St. Croix Sensory, Inc.

Fecal Malodor Reduction Efficacy Testing

Final Report – 17 November 2017

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Executive Summary

St. Croix Sensory, Inc. was contacted by Washroom Wizard Ltd to conduct a study to document the performance of the Ecobreeze at reducing fecal malodors in a controlled 4-hour test. All testing was conducted following ASTM International standards and guidelines including E1593-13, *Standard Practice for Assessing the Efficacy of Air Care Products in Reducing Sensorily Perceived Indoor Air Malodor Intensity* and principles of Consumer Specialty Products Association (CSPA) Standard, *Deodorization Efficacy Assessment – A Screening Method*. Testing was conducted in St. Croix Sensory's sensory testing laboratory utilizing eight stainless steel chambers of dimensions 1.2x1.2x1.5m (2.16m^3, 80ft^3) with 0.5 air exchanges per hour exhaust.

For this study, fecal malodor reduction effectiveness was tested with the Ecobreeze device using either a carbon filter alone or in combination with fragrance. Twenty assessors, trained and experienced at product and material sensory testing, evaluated test chambers at time zero, 30-minutes, 1-hour, 2-hours, 3-hours, and 4-hours. The assessors compared the test chambers to a reference malodor chamber and reported the degree of difference in malodor level utilizing magnitude estimation (ASTM E1697). They also reported the overall odor intensity (ASTM E544) and hedonic tone, and completed odor character profiles of the test chambers.

To capture differences in performance, the Ecobreeze devices were challenged with a fecal malodor at a strong intensity level, beyond that expected in normal restroom environments, which remained in the test chambers during the entire 4-hour test. The Ecobreeze device with both a carbon filter and fragrance had the best performance overall with malodor reduction scores as low as 11.4 within 30-minutes (89% reduction in the strong fecal malodor) and between 1.7 and 3.1 (more than 95% reduction) for the remainder of the test. These results were statistically different from the malodor control and the devices with carbon filters alone at all time points when the devices were running. The device with the carbon filter and fragrance also had the most change in odor characters and the most pleasant hedonic tone values. The Ecobreeze devices with carbon filters alone (no fragrance) also provided a significant reduction in the strong fecal malodor (10.0 – 23.4), a decrease in the sulfur (fecal) character, and an improvement in the hedonic tone when compared to the malodor control.

Introduction

St. Croix Sensory, Inc. is a sensory evaluation and training center located in Stillwater, Minnesota specializing in odor evaluation of odorous air, materials, and consumer products. Washroom Wizard Ltd contracted St. Croix Sensory to conduct a study to document the performance of the Ecobreeze device at reducing fecal malodors in a controlled 4-hour experiment following ASTM International E1593-13, *Standard Practice for Assessing the Efficacy of Air Care Products in Reducing Sensorily Perceived Indoor Air Malodor Intensity* and principles of Consumer Specialty Products Association (CSPA) method, *Deodorization Efficacy Assessment – A Screening Method*.

Methodology

Test Procedures

Washroom Wizard Ltd provided St. Croix Sensory with the Ecobreeze devices, carbon filters, and Tropical Heaven fragrance.

Stainless steel test chambers at St. Croix Sensory were utilized for this testing (see Figure 1). Each identical chamber is 1.2x1.2x1.5m (2.16m^3, 80ft^3) with a sniffing port, various access test ports, an exhaust ventilation system, and an access hatch. The chambers operated with 0.5 air exchanges per hour exhaust.

Figure 1. Four of the stainless steel chambers utilized for malodor reduction efficacy testing at St. Croix Sensory, Inc. The chambers are all identical 1.2x1.2x1.5m boxes with a sniffing port in the center on the front, multiple testing ports also on the front, two access and exhaust ports on the top, and an access hatch on the front. An exhaust system on top of the chambers is used to purge the chambers at the end of each test.

A reference chamber was prepared with the fecal malodor. Additional chambers were prepared with malodor alone (control) or malodor plus the Ecobreeze device with either a carbon filter or a carbon filter and fragrance. The following was the chamber design for the test:

Chamber 1: Malodor Reference
Chamber 2: Malodor Control
Chamber 3: Malodor + Device with Carbon Filter A
Chamber 4: Malodor + Device with Carbon Filter B (replicate)
Chamber 5: Malodor + Device with Carbon Filter + Fragrance

Fecal Malodor

Synthetic bathroom malodor used for this testing is a recipe originally published by the U.S. Government Services Administration as Specification FA 200-5, commonly referred to as "GSA Bathroom". This GSA bathroom malodor was diluted to 5% dipropylene glycol solution for this test. Approximately 2.5 grams of the malodor solution was pipetted onto 5-cm x 5-cm cellulose pads. Each pad was placed in an aluminum weigh boat and set, uncovered, in the center of each test chamber two hours before the test start time. The malodor remained in the chambers for the entire test period.

Note this malodor source is intended to create a strong intensity fecal malodor. The level is stronger than expected in a normal bathroom in order to allow differentiation in product trials (i.e. carbon only vs carbon with fragrance).

Product Application

The Ecobreeze devices, set to run constantly on a medium fan speed, were hung in the center of a side wall in their assigned test chambers immediately upon completion of the odor evaluations at time zero. The devices were plugged in and it was determined that the green light came on before closing the chamber access hatches. The chamber access hatches were also opened on the reference and malodor control chambers for a similar time (20-seconds) for consistency. Assessors evaluated the chambers 30 minutes after all devices were placed in the test chambers and again at 1-hour, 2-hours, 3-hours, and 4-hours.

Odor Evaluations

This odor study was conducted following ASTM International E1593-13, *Standard Practice for Assessing the Efficacy of Air Care Products in Reducing Sensorily Perceived Indoor Air Malodor Intensity* along with basic principles of CSPA, *Deodorization Efficacy Assessment – A Screening Method.* The ASTM Standard is a general practice, which allows for customizing procedures to the specific product being tested. The CSPA standard provides a more detailed procedure based on the ASTM method, however, specific parameters are still determined based on the goals of the testing.

All test chambers were evaluated by a panel of twenty assessors who determined the level of malodor relative to the reference chamber, the overall odor intensity of the chamber, and

odor characterization parameters. All assessors are trained and experienced in the techniques and procedures of odor evaluation. Assessors are not given any information about the odor samples being presented including the treatment type or properties.

The chambers were presented to assessors following a Latin Square design. This design alternates the order of sample presentation so chambers are observed in varying sequence. Assessors pause at least 30-seconds between the evaluation of the reference chamber and any of the test chambers.

Malodor Intensity

Malodor intensity was evaluated following a procedure called "Magnitude Estimation." This method is detailed in ASTM International E1697-05, *Standard Test Method for Unipolar Magnitude Estimation of Sensory Attributes*.

Magnitude estimation is a procedure where the intensity of one odor sample is compared to another sample. For example, the assessor would be presented odor sample A. The assessor would give the intensity of this odor an arbitrary value such as "100." The assessor would then be presented with sample B, and they would provide a rating based on sample A. Therefore, if sample B were perceived as half as intense as sample A, the assessor would give sample B an intensity of "50." This method is difficult to compare across many odors. It is best suited for comparing similar odors.

For this study, the assessors evaluated a reference malodor only chamber and were instructed that this reference sample had a malodor intensity of "100." The assessors then evaluated the other samples based on this reference. The assessors had previously been trained to ignore other odors present, such as the fragrance, and only evaluate the intensity of the malodor present. If they thought a specific odor sample had a malodor intensity that was half as intense as the reference, then they gave the sample a value of "50," regardless of the intensity of other odors present.

Whole Odor Intensity

Whole odor intensity evaluations (suprathreshold intensity) utilize n-butanol as a reference odorant following ASTM International E544-10, *Standard Practice for Referencing Suprathreshold Odor Intensity*. An eight (8) level intensity scale is utilized and is presented to the assessors with the IITRI Dynamic Dilution Binary Olfactometer ("Butanol Wheel").

The eight levels of the intensity scale are:

1. 12 ppm n-butanol
2. 24 ppm n-butanol
3. 48 ppm n-butanol
4. 97 ppm n-butanol
5. 194 ppm n-butanol
6. 388 ppm n-butanol
7. 775 ppm n-butanol
8. 1,550 ppm n-butanol

The assessors assess the odor from the test chamber and compared this presentation to the 8-point n-butanol scale. The odor intensity is reported as the n-butanol concentration equivalent in parts per million.

For this type of testing, whole odor intensity can help to confirm the performance of an air care product. A reduction in malodor without any fragrance should coincide with a reduction in the whole odor intensity. However, if a fragrance is introduced from the air care product, the odor intensity may increase. It can then help to review odor character profiling results in order to understand the complete picture.

Odor Characterization

Descriptive analysis is a sensory science term used to describe the action of a panel of assessors describing attributes about a product or sample (qualitative) and scaling the intensity of these attributes (quantitative).

Odor character, often called odor quality, is defined using reference vocabulary. Standard practice is to provide assessors with a standard list of descriptor terms. One example of such lists is the ASTM International publication D-61, *Atlas of Odor Character Profiles*. For this testing, the following odor character descriptors were utilized:

When an odor descriptor is assigned to an odor, they are rated by assessors for relative intensity on a 0 to 5, faint to strong, scale (0=not present). The odor testing descriptor data are then plotted on a spider plot (radar plot) with the distance along each axis representing the 0-5 scale for each of the categories. The plot creates a pattern that can be readily compared to spider plots for other samples. Specific odor descriptors are also presented in a histogram where each reported descriptor is listed with the percent of reporting assessors.

Hedonic Tone

Hedonic Tone is a subjective parameter of odor evaluations. Assessors rate the pleasantness/unpleasantness of the odor sample based on a scale of –10 (most unpleasant odor they have experienced) to +10 (most pleasant odor they have experienced). A zero represents a neutral odor where the assessor has no opinion about the odor being either pleasant or unpleasant. More variability will exist in hedonic tone results between tests than for other odor parameters since the results depend directly on the specific assessors making the observations and their personal experiences with odors in their lifetime.

Furthermore, the hedonic tone values provided by the trained assessors from this project should not be considered to represent the opinions of the general population, they should simply be used for comparing the change in unpleasantness of the malodor in the test chambers.

Results and Discussion

Fecal Malodor Results

Table 1 provides a listing of the magnitude estimation malodor ratings at time zero, 30-minutes, 1-hour, 2-hours, 3-hours, and 4-hours for all products. An analysis of variance (ANOVA) was run to compare performance along with a post-hoc Fisher's Least Significant Difference (LSD) test. Superscripts and color are used to display statistical significance. Figure 2 displays these results in graphical form. The magnitude estimation value can be viewed as a percent perceived reduction relative to the malodor level at the given time period, so a value of 25 would represent a perceived malodor level approximately 75% less than the malodor chamber at that time.

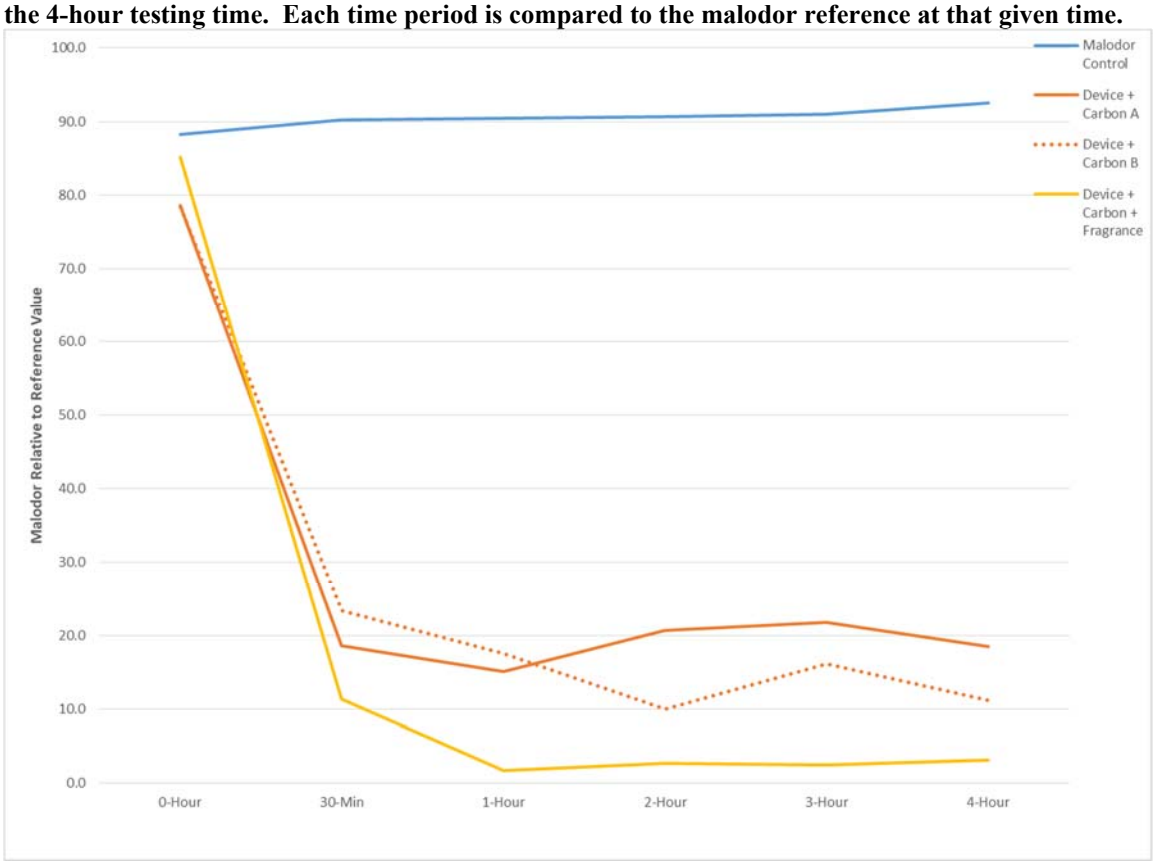
At time zero with no Ecobreeze devices running, the malodor scores ranged from 78.3 to 88.3 and were not significantly different. Once the devices were started, the Ecobreeze device with both a carbon filter and fragrance had the lowest malodor scores across all time points, with scores ranging from 1.7 at 1-hour to 11.4 at 30-minutes. The malodor scores for the replicates of a device with a carbon filter only ranged from 10.0 at 2-hours to 23.4 at 30-minutes and were all significantly lower than the malodor control chamber.

Table 1. Average assessor ratings of perceived malodor compared to reference chamber (100) for products tested with fecal malodor. Each time period was compared to malodor reference at that time.

	0-hour	*30-Min*	*1-hour*	*2-hour*	*3-hour*	*4-hour*
Malodor Control	88.3[a]	90.2[a]	90.5[a]	90.7[a]	91.0[a]	92.5[a]
Carbon A	78.6[a]	18.6[b]	15.1[b]	20.6[b]	21.8[b]	18.5[b]
Carbon B	78.3[a]	23.4[bc]	17.5[b]	10.0[c]	16.1[b]	11.2[bc]
Carbon + Fragrance	85.1[a]	11.4[c]	1.7[c]	2.7[d]	2.4[c]	3.1[c]

[abcd] **the same letter superscript and color coding within a column are not significantly different as determined by a Fisher's least significant difference (LSD) test.**

Figure 2. Fecal malodor reduction from all products based on magnitude estimation evaluation over the 4-hour testing time. Each time period is compared to the malodor reference at that given time.



Whole Odor Intensity Results

Table 2 provides the whole odor intensity ratings at time zero, 30-minutes, 1-hour, 2-hours, 3-hours, and 4-hours for all products. An analysis of variance (ANOVA) was run to compare performance along with a post-hoc Fisher's Least Significant Difference (LSD) test. Superscripts and color are used to display statistical significance. Figure 3 provides a graphical summary of the whole odor intensity evaluations over the 4-hour testing time. Figure 3 displays these results in graphical form.

At time zero with no Ecobreeze devices running, the overall intensity scores ranged from 70.3 to 114.2 ppm n-butanol and were not significantly different. The intensity scores

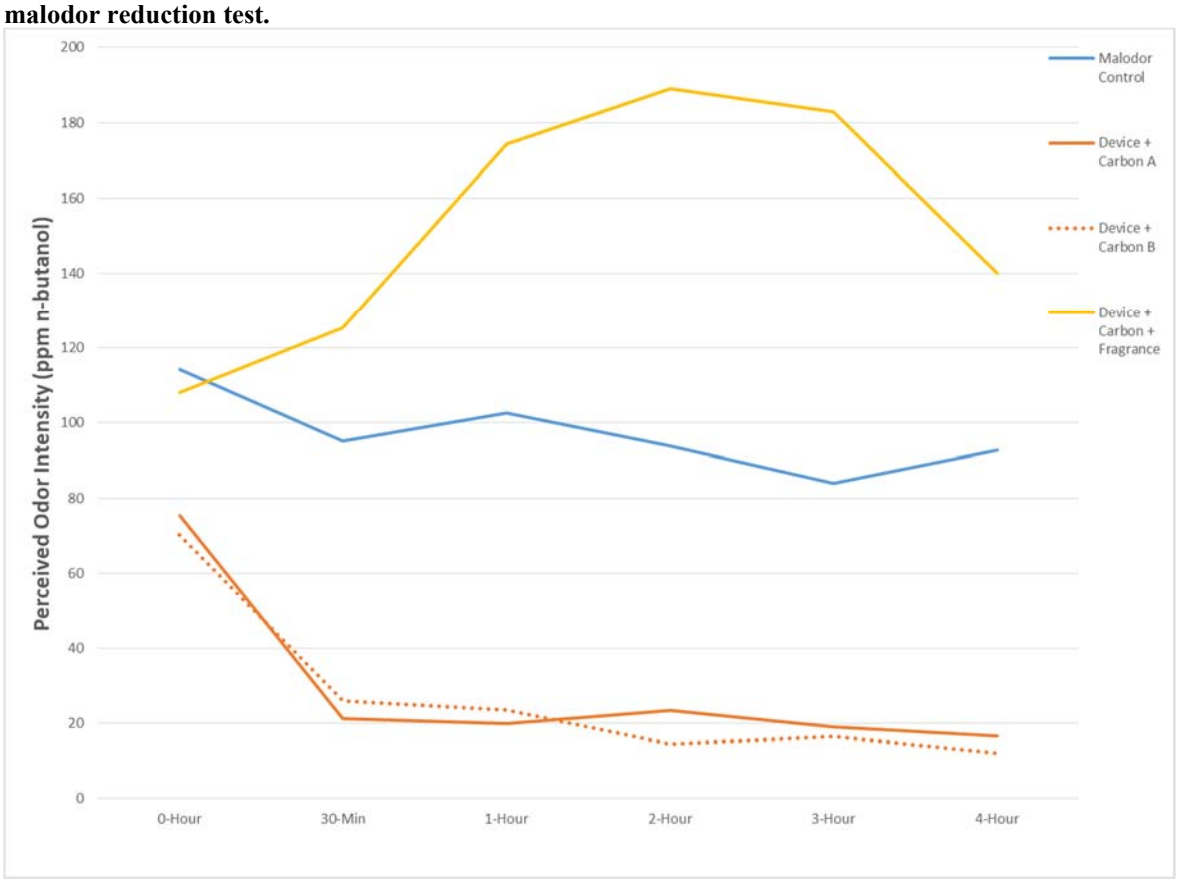
ranged from 83.9 to 102.6 ppm n-butanol for the malodor control and 125.4 to 189.1 for the Ecobreeze device with both a carbon filter and fragrance. These scores were not significantly different at any time point with the exception of 3-hours. The scores for the replicate carbon only chambers were significantly lower than both the malodor control and the device with a carbon filter and fragrance at all time points.

Table 2. Average perceived whole odor intensity of chamber odors.

	0-hour	*30-Min*	*1-hour*	*2-hour*	*3-hour*	*4-hour*
Malodor Control	114.2[a]	95.2[a]	102.6[a]	93.9[a]	83.9[b]	92.7[a]
Carbon A	75.4[a]	21.1[b]	19.9[b]	23.5[b]	19.0[c]	16.6[b]
Carbon B	70.3[a]	26.0[b]	23.6[b]	14.6[b]	16.6[c]	12.1[b]
Carbon + Fragrance	108.0[a]	125.4[a]	174.4[a]	189.1[a]	183.0[a]	140.0[a]

[abc] **the same letter superscript and color coding within a column are not significantly different as determined by a Fisher's least significant difference (LSD) test.**

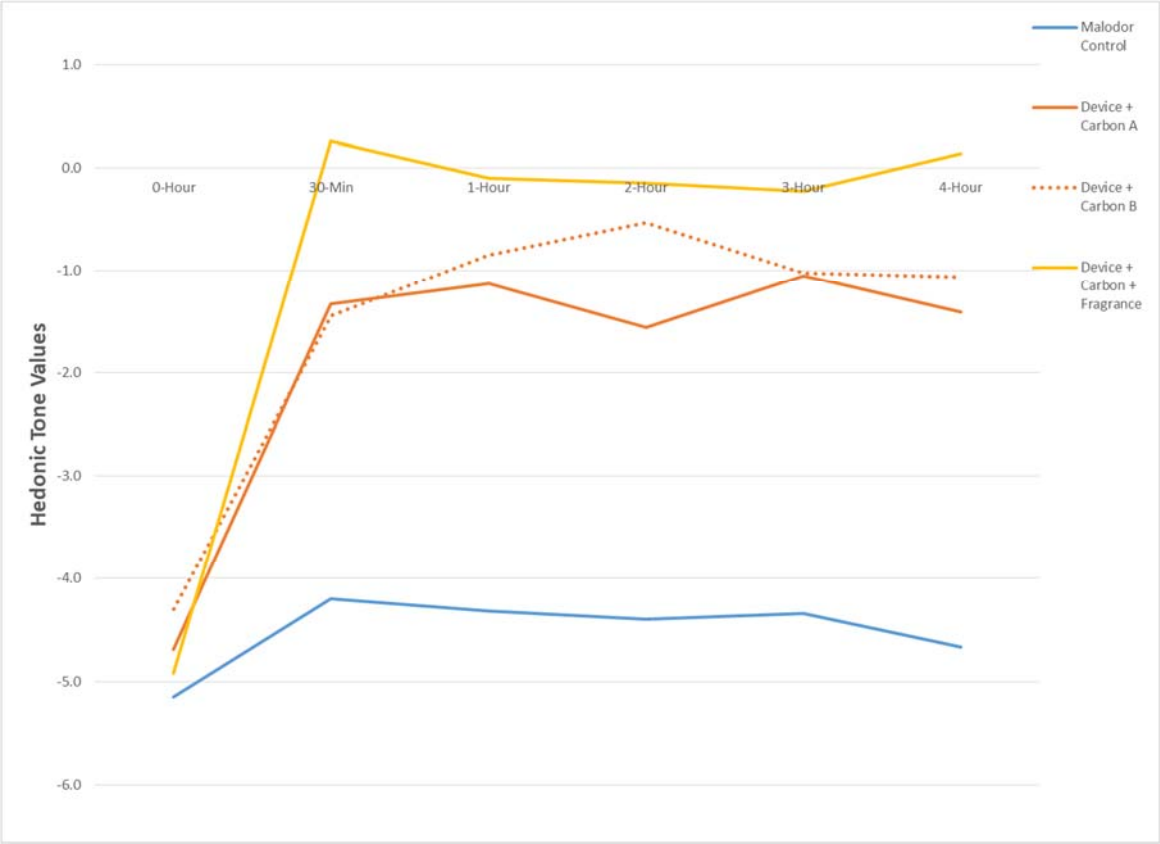
Figure 3. Perceived whole odor intensity (ppm n-butanol) of test chambers during the 4-hour fecal malodor reduction test.



Hedonic Tone Results

Figure 4 summarizes the hedonic tone results associated with the fecal malodor evaluations with all products. The hedonic tone scores ranged from +0.3 to -5.2 during the 4-hour test. The Ecobreeze device with both a carbon filter and fragrance had the most neutral hedonic tone values between 30-minutes and 4-hours (+0.3 to -0.2).

Figure 4. Hedonic tone values reported for the test chambers during the 4-hour fecal malodor reduction test.



Odor Characterization Results

Figures 5 through 10 provide summaries of the odor characterization of the fecal malodor reduction test with all products at time zero, 30-minutes, 1-hour, 2-hours, 3-hours, and 4-hours. The graphics display the mean value of the reported relative strength for the two replicates of the Ecobreeze device with a carbon filter only.

Sulfur (including fecal) was the predominant character descriptor for all chambers at time zero (with no devices running), and for the malodor control at all times. Sulfur (fecal) was still present but reduced for the Ecobreeze devices with carbon filters only between 30 minutes and 4-hours. Fruit became the predominant character descriptor for the Ecobreeze device with both a carbon filter and fragrance during the same time points.

Figure 5. Odor character profile at <u>time zero</u> for all samples during fecal malodor reduction test. The results of the Ecobreeze device with carbon are the means of two replicate samples.

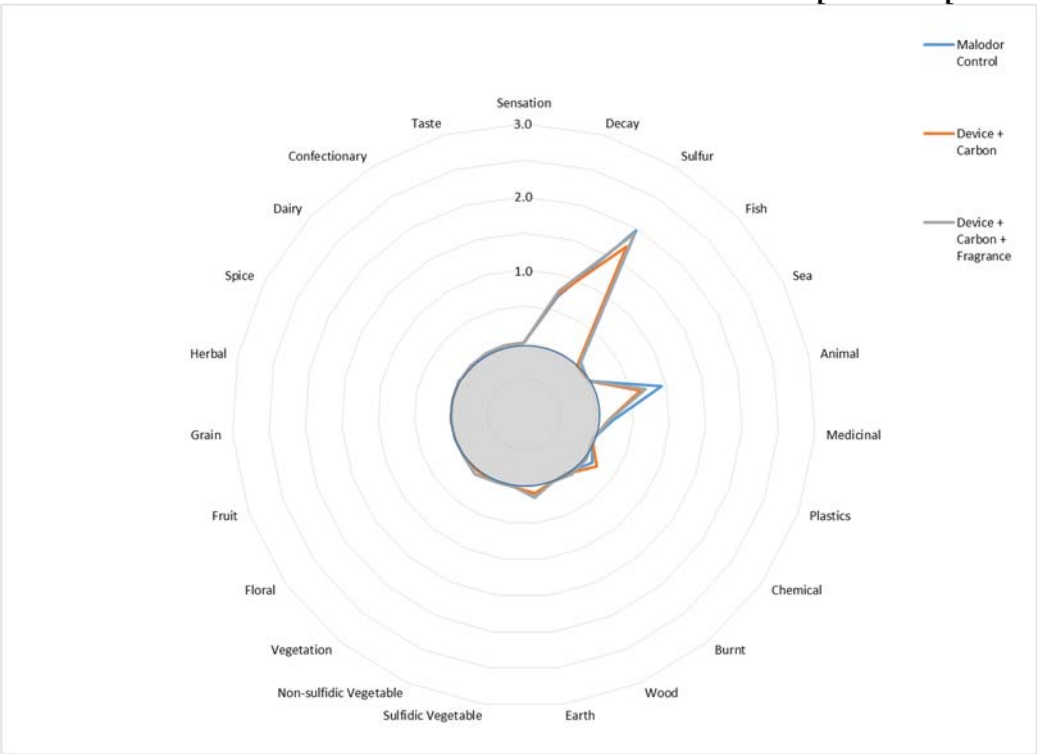


Figure 6. Odor character profile at <u>30-minutes</u> for all samples during fecal malodor reduction test. The results of the Ecobreeze device with carbon are the means of two replicate samples.

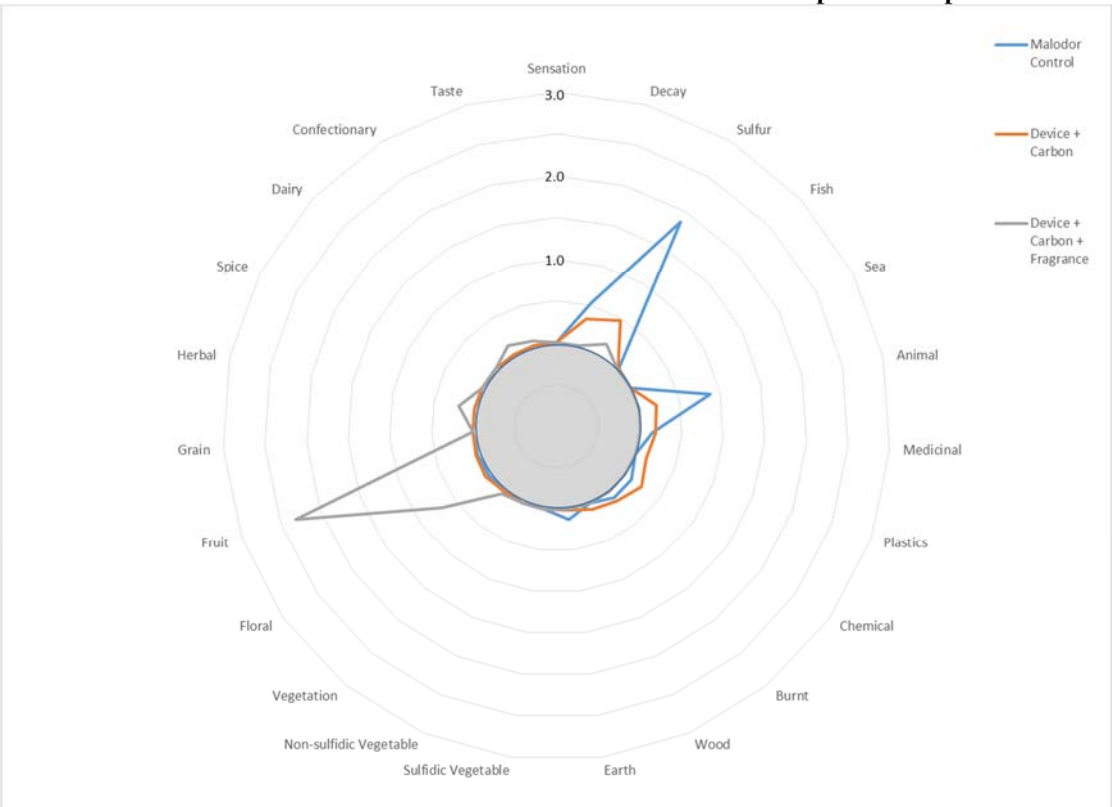


Figure 7. Odor character profile at <u>1-hours</u> for all samples during fecal malodor reduction test. The results of the Ecobreeze device with carbon are the means of two replicate samples.

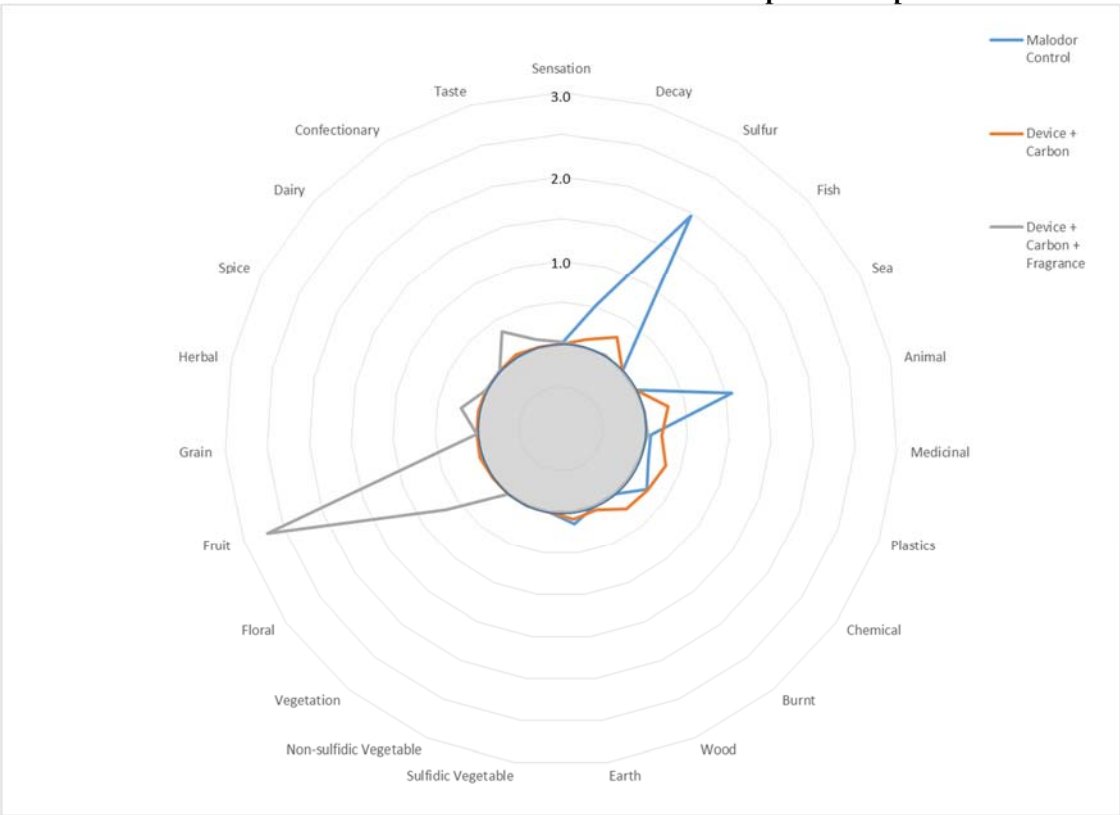


Figure 8. Odor character profile at 2-<u>hours</u> for all samples during fecal malodor reduction test. The results of the Ecobreeze device with carbon are the means of two replicate samples.

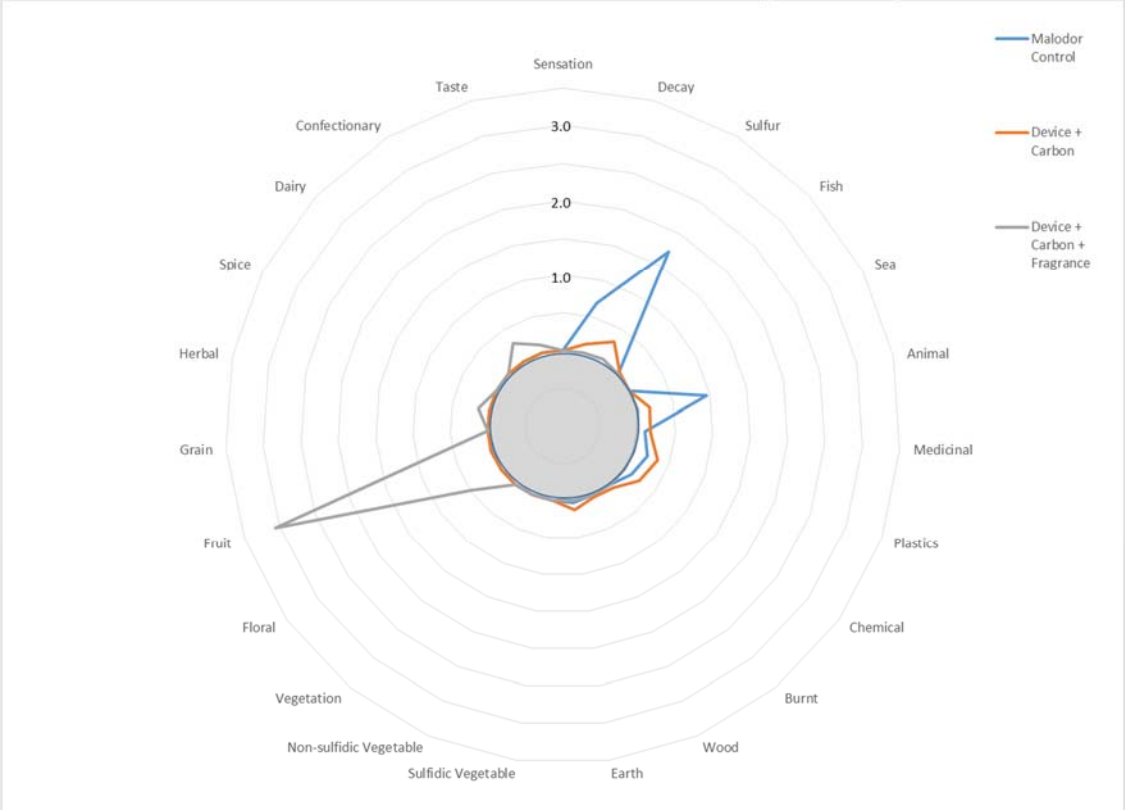


Figure 9. Odor character profile at 3-hours for all samples during fecal malodor reduction test. The results of the Ecobreeze device with carbon are the means of two replicate samples.

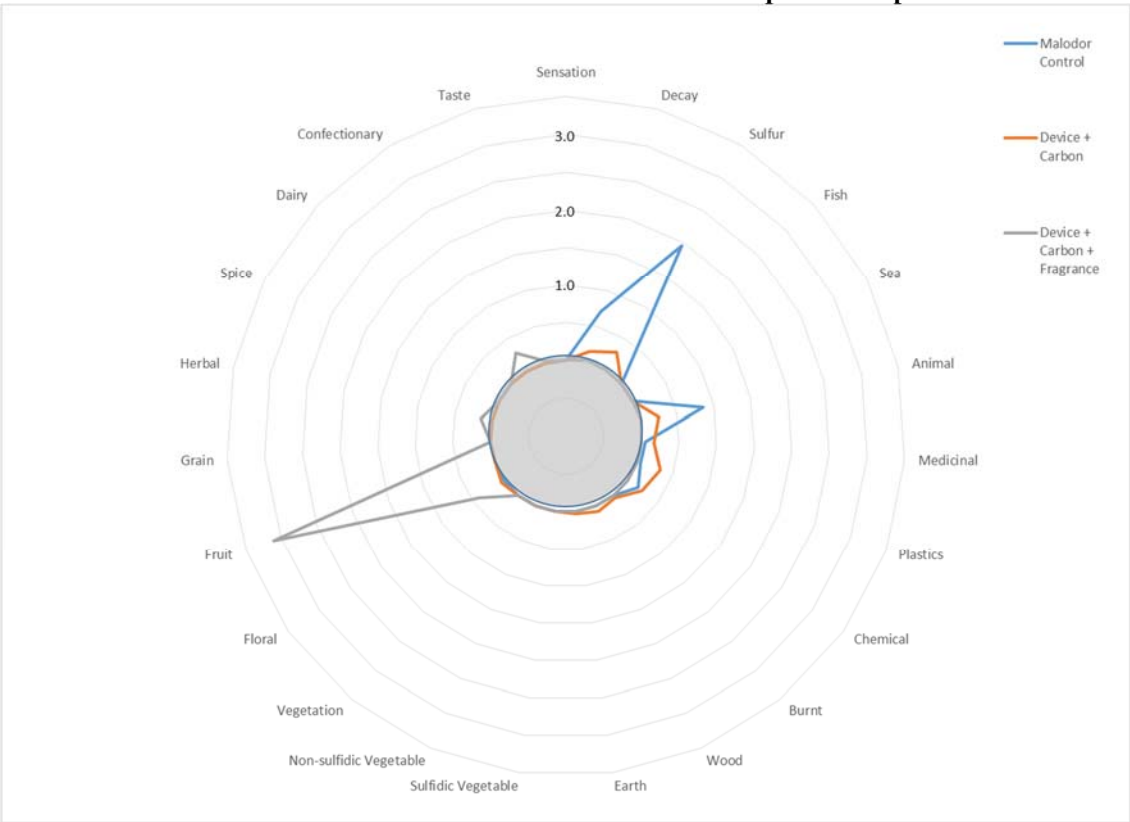
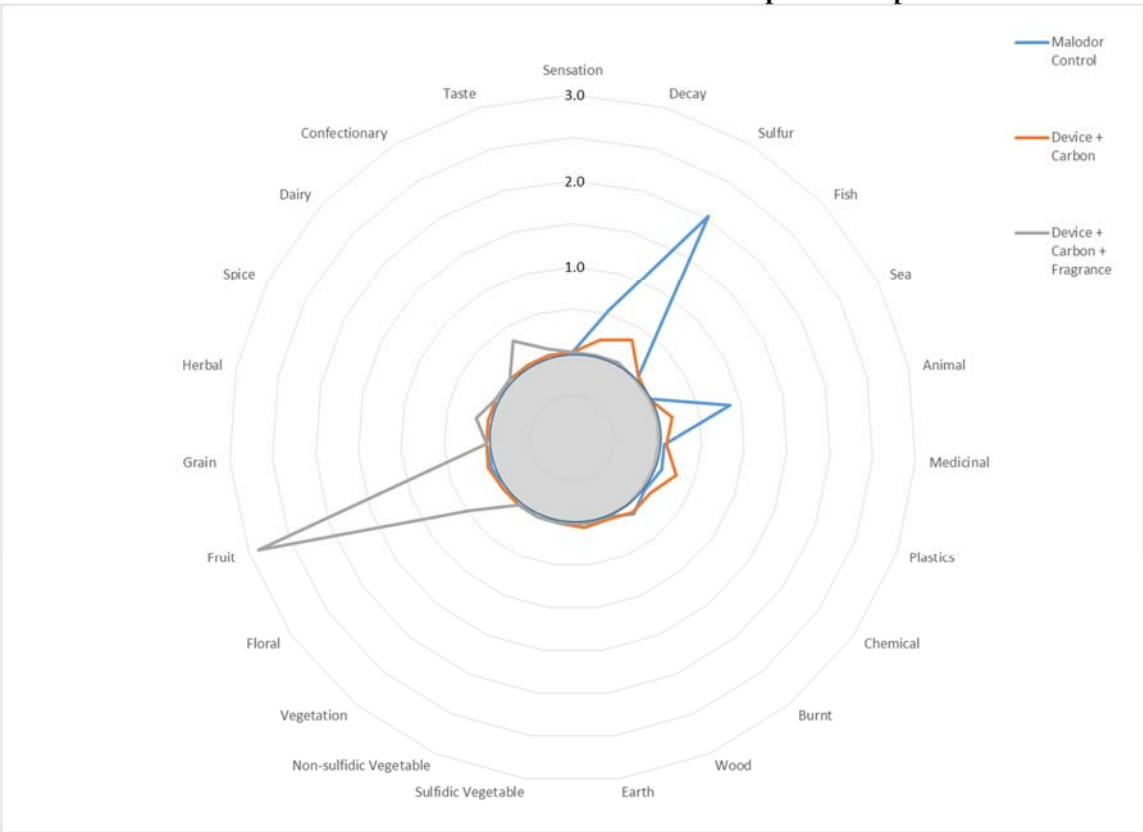


Figure 10. Odor character profile at 4-hours for all samples during fecal malodor reduction test. The results of the Ecobreeze device with carbon are the means of two replicate samples.



Summary and Conclusions

St. Croix Sensory, Inc. was contacted by Washroom Wizard Ltd to conduct a study to document the performance of the Ecobreeze at reducing fecal malodors in a controlled 4-hour test. All testing was conducted following ASTM International standards and guidelines including E1593-13, *Standard Practice for Assessing the Efficacy of Air Care Products in Reducing Sensorily Perceived Indoor Air Malodor Intensity* and principles of Consumer Specialty Products Association (CSPA) Standard, *Deodorization Efficacy Assessment – A Screening Method*. Testing was conducted in St. Croix Sensory's sensory testing laboratory utilizing eight stainless steel chambers of dimensions 1.2x1.2x1.5m (2.16m^3, 80ft^3) with 0.5 air exchanges per hour exhaust.

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This report is intended to provide results and interpretation of the fecal malodor reduction performance testing work performed by St. Croix Sensory on 10 November 2017. Please contact St. Croix Sensory with any additional questions about testing and related results.

St. Croix Sensory is ISO/IEC 17025:2005 Accredited

Certificate of Accreditation issued by
Perry Johnson Laboratory Accreditation, Inc.
Accreditation No.: 81047
Certificate No.: L14-130
Initial Accreditation Date: 19 May 2014

Mission Statement:

St. Croix Sensory is a laboratory dedicated to practicing state-of-the-art sensory evaluation and to advancing the science of sensory perception.

We are a family owned and operated business providing our clients with personal customer service, flexible scheduling, and timely results.

Our focus is to provide the best professional services available to make your project or product a success.

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