VITESY

Test Report

Vitesy technology

INDEX

ACRONYMS USED IN THE DOCUMENT

CFU
Colony-Forming Units

GC-MS
Gas Chromatography-Mass Spectrometry

F&V
Fruit and Vegetables

PCA
Plate Count Agar

PCO
Purification technology used in Vitesy Air and Fridge Purifiers

VOC(s)
Volatile Organic Compound(s)

tVOC(s)
total Volatile Organic Compound(s)

SAS
Surface Air System

POLLUTANT		FRIDGE SIZE	REDUCTION %	TIME
Microbiological agents	Bacteria	S	99.37 %	10 minutes
	Natural Contamination	S	96 %	3 days
	Pathogen Reduction Under Static Conditions (e. coli)	N/A	99.0 %	6 hours
	Pathogen Reduction Under Static Conditions (s. aureus)	N/A	96.0 %	6 hours
Odor	Real tVOC	M	80 %	5 hours
	Trimethylamine	S	73 %	5 hours
	Hexanal	M	85 %	24 hours
	Pentyl butyrate	M	88 %	24 hours
Ethylene	Ethylene	S	56,3 %	14 hours
Persistent Chemical Compounds	BTEX	S	> 99 %	5 hours

Fridge size:
Size S: 120-250 l
Size M: 260-370 l

Product shelf life up to ACCEPTABLE (*) level in days

PRODUCT	WITHOUT DEVICE	WITH DEVICE	VARIATION % (**)
Strawberry	3	10	70
Apricot	10	17	41
Cherry Tomato	14	22	36
Belgian Endive	3	7	57
Zucchini	10	22	55

METRIC	Product	Variation
MOLDS REDUCTION	STRAWBERRIES	6-8 times more mold-free fruits after 9 days
MOLDS REDUCTION	APRICOTS	+20% fruit without molds at 21 days
TEXTURE	ZUCCHINI	Double in respect control (T16days)
MOLDS REDUCTION	KIWI	Molds appear 4 days after
MOLDS REDUCTION	LEMONS	+40% pieces without molds after 13 days

(*) depending on the sensory characteristics (in particular: color/appearance - texture), 'acceptable' is meant as the product that although no longer presents the typical characteristics of fresh food is still considered edible and usable for normal domestic use by the End Consumer.

(**) Calculated as: [(no. days WITH – no. days WITHOUT)/(no. days WITH)]x100

In scientific studies conducted, Vitesy technology has shown the ability to extend the shelf-life of fruits and vegetables up to 12 days under specific conditions. It's important to note that this extension of shelf-life is influenced by various factors (such as, for example, product seasonality, pre-storage conditions, refrigerator characteristics, frequency of refrigerator door openings, correct product placement within the refrigerator, overcrowding with other products, refrigerator power fluctuations, etc.), and therefore, results may vary significantly. Consequently, it is not possible to provide guarantees of identical outcomes for all foods or situations. We recommend always following storage guidelines and not considering the product as a safeguard against foodborne illnesses or spoilage. **Please remember that Vitesy technology acts on the air inside your refrigerator, not directly on the food.**

BACTERIAL LOAD REDUCTION

Abatement of artificial bacterial load

PREMISE

Microbial contamination in a refrigerator can lead to food spoilage. It is important to minimize microbial contamination to maintain a high level of food quality inside the refrigerator. In fact, microbial contamination (bacteria, yeast, and molds) **accounts for 15% of post-harvest decay in fruits and vegetables.**

Bacillus Atrophaeus - *ATCC 9372* is a Gram-positive bacterium belonging to the genus Bacillus, commonly found in the environment. While it is not a human pathogen, it contributes to the decomposition of foods such as vegetables, meat, and dairy products.

It has the ability to form spores, allowing it to survive in extreme environmental conditions. These spores can be transported into the refrigerator environment through the air or food itself and remain dormant, waiting for favorable conditions to germinate and grow, potentially leading to food contamination.

In general, strains of the Bacillus genus serve as important models for validation studies due to their versatility and resistance to external factors. This makes it possible to transfer the results obtained to other bacterial species, such as E. coli, Salmonella, and so on.

SETUP

We evaluated the effectiveness of bacterial reduction by Vitesy technology placed inside a 180L refrigerator. In order to assess microbial reduction significantly, an artificial contamination was created inside the refrigerator by nebulizing a suspension of ***Bacillus Atrophaeus*** - *ATCC 9372* using an ultrasonic vaporizer. The laboratory's protocol for this evaluation involved the following steps:

① Nebulization of the bacterial suspension inside the refrigerator for 20 minutes.

② Stoppage of nebulization and activation of the Vitesy technology for the next **10 minutes** (Vitesy technology means “Vitesy technology” or an analogue Vitesy technology without photocatalytic activity that guarantees the same air flow).

③ Sampling of 30 liters of air through a specific hole created in the refrigerator using an active sampler for orthogonal impact **SAS** (Surface Air System), where an **agarized soil plate**, PCA (Plate Count Agar) was placed to allow the growth of microorganisms present in the air volume that impact on the soil itself.

④ Incubation of the plates at 30°C for 24-48 hours and subsequent quantification of viable microorganisms in the sampled air volume (ISTISAN Method 2013/37).

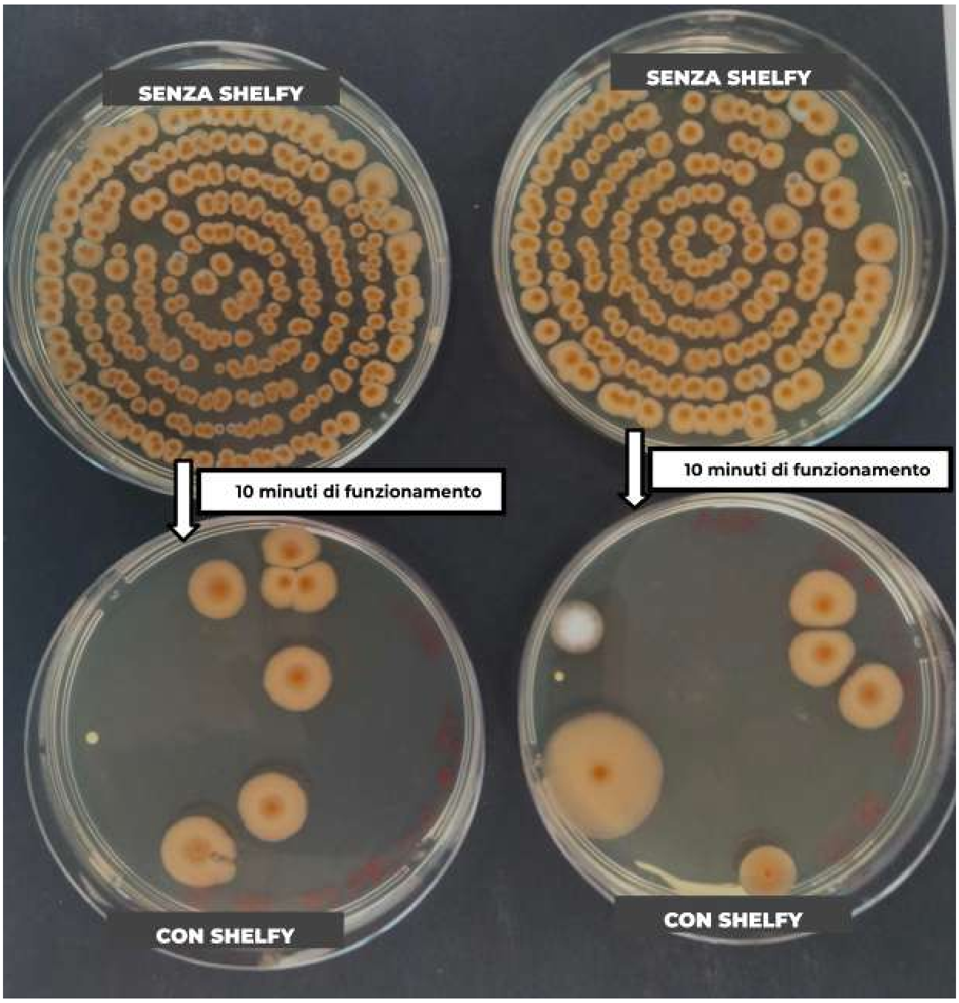
Microorganisms present in the air adhere to the soil and, after an adequate incubation period, give rise to colonies visible to the naked eye, which can be counted. The level of microbial contamination is expressed as **CFU** (Colony-Forming Units) **per cubic meter of air.**

The entire procedure was repeated both with the active Vitesy technology (Vitesy technology) and using a similar Vitesy technology in the same step, but without photocatalytic activity (White). This was done to eliminate the potential component of microbial reduction in the air due to the "natural deposition of aerosol particles on surfaces" and to compare results with and without Vitesy technology.

Furthermore, the entire procedure was repeated in multiple replicates to obtain **robust and reproducible data.**

RESULTS

A significant difference (see **Figure**) is observed between the test conducted with Vitesy technology and the test conducted without the photocatalytic technology. This difference indicates a mean logarithmic reduction of 2.2 with a standard deviation of 0.1. In practical terms, this translates to a remarkable **99.37%** reduction in the microbial load within just **10 minutes of operation**. In this result it is considered only tests with an initial inoculum greater than 10,000 CFU/m^3.



PCA without Vitesy technology (left) and with Vitesy technology (right) after 10 minutes

CONCLUSIONS

Based on the test results, Vitesy's technology has proven effective in **rapidly reducing airborne bacteria,** contributing to a **significant decrease in fridge contamination.**

REDUCTION OF MICROBIAL LOAD IN THE AIR

Reduction of Naturally Occurring Airborne Bacterial and Fungal Load

PREMISE

Microbial contamination in a refrigerator can lead to food spoilage. It is important to minimize microbial contamination to maintain a high level of food quality inside the refrigerator. In fact, microbial contamination (bacteria, yeast, and molds) accounts **for 15% of post-harvest decay in fruits and vegetables.**

SETUP

The effectiveness of reducing the **naturally occurring bacterial and fungal load** in the air using Vitesy technology was evaluated by placing it inside 2 identical 220-liter refrigerators:

→ Refrigerator No. 1 - Control

→ Refrigerator No. 2 - Containing Vitesy technology (Eco Mode)

The refrigerators were placed in the same room and close to each other. To homogenize internal contamination in the refrigerators, the doors were opened for approximately 5 hours. After the 5 hours, the refrigerators were closed and the Vitesy system was turned on. After 48 hours, the refrigerators were opened and culture media plates were placed on the shelves to evaluate the microbial load present.

The culture media included:

→ 6 plates per refrigerator containing Plate Count Agar (PCA agar) for the evaluation of total bacterial load according to **ISO 4833**

→ 6 plates per refrigerator containing Yeast Glucose Chloramphenicol Agar (YGC agar) for the evaluation of yeasts and molds according to **ISO 7954**

On each shelf of the refrigerator, 3 plates of each medium were placed.

The plates were open, the lid placed under the part containing the agar, and left for 3 days to facilitate gravity contamination by any microorganisms present in the refrigerator air.

After 3 days, the plates were retrieved, closed, and placed in an incubator at 25°C for 3-5 days to promote the development of contaminating microorganisms. Colony counts were then performed.

The test was repeated 2 times.

Test conducted in collaboration with Università degli Studi di Udine

The data obtained from microbiological analyses were compared through statistical analysis: Analysis of Variance (One-Way ANOVA) and means were separated using Tukey's test.

RESULTS

Table 1 summarizes the contamination levels of the refrigerators with and without Vitesy technology.

	TEST 1	**TEST 2**
Fridge n.1	72.0 (16.9)	42.2 (15.2)
Fridge n.2 (with Vitesy technology)	2.1 (0.7)	2.0 (0.2)

Table - Contamination levels: values are presented as the mean (standard deviation)

The microorganisms present on both the PCA and YGC Agar plates consisted of molds; no bacteria were observed.

As seen in both tests, the Vitesy technology reduced the microbial concentration in the air. This reduction was significant ($p < 0.05$) and varied depending on the test. In any case, a decrease in contamination was observed, with reductions of 97% in the first test and 95% in the second test, respectively.

CONCLUSIONS

Based on the test results, Vitesy's technology has proven effective in **rapidly reducing** the naturally occurring **airborne microorganisms,** contributing to a **significant decrease in fridge contamination**.

ODOR REDUCTION IN REFRIGERATOR:

Test in Real Refrigerator

Reduction of VOCs from natural sources

PREMISE

The objective of this test is to define the ability of the Vitesy Vitesy technology to keep the level of VOCs (Volatile Organic Compounds) in the refrigerator low. VOCs are emanated mainly from F&V (Fruits and Vegetables) during the various stages of ripening, and their presence inside the refrigerator **negatively affects the ripening of F&V itself,** accelerating it, and **the organoleptic properties**, i.e. the physical-chemical characteristics of a food perceived by the sense organs (smell, sight, taste).

In this test, **avocados** and **apples** are used to generate VOCs because they are climacteric foods and, as such, continue ripening after being detached from the plant. The ripening phenomenon is induced by **ethylene** (CH2=CH2), a colorless and odorless gaseous plant hormone that plays a crucial role in fruit growth, development and storage, even when present in small concentrations, such as ppm (parts per million) or even ppb (parts per billion). Climacteric food, as it ripens, produces ethylene; the more ethylene there is in the air, the more the food is stimulated to produce ethylene itself.

Apples and avocados are among the major ethylene emitters.

SETUP

Two refrigerators of the same brand and model were used for the tests. The internal volume is 370 liters, or 0.37 m^3. The refrigerators were set at 4°C.

Unripe avocados (hard to the touch) and three types of apples were purchased. Each food item was placed with the same arrangement in both refrigerators.

By means of Teflon tubes, air sampling points were created outside the refrigerator so that air sampling could be performed without opening the refrigerator doors. The air in each refrigerator is sampled on the shelf.

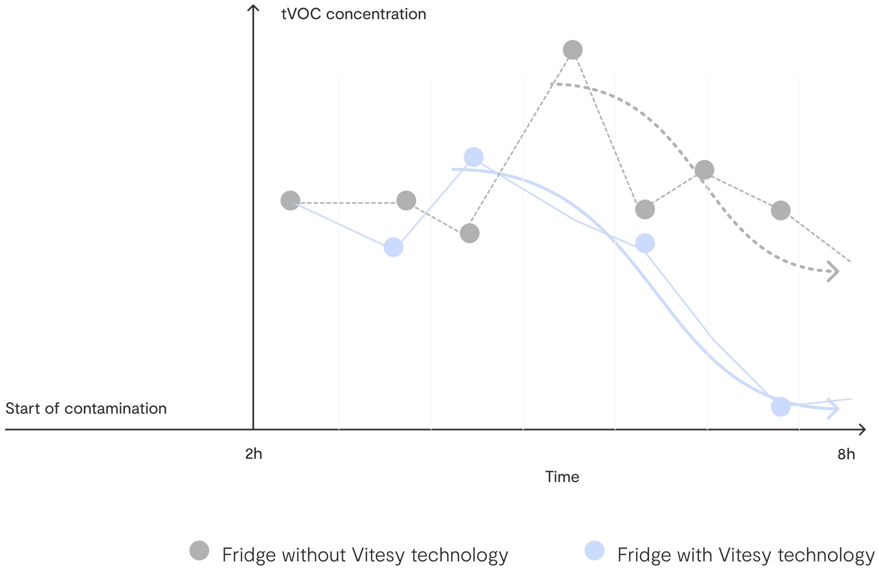
The Tiger Ion (PID technology), which measures the tVOC level in the refrigerator in isobutylene equivalent, was used to perform the sampling.

The Vitesy Vitesy technology is inserted in **refrigerator 1.**

VOC levels were recorded for 7 hours; the contamination occurred about ten minutes before t0.

RESULTS

The collected data were normalized using the Z-score. It can be seen that in refrigerator 1 the tVOC concentration remains constant for the first two hours thanks to the Vitesy Vitesy technology, after which it begins to decrease and in a little more than 4 hours returns to values comparable to the initial values (t:-2). **5 hours** after the forced increase in VOCs (t:0) with natural source in refrigerator 1 there is an **80% reduction.**



tVOC (total Volatile Organic Compound) in the two fridges, the orange curve represents the trend in refrigerator 1, i.e. with Vitesy technology, while the green curve represents refrigerator 2, without Vitesy technology (reference white)

In the refrigerator without the Vitesy Vitesy technology, however, the concentration tends to increase in the first three hours, after which slowly decreases, without returning to values comparable to those at the beginning of the test.

CONCLUSIONS

Based on the test results, Vitesy's technology has proven effective in **keeping the level of VOCs inside the refrigerator low**; after increasing the tVOC concentration with natural source (avocados and apples) in the refrigerator, **in 5 hours we observed an 80% reduction.**

VITESY TECHNOLOGY ACTIVITY ON PATHOGENIC MICROORGANISMS

Static Reduction Tests of Escherichia coli and Staphylococcus aureus

PREMISE

Air-based activity tests are not suitable for pathogenic microorganisms. For this reason, an alternative methodology was chosen, enabling the comparison of the activity of the microorganism used in dynamic aerosol tests with that of other microorganisms commonly found in the food industry: **Escherichia coli** and **Staphylococcus aureus.** These were selected to represent two major bacterial families, Gram-negative and Gram-positive bacteria, that typically show differing responses to antimicrobial treatments.

SETUP

To carry out the study, the laboratory developed a static test protocol involving the direct inoculation of the target microorganism onto the photocatalytic filter under evaluation, as well as onto a raw (untreated) filter used as a control.

→ Bacterial Strains Tested:

→ Bacillus atrophaeus – ATCC 9372

→ Escherichia coli – ATCC 8739

→ Staphylococcus aureus – ATCC 6538

Preparation of bacterial inoculum for each strain at a concentration of 10^8 CFU/ml, with bacterial titre confirmation. Application of 0.2 ml of bacterial suspension via spray to one side of both the untreated and Vitesy filters, called the inoculated side.

After inoculation, the Vitesy filter was exposed to visible light to activate the photocatalytic technology, exposure of the Vitesy filter to visible light for a total of 6 hours as follows: 4 hours on the inoculated side, 2 hours on the opposite side; the untreated filter was kept in the dark for 6 hours.

At the end of the light exposure period, each filter was transferred to a sterile bag containing Maximum Recovery Diluent (MRD) and agitated for several minutes to recover any viable microorganisms.

The viable microorganisms suspended in the recovery solution were quantified using the plate count method, with appropriate serial dilutions and inclusion plating.

Incubation conditions were 30°C for Bacillus atrophaeus and 37°C for Escherichia coli and Staphylococcus aureus

After incubation, colonies (CFUs) were counted on each plate to determine the number of viable microorganisms recovered from each filter.

RESULTS

The Table 2 summarizes the bacterial reduction observed in the static test with the three strains:

Logarithmic and percentage reduction of viable bacterial count after 6-hour exposure to visible light on the Vitesy photocatalytic filter, compared to untreated control.

	BACILLUS ATROPHAEUS	E. COLI	S. AUREUS
REDUCTION	2.1 log (99.2 %)	2.0 (99.0 %)	1.4 (96.0 %)

The data show a logarithmic bacterial reduction between 1.4 and 2.1 log, corresponding to a percentage reduction between 96% and 99%, under the defined test conditions.

CONCLUSIONS

Based on the test results, Vitesy's technology has proven to reduce pathogens microorganisms. These static tests enabled a comparison of the photocatalytic technology's efficacy against Bacillus atrophaeus (assessed via dynamic aerosol tests) with that observed for other representative foodborne pathogens. The results demonstrated similar antimicrobial efficacy, confirming the broad-spectrum potential of the Vitesy photocatalytic filter.

ODOR REDUCTION IN REFRIGERATOR:
Trimethylamine, Hexanal and Pentyl butyrate

Reduction of fish odor, spoiling meat and fermented cheese

PREMISE

The aim of the test is to determine the capabilities of the new Vitesy system to remove a target pollutant from a **closed system** (experimental setup). The identified pollutants are trimethylamine, hexanal and pentyl butyrate and tests have been conducted both with the product and without it, with scheduled sampling.

Trimethylamine is an organic compound known for emitting a **pungent** odor resembling **decomposing fish**. It is a nitrogen compound commonly associated with unpleasant odors in refrigerators.

Hexanal is an aldehyde with a sharp and unpleasant odor, often associated with moldy or rancid smells. Hexanal can develop as a result of the decomposition of foods containing fats, such as vegetable oils or certain types of meat.

Pentyl butyrate is an ester that can have an odor reminiscent of rancid butter or fermented cheese. It can develop when foods containing fats, such as butter or certain cheeses, begin to deteriorate due to lipid oxidation, giving it a fairly distinct and noticeable cheese/rancid aroma.

These compounds not only produce **unwanted odors inside the refrigerator** but also lead to **odor cross-contamination.** This is a process through which odors or aromas from one food item or substances within the fridge transfer to other foods or objects in the surrounding environment. This contamination can have a significant impact on the quality of food and the **overall sensory experience,** making food less appetizing or negatively affecting its taste.

SETUP
Trimethylamine

A cubic plexiglass box with an internal volume of **118 liters** was used for the tests. The plexiglass box was employed to exclude any air infiltrations and prevent dilution effects. This approach aligns with the type of environment being simulated, namely, an environment with limited air exchange, similar to the inside of refrigerators.

For qualitative characterization and to assess the reduction of trimethylamine, **a gas chromatograph coupled with a mass detector** equipped with a **thermal desorption system** was used. Compounds within the experimental box were extracted using a low-flow pump, adsorbed onto Tenax tubes, and then analyzed. The Tenax tubes were conditioned immediately before each test to ensure the absence of any volatile organic compounds (VOCs) that might be present. A low-flow pump (Gilian) was used for sample collection, enabling the acquisition of samples for analysis at a rate of 100 mL/min.

Considering the significance of **humidity** typically present inside refrigerators, the box was pre-treated to raise relative humidity levels.

To introduce the pollutant sample, which consisted of air containing trimethylamine, a syringe was employed. Ten minutes after introducing the sample into the test box to stabilize the trimethylamine concentration, samples were collected at predetermined intervals, with a focus on evaluating the m/z 58 ion (the most abundant and representative fragment of trimethylamine).

The test was conducted both with and without Vitesy technology.

SETUP

Hexanal and Pentyl butyrate

The Vitesy technology is placed inside the refrigerator in off-mode during the saturation of the environment with the pollutant. Hexanal aldehyde and pentyl butyrate were selected as the target molecules, and used in high concentrations, that is the equilibrium concentration of the vapor phase with the liquid phase in the refrigerator volume at the average temperature of 4°C and pressure of 1 atm. A sampling point was set up through a Teflon tube closed at the outer end by a tap with luer-lock connection so that ambient air sampling could be performed without opening the refrigerator door.

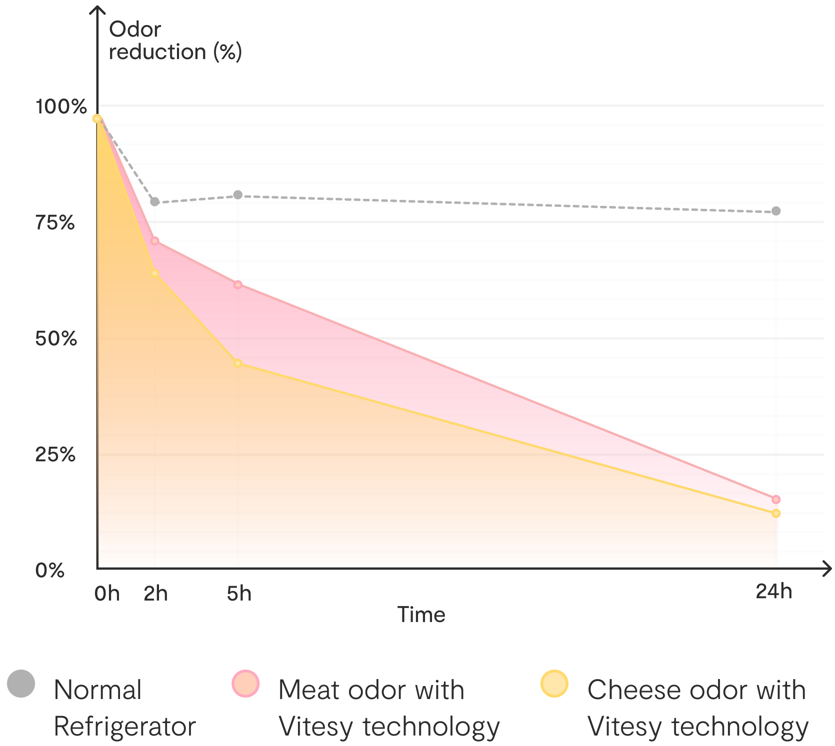
The refrigerator was contaminated with the tested target substance by leaving an open glass container containing 0.5 mL of the liquid pollutant inside the refrigerator for 16 hours. Then the container inside the refrigerator was closed and sampling was performed at time t=0, the vapor phase collected was placed in a glass vial with a cap for headspace analysis containing 5 uL of internal standard. It was verified that the opening and closing of the door required to perform this operation did not significantly change the initial pollutant concentration.

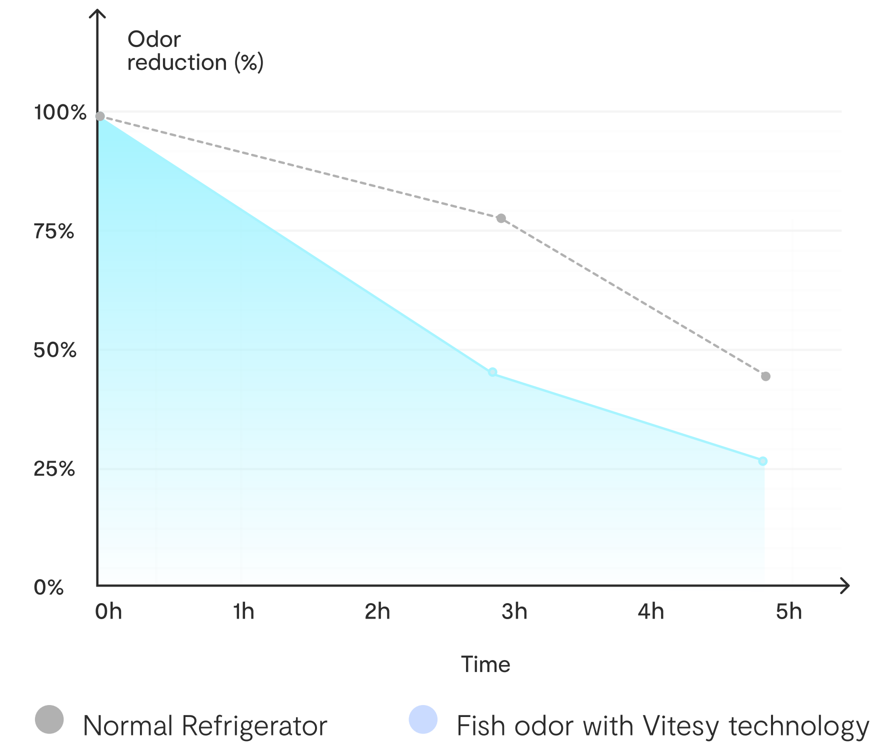
The concentration of the pollutant was measured during 24-hours, by sampling at 0h - 2h - 5h - 24h, tests were performed with and without Vitesy technology, tests were performed on one pollutant per time.

The samples thus obtained were analyzed in triplicate at GC-MS, the results are related to the area of the internal standard.

RESULTS

Results are synthesized in **Figures.**





Reduction of the target molecules

CONCLUSIONS

Based on the test results, Vitesy's technology has proven **effective in reducing odors;** tests were conducted over several days under conditions, particularly concerning humidity, that resemble those found inside refrigerators.

The choice of pollutants as the compound for these tests was primarily motivated by their characteristic odor and the need to avoid any interfering molecules in the air to be analyzed, which could lead to further assumptions. Conducting individual tests on different days allowed for the cleaning and reconditioning of the facility, thus avoiding potential artifacts. This approach also ensured excellent reproducibility of the experimental setup.

From the test performed, it is shown that the Vitesy technology is able to **minimize the fridge cross-contamination** by neutralizing unwanted odors and maintaining a healthy environment inside the refrigerator.

ETHYLENE REDUCTION

Reduction of the aging accelerator of fruits and vegetables

PREMISE

Ethylene is a colorless, odorless, gaseous plant hormone that plays a crucial role in the growth, development, and preservation of fruits and vegetables (F&V).

The removal of this molecule from the air helps slow down the ripening process and minimizes the spoilage of perishable products.

The quantity of ethylene emitted by F&V varies significantly depending on the type of product under analysis, its ripeness, and environmental conditions (such as humidity, the presence of gasses like oxygen and carbon dioxide, and temperature).

SETUP

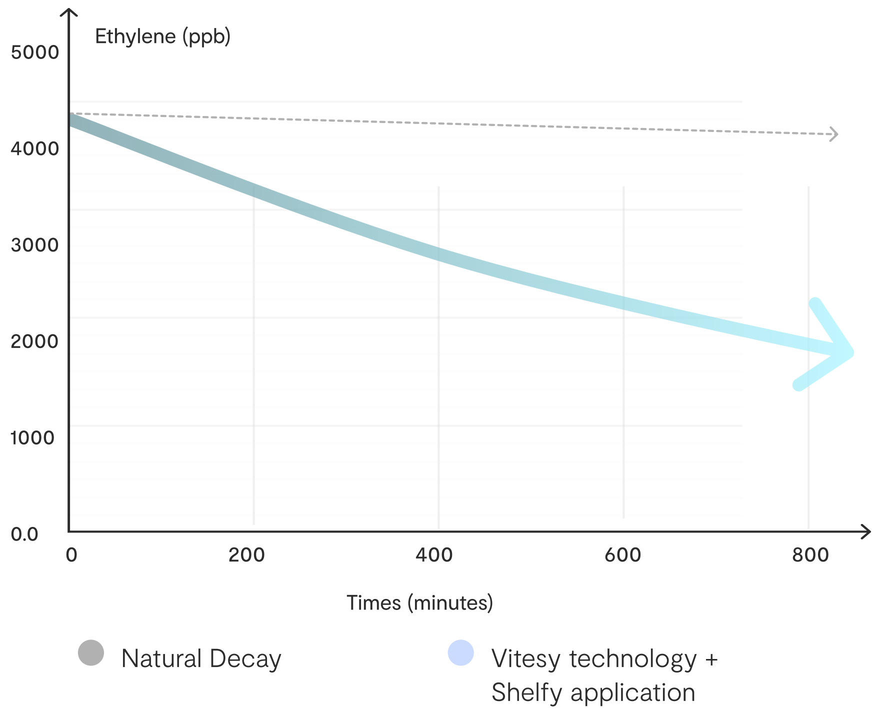
A cubic plexiglass box with an internal volume of **210 liters** was used for the tests. The plexiglass box was employed to exclude any air infiltrations and prevent dilution effects. This approach aligns with the type of environment being simulated, namely, an environment with limited air exchange, similar to the inside of **refrigerators**.

The real time analysis has been conducted thanks to **SYFT Voice200 ULTRA Advanced SIFT Mass Spectrometer**, that provides instantaneous identification and quantitation of VOCs and inorganic gases using a fully integrated, extensive chemical ionization library.

Considering the significance of humidity typically present inside refrigerators, the box was pre-treated to raise relative humidity levels.

RESULTS

Based on the test results, Vitesy's technology has proven effective in reducing odors; tests were conducted over several days under conditions, particularly concerning humidity, that resemble those found inside refrigerators. The choice of pollutants as the compound for these tests was primarily motivated by their characteristic odor and the need to avoid any interfering molecules in the air to be analyzed, which could lead to further assumptions. Conducting individual tests on different days allowed for the cleaning and reconditioning of the facility, thus avoiding potential artifacts. This approach also ensured excellent reproducibility of the experimental setup. From the test performed, it is shown that the Vitesy technology is able to minimize the fridge cross-contamination by neutralizing unwanted odors and maintaining a healthy environment inside the refrigerator.



Real time reduction of ethylene

CONCLUSIONS

Based on the test results, Vitesy's technology has proven effective in reducing ethylene.

REDUCTION OF PERSISTENT COMPOUNDS

Reduction of BTEX: Benzene, Toluene, Ethylbenzene, Xylenes

PREMISE

BTEX refers to a group of volatile organic compounds—Benzene, Toluene, Ethylbenzene, and Xylenes—known for their **chemical stability and persistence** in the environment. These compounds are commonly associated with petroleum-based products and industrial emissions, and are of particular **concern** due to their **potential health impacts** and **resistance to degradation.**

Although BTEX compounds are not typically generated inside refrigerators, they were selected for this study as **model pollutants to evaluate the effectiveness of the Vitesy photocatalytic technology** in degrading persistent and stable organic compounds under controlled conditions.

SETUP

A cubic plexiglass box with an internal volume of **210 liters** was used for the tests. The plexiglass box was employed to exclude any air infiltrations and prevent dilution effects. This approach aligns with the type of environment being simulated, namely, an environment with limited air exchange, similar to the inside of **refrigerators.**

BTEX compounds were introduced into the test chamber through spontaneous evaporation of standard liquid mixtures. The degradation of these volatile organic compounds was assessed by conducting three air samplings at the following time points: T0 (baseline, before activation), T2h (after 2 hours), T5h (after 5 hours).

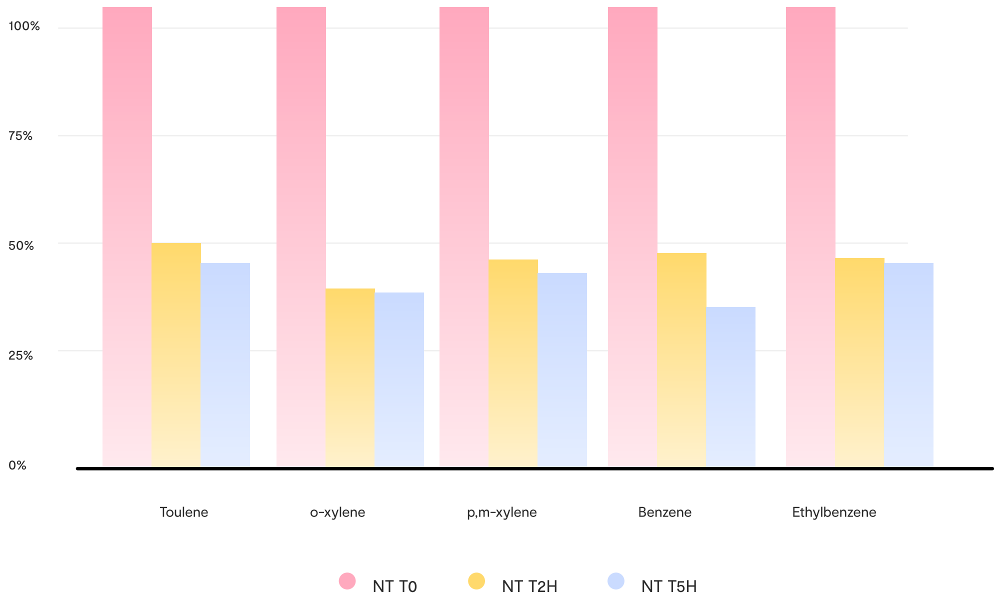
Air sampling was performed at a flow rate of 1 L/min, using jumbo sorbent tubes (chemical desorption-CS_2). Each sampling event collected 30 liters of air.

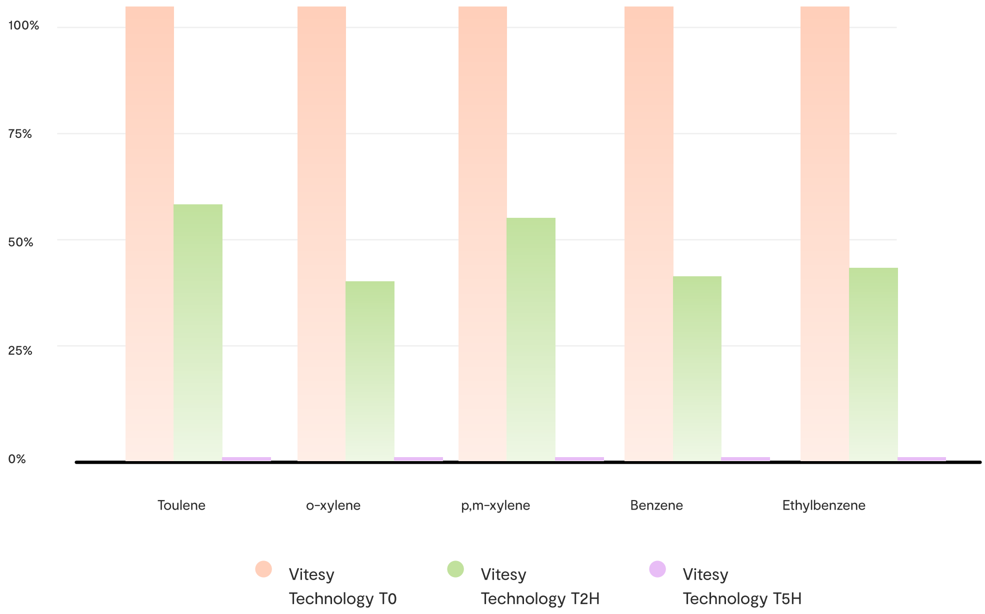
The device was positioned centrally inside the chamber and operated in performance mode throughout the test.

Environmental conditions were kept constant at 18–20°C and 30–40% relative humidity. To validate the photocatalytic effect, a control test (blank) was performed under identical conditions using an untreated filter, without photocatalytic coating.

The collected samples were analyzed using Gas Chromatography–Mass Spectrometry (GC-MS) for the quantification of BTEX concentrations.

The results are shown in the figure below. After an initial stabilization phase, BTEX compounds— as expected—remain persistent in the test environment.





BTEX Concentration Trends at T0, T2h, and T5h in Not-Treated Filter (NT) and Vitesy Photocatalytic Technology

CONCLUSIONS

Based on the test results, Vitesy's technology has proven **effective** in **reducing BTEX.**

SHELF-LIFE ASSESSMENT OF FRESH FOOD PRODUCTS
(fruits, vegetables)

PREMISE

An experimental study was carried out according to a work plan defined in agreement with CSI Spa. The study was set up during the period 19/07 – 16/08/2022 at the FPM Laboratory - Food Packaging Materials of CSI Spa, at its Bollate (MI) facility.

The purpose of the test is to evaluate the effect of Vitesy technology in terms of prolonging the shelf life of fresh food products stored in the refrigerator.
Vitesy technology treats the air inside the refrigerator through photocatalysis, removing odors and microorganisms such as mold and bacteria.
To carry out this evaluation, the test involved storing fresh food products inside the refrigerator.

As requested by Vitesy, the types of products tested are:

→ FRUITS
→ VEGETABLES

The products were placed in equal amounts and in equal ways inside two identical refrigerators. The refrigerators are set with temperature + 6°C, in order to create storage conditions similar to domestic storage. Vitesy technology was placed inside the first refrigerator. The Vitesy technology was provided by Vitesy (Vitesy technology - code ZZ-MILSAA00 – ref. DDT 22000062 dated 15/07/2022 Vitesy-Laboratori Fabrici srl). The Vitesy technology is not present in the second refrigerator.

By monitoring the products over time, in timed steps, and performing microbiological, chemical-physical and sensory determinations on the products, the study aims to evaluate any differences in terms of shelf-life extension between the product stored in the refrigerator with Vitesy technology compared to the same products stored in the refrigerator without the Vitesy technology.

SETUP

Taking into account some preliminary empirical tests, the inherent characteristics of the products, the representativeness of broader product families, and also depending on the seasonality and availability at the time of purchase, the test was conducted on the following references: strawberry, apricot, apple, cherry tomato, belgian endive, and zucchini.

The Laboratory arranged for the purchase of the samples on behalf of Vitesy. On the day of purchase, the products were placed inside the two refrigerators, previously set at +6°C and sanitized.

The refrigerators used are two refrigerators provided by the CSI Laboratory that were made available for the conduct of the study. These were FRIGOTERMOSTATO FOC 225I – VELP Scientifica.

Setup at T0: Refrigerator WITH Vitesy technology (left) and WITHOUT Vitesy technology (right)

During the testing period, this equipment was used exclusively for conducting the experiment. An avocado was placed inside both refrigerators with the aim of emitting ethylene and accelerating the ripening processes of fruit and vegetable products.
No analytical tests are planned on avocado.

Following are the analysis conducted to monitor the storage status of the products over time.
These are the parameters identified as significant in relation to the matrices analyzed and the final purpose of the experiment

→ Organoleptic evaluations

→ Total bacterial load

→ Mesophilic lactic acid bacteria

→ Yeasts

→ Molds

→ Enterobacteriaceae

→ Escherichia coli (on fruit only)

→ Staphylococcus aureus (on fruit only)

→ Moisture

The study included sample monitoring with 7 analytical steps, timed as follows:

TIMES		ANALYSIS DATE
T0	upon purchase of samples	in analysis on 19/07
T3	+3 days of storage	in analysis on 22/07
T7	+7 days of storage	in analysis on 26/07
T10	+10 days of storage	in analysis on 29/07
T14	+14 days of storage	in analysis on 02/08
T17	+17 days of storage	in analysis on 05/08
T22	+22 days of storage	in analysis on10/08

RESULTS

Strawberry

Strawberry T0

T0

T_3days

Strawberry T_3days (with Vitesy technology - left; without Vitesy technology - right)

T_7days

Strawberry T_7days (with Vitesy technology - left; without Vitesy technology - right)

T_10days

Strawberry T_10days (with Vitesy technology - left; without Vitesy technology - right)

Regarding the microbiological evaluations, the parameters found to be the most significant are **Total bacterial load, Lactic acid bacteria, Molds and Yeasts.**

For these, the values found show a growth trend that up to almost T_10days is well defined and shows that **the bacterial and fungal contamination is numerically higher** in the sample kept in the refrigerator without Vitesy technology than in the sample in the refrigerator with Vitesy technology.

The **sensory evaluations are in line with this result,** i.e. up to T_10days the strawberries in the refrigerator with Vitesy technology have significantly better sensory characteristics (appearance / texture / stains / mildew); the strawberries in the refrigerator with Vitesy technology have firmer flesh - no rot and mildew spots; the strawberries in the refrigerator without Vitesy technology: less firm flesh with liquid release - stains and mildew - wilting.

RESULTS

Apricot

Apricot T0

T_0days

T_3days

Apricot T_3days (with Vitesy techno-logy - left; without Vitesy technology - right)

T_7days

Apricot T_7day (picture on the left: with Vitesy technology - left side; without Vitesy technology - right side; picture on the right: with Vitesy technology - left side; without Vitesy technology - right side)

T_10days

Apricot T_10days (with Vitesy tech-nology - left; without Vitesy technology - right)

T_14days

Apricot T_14days (with Vitesy techno-logy - left; without Vitesy technology - right)

T_17days

Apricot T_17days (with Vitesy techno-logy - left; without Vitesy technology - right)

Relative to microbiological evaluations, the parameters found to be the most significant are **Total bacterial load, Lactic acid bacteria and Yeasts.**

These parameters show that microbial contamination tends to be higher in the sample kept in the refrigerator without Vitesy technology, the differences in these parameters are in the **1-2 order of magnitude**, and the sensory evaluations track a product evolution over time **in line with the analytical results.**

Up to step T_7days the two samples are comparable.

At T_10days in external appearance the products are still similar; on opening, however, it is evident that the sample stored in the refrigerator without Vitesy technology has a less firm texture and pulp. This difference becomes more pronounced at T_14days, accompanied by the appearance of dark and rotten spots (no evidence of mold) on the fruits stored in the refrigerator without Vitesy technology.

Similar situation at T_17days: in the sample stored in the refrigerator with Vitesy technology, the apricot, although no longer characterized by the firmness and turgidity that characterizes the product at T0, does not show mold/rot nor stains with abnormal coloration, elements instead found on sample stored in the refrigerator without Vitesy technology.

RESULTS

Cherry tomato

Cherry tomato T0

T_0days

T_3days

Cherry tomato T_3days (with Vitesy technology - left; without Vitesy technology - right)

T_7days

Cherry tomato T_7days (with Vitesy technology - left; without Vitesy technology - right)

T_10days

Cherry tomato T_10days (with Vitesy technology - left; without Vitesy technology - right)

T_14days

Cherry tomato T_14days (with Vitesy technology - left; without Vitesy technology - right)

T_17days

Cherry tomato T_17days (picture on the left: with Vitesy technology - left side; without Vitesy technology - right side; picture on the right: with Vitesy technology - left side; without Vitesy technology - right side)

T_22days

Cherry tomato T_22days (with Vitesy technology - left; without Vitesy technology - right)

The most significant parameter proves to be the mold trend which, from T_17days, in the sample stored in the refrigerator without Vitesy technology, shows an increase up to 103 ufc/g (an order of magnitude higher than the values found in the previous steps, for both samples). The molds, after all, as known in food microbiology are typical alternants of the 'tomato' product.

As far as organoleptic characteristics are concerned, the two samples do not show significant differences until T_7days, after which the wilting defect takes over and becomes progressively more pronounced in intensity and % of spread.

At T_10days it is present on about 20-30% of the units stored in the refrigerator without Vitesy technology (it is absent in the cherry tomatoes stored in the refrigerator with Vitesy technology); at T_14days the percentage increases to about 30-40%; in the sample with Vitesy technology the percentage is 10-20%.

In the refrigerator without Vitesy technology, the increase in mold shown by analytical determinations (T_17days) also corresponds to visible mold on the samples. At T_22days, in fact, the sample stored in the fridge without Vitesy technology shows mold and dark spots, **not present in the product in the refrigerator with Vitesy technology.**

RESULTS
Belgian endiv

Belgian endive T_0

T_0days

T_3days

Belgian endive T_3days (with Vitesy technology - left; without Vitesy technology - right)

T_7days

Belgian endive T_7days (with Vitesy technology - left; without Vitesy technology - right)

The evidence from the tests on the ‘belgian endive’ product identifies that bacterial contamination is higher in the sample without Vitesy technology than in the product with.

As far as the organoleptic characteristics are concerned, the evaluations carried out (on whole head and on partially ‘flaked’ head) at T_7days show that the product in the refrigerator with Vitesy technology was better preserved: the outer leaves are of better appearance, less ‘crumpled’ and dark at the edges, and at the ‘flaking’ test the leaves maintain a greater texture and turgidity.

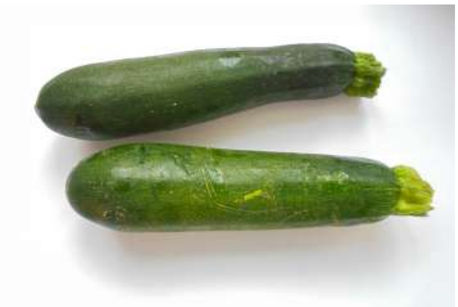
RESULTS

Zucchini

Zucchini T0

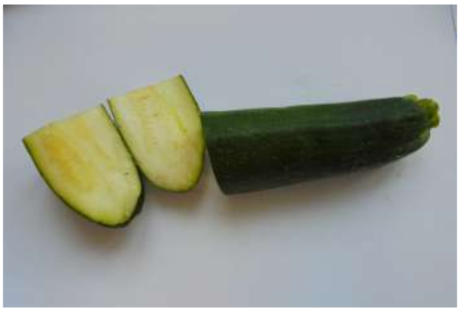
T_0days

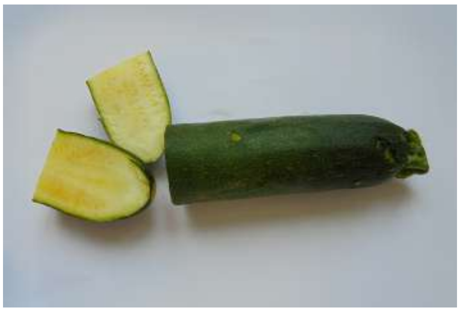
T_3days



Zucchini T_3days (with Vitesy technology - left; without Vitesy technology - right)

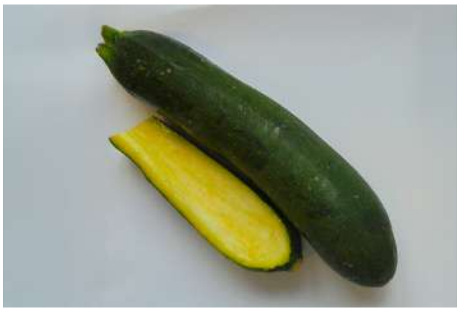
T_7days

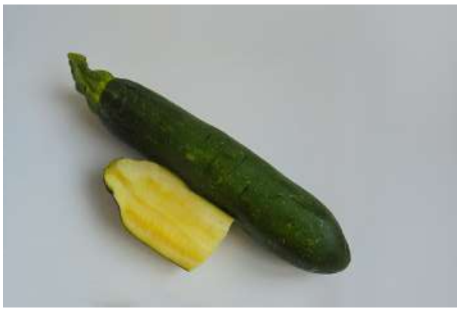




Zucchini T_7days (with Vitesy technology - left; without Vitesy technology - right)

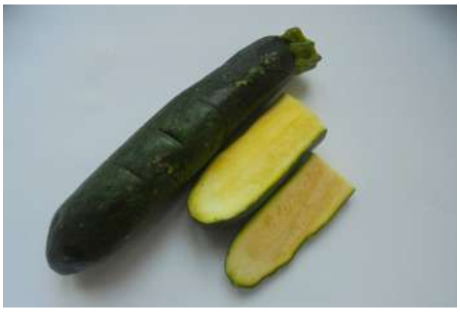
T_10days





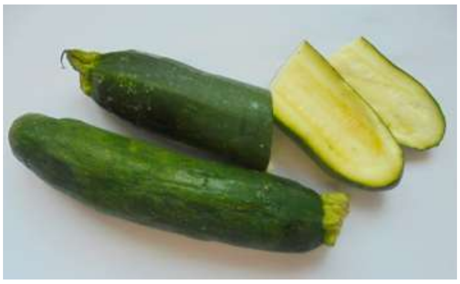
Zucchini T_10days (with Vitesy technology - left; without Vitesy technology - right)

T_14days



Zucchini T_14days (with Vitesy technology - left; without Vitesy technology - right)

T_17days

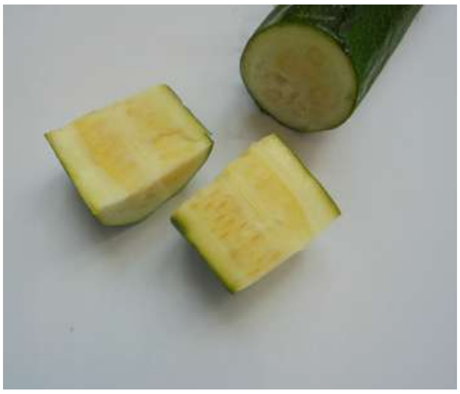


Zucchini T_17days (with Vitesy technology - left; without Vitesy technology - right)

T_22days

Zucchini T_22days (with Vitesy technology - left; without Vitesy technology - right)

T_22days



Zucchini T_22days (with Vitesy Technology - left; without Vitesy Technology - right)

For the tested product 'zucchini' regarding the microbiological analysis, the parameter found to be most significant is the **total bacterial load.** Between sample stored in refrigerator with Vitesy technology and refrigerator without Vitesy technology in terms of bacterial contamination from T_17days the product stored without Vitesy technology has a higher microbial load by about an order of magnitude than the sample kept in the refrigerator with Vitesy technology.

The evidence emerged from the organoleptic evaluations show that up until T_10days the two samples are comparable, then already from T_14days the loss of turgidity and firmness becomes more pronounced in the sample stored in the refrigerator without Vitesy technology; this difference is already evident in the appearance, but is more noticeable when cut.

In the following steps T_17days and T_22days this difference becomes even more pronounced, as shown in the photos above.

It should be noted that until the end of the study (22 days) both samples show no visible rot / stains or mold. Despite the prolonged storage, this should be attributed to the product's own characteristics and to the quality and freshness of the raw material used in the study.

CONCLUSIONS

The evidence from the present study returns **encouraging results about Vitesy technology's ability to extend the shelf life of fresh food products stored in the refrigerator.**

In the foods tested in the laboratory and stored in the refrigerator with the Vitesy technology, it is observed that **bacterial and fungal contamination tend to be lower (1-2 orders of magnitude) over the time period monitored** than the respective products kept in the refrigerator without the Vitesy technology.

(*) depending on the sensory characteristics (in particular: color/appearance - texture), 'acceptable' is meant as the product that although no longer presents the typical characteristics of fresh food is still considered edible and usable for normal domestic use by the End Consumer.

The organoleptic evaluations show that the the Vitesy technology is effective in slowing the aging of the tested products, postponing the appearance of wilting, softening, staining and rotting.

By resuming and summarizing the point considerations made for each reference, evaluations for Vitesy technology's effect on prolonging the product's shelf life, estimated as a % increase in days of shelf life, can be developed:

Product shelf life up to ACCEPTABLE (*) level in days

PRODUCT	WITHOUT VITESY TECHNOLOGY	WITH VITESY TECHNOLOGY	VARIATION % (**)
Strawberry	3	10	70
Apricot	10	17	41
Cherry Tomato	14	22	36
Belgian Endive	3	7	57
Zucchini	10	22	55

(**) Calculated as: [(no. days WITH – no. days WITHOUT)/(no. days WITH)] x100

It is important to emphasize that the reported indications are for the experimental conditions adopted in the study, thus related to the storing temperature and even more to the quality (microbiological and of freshness) of the raw materials used to conduct the study.

TEXTURE ANALYSIS WITH VITESY TECHNOLOGY

Case Study with Zucchini Using Eco Mode

PREMISE

Texture is a key indicator of freshness and overall quality in fruits and vegetables. A firm and crisp texture is typically associated with recently harvested produce, while loss of firmness signals the onset of aging, moisture loss, and degradation of structural integrity. Monitoring texture over time allows for an objective assessment of how preservation technologies can extend the shelf life and maintain the sensory appeal of fresh foods.

SETUP

Before the test, both refrigerators (240 liters), identical in model and both set to 4°C, were thoroughly cleaned and disinfected. **Refrigerator 1** – Control (no Vitesy Technology); **Refrigerator 2** – Equipped with Vitesy Technology **in Eco Mode**

The food items were sourced from a local vendor on the day in which the test started**. 30 zucchinis** were used, together with **8 apples**, used to increase the ethylene effect in the storage environment. Three sampling points were defined: **T0 (baseline), T8 days, and T16 days**. At T0, a total of **6 zucchini** were analyzed. At both T8 and T16, **6 zucchini from each refrigerator** were tested.

During each sampling, **texture analysis** was performed following the method described by **Bourne, M. C. (1966). "Measure of Shear and Compression Components of Puncture Tests", Journal of Food Science, 31, 282.**

The data obtained from the physico-chemical analyses were statistically evaluated using **One-Way Analysis of Variance (ANOVA).** When significant differences were found, **Tukey's post hoc test** was applied to compare means.

RESULTS

The results are presented in **Table X.**

Table X – Physico-Chemical Evaluation of Zucchini Texture – Mean ± SD [N]

REFRIGERATOR	SAMPLING TIME	TEXTURE [N] (MEAN ± SD)
1 – Control	T0	382.3 ± 88.6
	T8	329.7 ± 76.1
	T16	152.6 ± 40.7
2 – ECO Mode	T0	382.3 ± 88.6
	T8	337.0 ± 55.3
	T16	294.8 ± 103.9

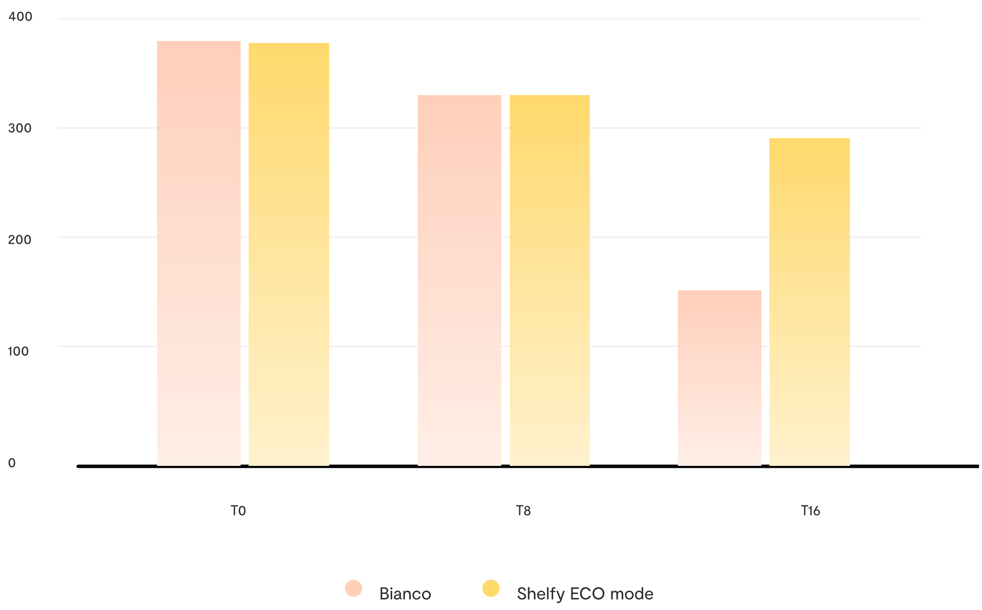
Texture Statistical Comparison Between Treatments (Tukey's Test)

At **T0**, the texture values for both refrigerators are identical, as they refer to the same initial sample batch.

Statistical Analysis

The statistical evaluation of texture over time showed the following significance levels, summarized in following **Table** and illustrated in Figure Y.

SAMPLING TIME	REFRIGERATOR 1 (CONTROL)	REFRIGERATOR 2 (VITESY)	NOTES
T0	a	a	–
T8	b	a	Texture in Fridge 1 < Fridge 2
T16	c	a	Texture in Fridge 1 < Fridge 2



CONCLUSIONS

Texture analysis at T8 and T16 revealed a statistically significant difference between zucchinis stored in the refrigerator equipped with Vitesy Technology in ECO mode and those stored in the control refrigerator.

At T0, T8, and T16, the texture values for zucchinis in Refrigerator 2 (Shelfy ECO) did not show statistically significant differences over time, indicating better preservation.

Zucchinis stored in Refrigerator 1 (Control) experienced a texture decrease of approximately 60% over 16 days, which is three times greater than the reduction observed in Refrigerator 2, where the decrease was around 20%.

The reduction in texture indicates the onset of the aging process, during which the pulp becomes softer and loses its initial firmness and crispness.

At day 16, the texture of zucchinis stored in Refrigerator 2 (with Shelfy in ECO mode) was 1.9 times higher than that of zucchinis in the control fridge.

MOLD ANALYSIS OVER TIME WITH VITESY TECHNOLOGY

Case Study with Kiwis, Strawberries, Apricots and lemon slices

PREMISE

Mold growth was monitored throughout the storage period. The analysis focused on the development of visible mold on the surface of the produce at different time intervals. Regular inspections were carried out to assess the extent of mold formation, with observations recorded at key points during the test period. The objective was to evaluate how the preservation technology impacted mold growth compared to the control conditions.

SETUP

Before the test, both refrigerators (240 liters), identical in model and both set to 4°C, were thoroughly cleaned and disinfected. **Refrigerator 1** – Control (no Vitesy Technology); **Refrigerator 2** – Equipped with Vitesy Technology in Performance mode. In each test, we ensured that both refrigerators contained the same number of food items, which were then monitored over time to assess changes in quality and spoilage.

Test 1 - Kiwi (with standardized cuts)

Test 2 - Strowberries

Test 3 - Apricots

Test 4 - Lemons (standardized slices)

RESULTS

The data demonstrated a slowing down of fungal activity in refrigerators equipped with Vitesy technology. The percentage of spoiled fruits in the refrigerators containing Vitesy technology was lower. Specifically, the following observations were made:

① On **day 21, apricots** showed mold growth in 1 out of 3 fruits in the control fridge, while in the fridge with Vitesy technology, only 1 out of 10 fruits showed mold. Vitesy technology allows 3 times more mold-free apricots after 9 days.

② **Kiwis** with Vitesy technology, properly superficially cut with a sterilized knife at each incision, experienced a **delay in mold growth of 4 days.**

③ **On day 9, strawberries** in the control fridge showed mold on 71% of the fruits, whereas in the fridge with Vitesy technology, only 8% were moldy. By day 14, this trend continued, with nearly 90% of strawberries moldy in the control fridge compared to less than half in

Test conducted in collaboration with Università degli Studi di Udine the fridge with Vitesy technology. In a subsequent test, the trend was confirmed (day 10: 67% vs 20%). Vitesy technology allows 6-8 times more mold-free strawberries after 9 days.

④ **On day 13, lemon slices,** carefully cut with a sterilized knife at each incision, showed only 30% mold growth in the fridge with Vitesy technology, while in the control fridge, 50% of the slices had mold. This resulted in a **40% lower mold growth in the fridge with Vitesy technology compared to the control.** Vitesy technology allows almost 2 times more mold-free lemon slices after 13 days.

CONCLUSIONS

The numbers in the tests are not always the same across the various variables. However, the positive impact of the technology consistently shows the same trend, demonstrating its effectiveness in reducing spoilage and extending the freshness of the produce.

OBSERVATIONAL ANALYSIS OF FOOD WITH AND WITHOUT VITESY TECHNOLOGY

Case Study with Red chicory and Broccoli

SETUP

Before the test, both refrigerators (240 liters), identical in model and both set to 4°C, were thoroughly cleaned and disinfected. Refrigerator 1 – Control (no Vitesy Technology); Refrigerator 2 – Equipped with Vitesy Technology in Performance mode. In each test, we ensured that both refrigerators contained the same number of food items, which were then monitored over time to assess changes in quality and spoilage.

→ Test 1 - Red chicory

→ Test 2 - Broccoli

RESULTS

Red chicory day 0


Red chicory T_0days (with Vitesy technology - left; without Vitesy technology - right)

Red chicory day 3


Red chicory T_3days (with Vitesy technology - left; without Vitesy technology - right)

Red chicory day 9

Red chicory T_9days (with Vitesy technology - left; without Vitesy technology - right)

Red chicory day 11

Red chicory T_11days (with Vitesy technology - left; without Vitesy technology - right)

Red chicory day 19

Red chicory T_19days (with Vitesy technology - left; without Vitesy technology - right)

Red chicory T_19days (with Vitesy technology - left; without Vitesy technology - right)

Broccoli day 0

Broccoli T_0days (with Vitesy technology - left; without Vitesy technology - right)


Broccoli day 4

Broccoli T_9days (with Vitesy technology - left; without Vitesy technology - right)


Broccoli day 15

Broccoli T_15days (with Vitesy technology - left; without Vitesy technology - right)


Broccoli day 20

Broccoli T_20days (with Vitesy technology - left; without Vitesy technology - right)

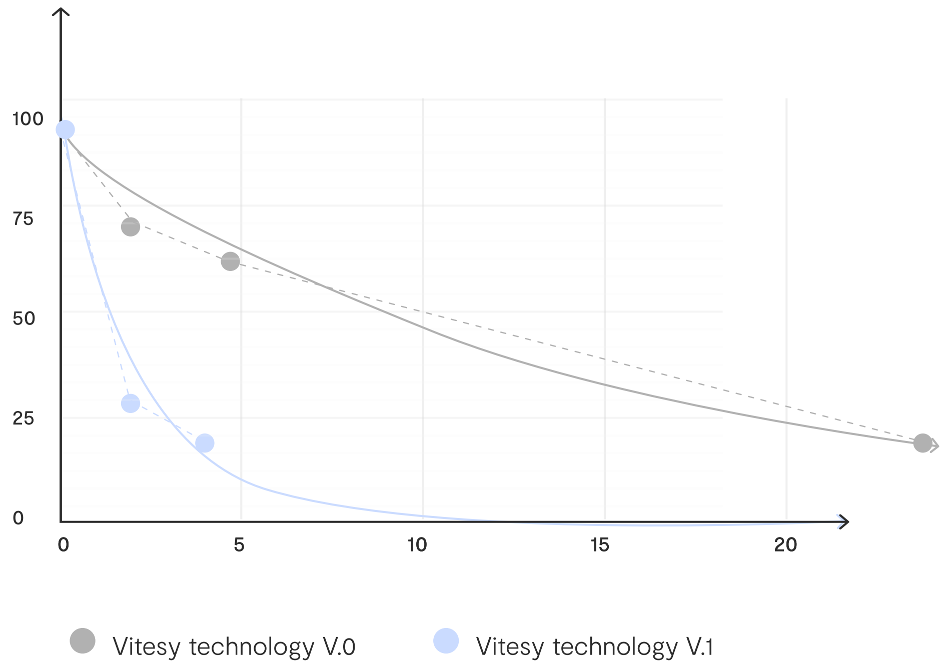

CONCLUSIONS

The observational tests highlighted promising outcomes when using the Vitesy Technology. Compared to the control, food items stored with Vitesy technology showed delayed signs of spoilage and overall better preservation of quality.

VITESY TECHNOLOGY: V.0 VS V.1

The tests were carried out in collaboration with third-party laboratories, following protocols jointly developed to ensure reliability and scientific rigor.

Comparison of Hexanal Degradation Velocity



Static Degradation Evaluation

STRAIN: BACILLUS ATROPHAEUS	Percentage reduction compared to the untreated sample in the dark after 6 hours of illumination (4 hours on the contaminated side + 2 hours on the opposite side).
Reduction v.0	2.1 log (99.2 %)
Reduction v.1	4.1 log (99.992%)

VITESY