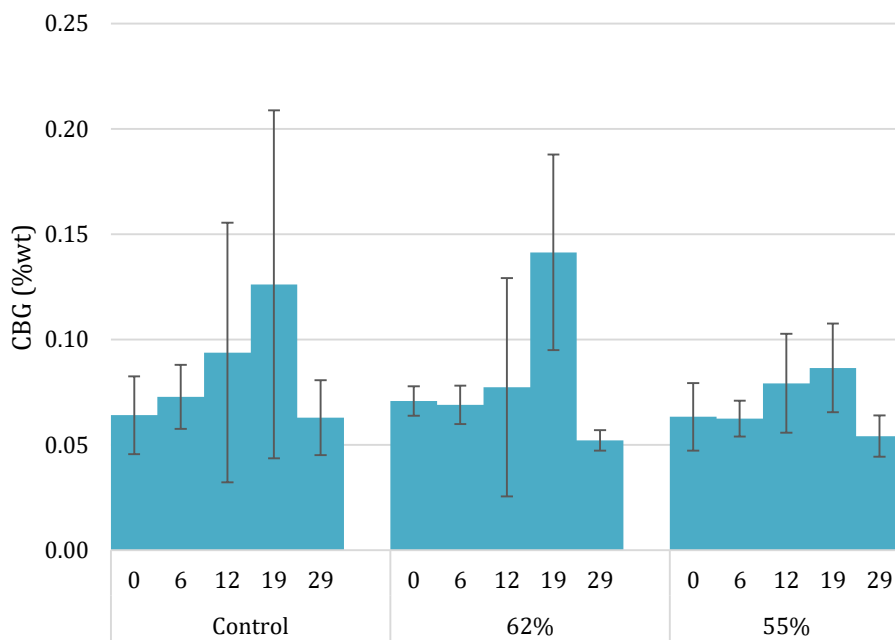


Figure 8. CBG results for the short term study

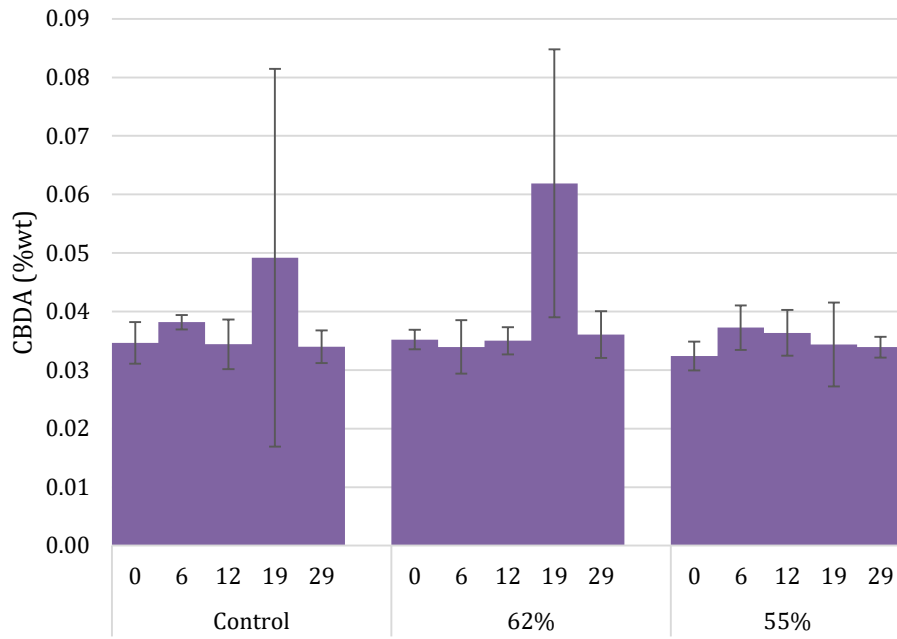


Figure 9. CBDA results for the short term study



3.4 Pictures of plant material at start and end date

Photos were taken of the cannabis in the storage container. The pictures at the start and the end of the experiment can be found in figure 10. No difference in appearance was noticed between the various samples and treatments.

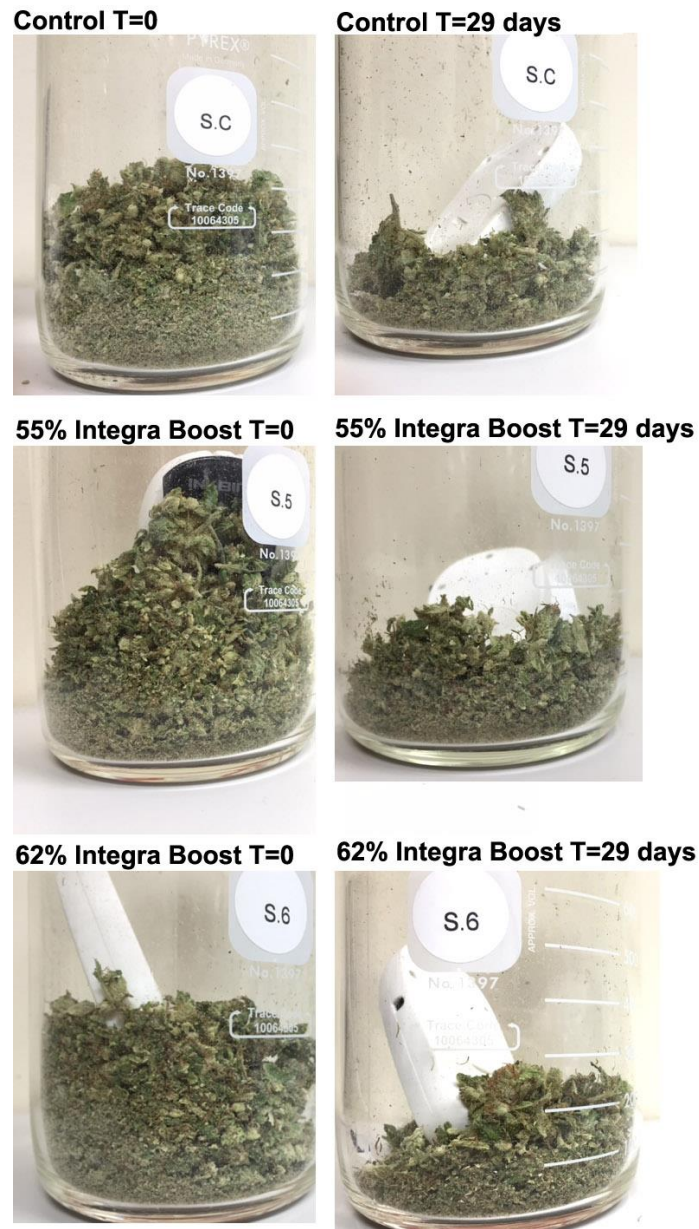


Figure 10. Cannabis in storage container at start and end of the short term experiment



4 Conclusion and Discussion

INTEGRA Boost packs are able to create stable relative humidity environments by adding and removing moisture as necessary, therefore offering 2-way humidity control. Cannabis stored without INTEGRA Boost lost a significant amount of moisture over time, but the cannabis stored in the presence of humidity packs was stable.

None of the investigated conditions showed degradation of the cannabinoids. For this reason it is not possible to conclude that the presence of INTEGRA Boost prevents cannabinoid degradation. We can however conclude that the presence of INTEGRA Boost does not cause the degradation of cannabinoids. It appears that THCA is quite stable and experiments need to be ran for a much longer period of time in order to detect degradation.



Appendix 1. Sample results for loss on drying

Condition	Day	Replicate	Wet Sample (g)	Dry Sample (g)	LOD (%)
Control	0	1	0.5023	0.4827	3.9120
Control	0	2	0.5056	0.4860	3.8804
Control	0	3	0.4990	0.4813	3.5449
62%	0	1	0.5065	0.4873	3.7904
62%	0	2	0.4892	0.4715	3.6061
62%	0	3	0.5042	0.4853	3.7582
55%	0	1	0.5033	0.4831	4.0153
55%	0	2	0.4969	0.4767	4.0514
55%	0	3	0.4954	0.4754	4.0213
Control	6	1	0.4930	0.4635	5.9938
Control	6	2	0.5032	0.4725	6.0970
Control	6	3	0.4975	0.4659	6.3459
62%	6	1	0.5032	0.4723	6.1387
62%	6	2	0.4908	0.4608	6.1222
62%	6	3	0.5097	0.4785	6.1216
55%	6	1	0.4960	0.4601	7.2460
55%	6	2	0.5013	0.4635	7.5363
55%	6	3	0.5094	0.4712	7.5005
Control	12	1	0.5091	0.4789	5.9338
Control	12	2	0.5050	0.4731	6.3108
Control	12	3	0.4931	0.4610	6.5159
62%	12	1	0.4927	0.4552	7.6191
62%	12	2	0.4948	0.4530	8.4485
62%	12	3	0.5063	0.4642	8.3037
55%	12	1	0.5028	0.4713	6.2627
55%	12	2	0.4961	0.4640	6.4822
55%	12	3	0.5077	0.4745	6.5491



Condition	Day	Replicate	Wet Sample (g)	Dry Sample (g)	LOD (%)
Control	19	1	0.4883	0.4595	5.9022
Control	19	2	0.4940	0.4646	5.9498
Control	19	3	0.4987	0.4693	5.8859
62%	19	1	0.4922	0.4545	7.6570
62%	19	2	0.4952	0.4573	7.6515
62%	19	3	0.4971	0.4593	7.6176
55%	19	1	0.4941	0.4609	6.7268
55%	19	2	0.5026	0.4686	6.7554
55%	19	3	0.5076	0.4717	7.0707
Control	29	1	0.5016	0.4733	5.6344
Control	29	2	0.5036	0.4735	5.9712
Control	29	3	0.4914	0.4643	5.5145
62%	29	1	0.4872	0.4521	7.1948
62%	29	2	0.4998	0.4643	7.1014
62%	29	3	0.4997	0.4628	7.3864
55%	29	1	0.5123	0.4816	5.9867
55%	29	2	0.5125	0.4784	6.6551
55%	29	3	0.4890	0.4567	6.6090

Sample type	Day	Average (% LOD)	StdevA	95% conf interval (n=3)
Control	0	3.779	0.203	0.230
	6	6.146	0.181	0.205
	12	6.253	0.295	0.334
	19	5.913	0.033	0.038
	29	5.707	0.237	0.268
62% humidity	0	3.718	0.098	0.111
	6	6.127	0.010	0.011
	12	8.124	0.443	0.501
	19	7.642	0.021	0.024
	29	7.228	0.145	0.164
55% humidity	0	4.029	0.019	0.022
	6	7.428	0.158	0.179
	12	6.431	0.150	0.170
	19	6.851	0.191	0.216
	29	6.417	0.373	0.422



Appendix 2. Sample results for Cannabinoids

The following table contains the individual sample results of the replicates. Data for CBN, CBD and CBC not shown as they were not detected in any sample.

Sample	Day	Replicate	THC max	THC	THCA	CBDA	CBG	CBGA
Control	0	1	16.58	0.19	18.68	0.04	0.08	0.32
Control	0	2	14.60	0.23	16.39	0.03	0.06	0.18
Control	0	3	12.99	0.24	14.53	0.03	0.05	0.29
62%	0	1	15.13	0.17	17.05	0.03	0.06	0.27
62%	0	2	14.49	0.27	16.21	0.03	0.08	0.24
62%	0	3	16.52	0.17	18.63	0.04	0.07	0.27
55%	0	1	15.77	0.20	17.74	0.03	0.07	0.22
55%	0	2	15.08	0.28	16.87	0.03	0.07	0.26
55%	0	3	13.22	0.21	14.83	0.03	0.05	0.24
Control	6	1	15.84	0.18	17.86	0.04	0.06	0.22
Control	6	2	16.78	0.21	18.89	0.04	0.07	0.29
Control	6	3	15.74	0.21	17.71	0.04	0.09	0.25
62%	6	1	13.34	0.18	14.99	0.03	0.06	0.23
62%	6	2	15.49	0.24	17.39	0.04	0.08	0.28
62%	6	3	15.53	0.24	17.43	0.04	0.07	0.30
55%	6	1	15.30	0.19	17.23	0.03	0.07	0.24
55%	6	2	15.10	0.15	17.04	0.04	0.05	0.25
55%	6	3	16.41	0.18	18.51	0.04	0.07	0.24
Control	12	1	15.70	0.24	17.62	0.03	0.10	0.30
Control	12	2	16.67	0.19	18.78	0.04	0.09	0.24
Control	12	3	13.65	0.20	15.33	0.03	ND	0.27
62%	12	1	16.06	0.30	17.97	0.03	ND	0.26
62%	12	2	16.80	0.30	18.81	0.04	0.09	0.29
62%	12	3	15.26	0.23	17.13	0.04	0.07	0.20
55%	12	1	16.34	0.30	18.29	0.03	0.06	0.37
55%	12	2	16.06	0.23	18.05	0.03	0.07	0.31
55%	12	3	18.17	0.27	20.41	0.04	0.10	0.27
Control	19	1	15.95	0.39	17.73	ND	ND	0.29
Control	19	2	15.93	0.22	17.91	0.05	0.13	0.30
Control	19	3	15.23	0.26	17.07	0.05	0.12	0.24
62%	19	1	16.17	0.22	18.19	0.05	0.13	0.26
62%	19	2	17.43	0.37	19.44	0.05	0.11	0.22
62%	19	3	16.31	0.22	18.34	0.09	0.19	0.27
55%	19	1	15.06	0.20	16.93	0.03	0.07	0.22
55%	19	2	15.44	0.21	17.36	0.03	0.08	0.22
55%	19	3	16.01	0.24	17.97	0.04	0.11	0.22



Sample	Day	Replicate	THC max	THC	THCA	CBDA	CBG	CBGA
Control	29	1	12.59	0.17	14.17	0.03	0.05	0.23
Control	29	2	16.61	0.31	18.58	0.04	0.08	0.27
Control	29	3	16.28	0.25	18.28	0.03	0.06	0.25
62%	29	1	14.52	0.33	16.17	0.03	0.05	0.25
62%	29	2	15.87	0.30	17.76	0.03	0.05	0.27
62%	29	3	18.43	0.32	20.63	0.04	0.06	0.31
55%	29	1	15.22	0.22	17.09	0.03	0.05	0.23
55%	29	2	16.19	0.27	18.14	0.03	0.06	0.26
55%	29	3	16.18	0.33	18.07	0.04	0.06	0.24

The following table shows the average of the replicates.

Average content by weight (%) (n=3)							
		THC max	THC	THCA	CBDA	CBG	CBGA
Control	0	14.72	0.22	16.53	0.03	0.06	0.26
	6	16.12	0.20	18.15	0.04	0.07	0.25
	12	15.34	0.21	17.24	0.03	0.09	0.27
	19	15.70	0.29	17.57	0.05	0.13	0.28
	29	15.16	0.24	17.01	0.03	0.06	0.25
62%	0	15.38	0.20	17.30	0.04	0.07	0.26
	6	14.79	0.22	16.60	0.03	0.07	0.27
	12	16.04	0.27	17.97	0.03	0.08	0.25
	19	16.64	0.27	18.66	0.06	0.14	0.25
	29	16.27	0.32	18.19	0.04	0.05	0.28
55%	0	14.69	0.23	16.48	0.03	0.06	0.24
	6	15.61	0.17	17.59	0.04	0.06	0.24
	12	16.86	0.26	18.92	0.04	0.08	0.32
	19	15.50	0.22	17.42	0.03	0.09	0.22
	29	15.86	0.27	17.77	0.03	0.05	0.24



The following tables shows the relative standard deviation of the replicate measurements.

StdevA (n=3)							
Sample type	Day	THC max	THC	THCA	CBDA	CBG	CBGA
Control	0	1.80	0.03	2.08	0.00	0.02	0.07
	6	0.57	0.02	0.64	0.00	0.01	0.04
	12	1.54	0.03	1.76	0.00	0.05	0.03
	19	0.41	0.09	0.44	0.03	0.07	0.03
	29	2.23	0.07	2.47	0.00	0.02	0.02
62%	0	1.04	0.05	1.23	0.00	0.01	0.02
	6	1.26	0.03	1.40	0.00	0.01	0.04
	12	0.77	0.04	0.84	0.00	0.05	0.05
	19	0.69	0.09	0.69	0.02	0.04	0.02
	29	1.98	0.02	2.26	0.00	0.00	0.03
55%	0	1.32	0.05	1.50	0.00	0.01	0.02
	6	0.71	0.02	0.80	0.00	0.01	0.01
	12	1.14	0.03	1.30	0.00	0.02	0.05
	19	0.48	0.02	0.52	0.01	0.02	0.00
	29	0.56	0.05	0.58	0.00	0.01	0.02

The following table shows the 95% confidence interval calculated from the standard deviation and the number of replicates.

95% confidence interval (n=3)							
Sample type	Day	THC max	THC	THCA	CBDA	CBG	CBGA
Control	0	2.03	0.03	2.35	0.00	0.02	0.08
	6	0.65	0.02	0.73	0.00	0.02	0.04
	12	1.74	0.03	1.99	0.00	0.06	0.03
	19	0.46	0.10	0.50	0.03	0.08	0.04
	29	2.53	0.08	2.79	0.00	0.02	0.02
62%	0	1.17	0.06	1.39	0.00	0.01	0.02
	6	1.42	0.04	1.58	0.00	0.01	0.04
	12	0.87	0.05	0.95	0.00	0.05	0.06
	19	0.78	0.10	0.78	0.02	0.05	0.03
	29	2.24	0.02	2.56	0.00	0.00	0.03
55%	0	1.49	0.05	1.69	0.00	0.02	0.02
	6	0.80	0.02	0.90	0.00	0.01	0.01
	12	1.30	0.04	1.47	0.00	0.02	0.06
	19	0.54	0.03	0.59	0.01	0.02	0.00
	29	0.63	0.06	0.66	0.00	0.01	0.02