

Decontamination studies on ready-to-eat strawberries

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Actual trends of nutrition seeks the consumption of fresh food and more demanding from conscious consumers

Fresh fruit and vegetables



Why Ready-to-eat fruits and vegetables?

Minimal processes: washing, cutting, disinfection

Fast-paced and healthy lifestyle



Packaged under modified atmosphere



**These products should
also be safe foods**

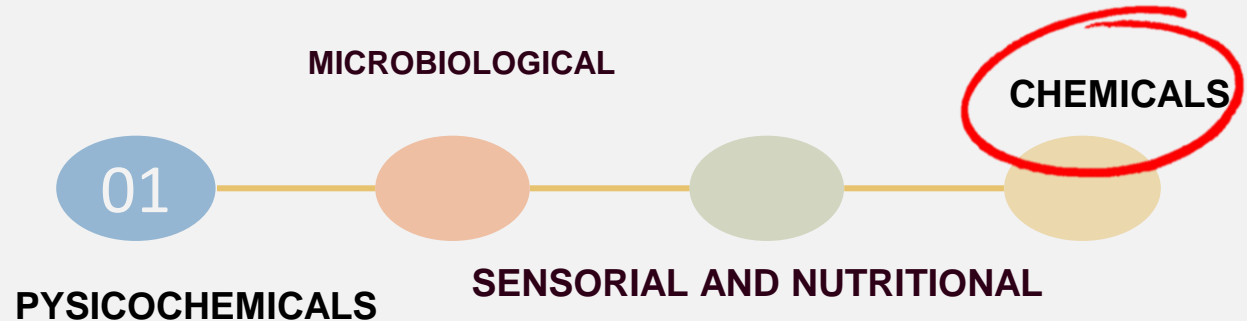


But, what happens with the
intrinsic chemical
contamination a fresh food
could have?

FOOD SAFETY

“Food safety refers to all those risks associated with food that can affect people's health, either due to natural risks, such as those caused by contamination, either chemical, biological, due to the incidence of pathogens, or that can increase the risk of chronic diseases such as cancer, cardiovascular ones and others”.

FAO, WHO



Safety of RTE F&V: Chemical Contamination

**Major demand
of food**

Safety of RTE F&V: Chemical Contamination

**Major demand
of food**

**Development of
chemical
packages**

Safety of RTE F&V: Chemical Contamination

**Major demand
of food**

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graph TD; A[Major demand of food] --> B[Development of chemical packages]; B --> C[Increase on the use of agrochemicals];
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The diagram consists of three stacked, rounded rectangular boxes on the left side of the slide. The top box is yellow and contains the text 'Major demand of food'. The middle box is light blue and contains 'Development of chemical packages'. The bottom box is also light blue and contains 'Increase on the use of agrochemicals'. Curved arrows point from the bottom of the yellow box to the top of the light blue box, and from the bottom of the first light blue box to the top of the second light blue box, indicating a downward flow of influence or causality.

**Development of
chemical
packages**

**Increase on the
use of
agrochemicals**

Safety of RTE F&V: Chemical Contamination

**Major demand
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**Development of
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How
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Safety of RTE F&V: Chemical Contamination

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**Maximum
Residue Levels:
MRLs**

The maximum concentration of pesticide residues permitted or legally acceptable in a food, either of animal or agricultural origin (FAO, 2002).

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- **Controls by authorities**

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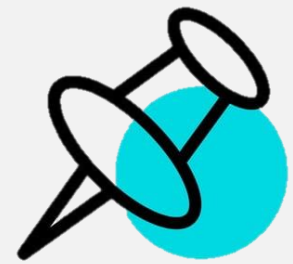
**Maximum
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MRLs**

**The maximum concentration of
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**RTE F&V are
consumed as such.**

- **Respect GAPs.**
- **Controls by authorities**

Aim of Minimally Processed Foods (MPFs)



Keep the safety of foods with high water activity that will be minimally processed and ensure consumers protection, while keeping all the food nutritious properties

Goal of the work



To evaluate some Minimal Process and their incidence on the microbiological, sensory and the pesticide residues concentration as well as their possible transformation products when applied to FRESH STRAWBERRIES



**Gold medal as the
consumed fresh fruit
with more number of
pesticide residues.**

¿Why Strawberries?

Dirty Dozen™

EWG's 2021 Shopper's Guide to Pesticides in Produce™



1. Fresas



2. Espinaca



3. Col rizada, berza
y hojas de mostaza



Work strategy



01

**Analytical
methodology**

02

**Effect of
minimal
processing
operations**

**Effect of modified
atmosphere**

Results

03

04



To develop an Analytical methodology

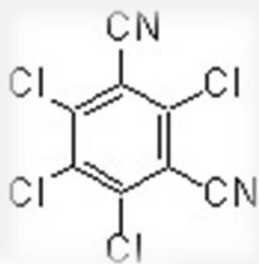


01

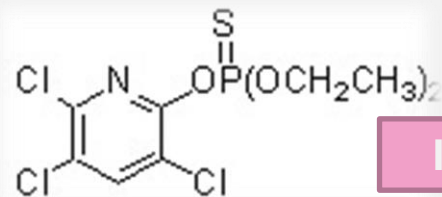
- Defined Scope
- Validated method: Sampling Procedure
Preparation Method
Instrumental Adjustment
Figures of merit for the specific methodology

HOW TO DEFINE THE SCOPE?



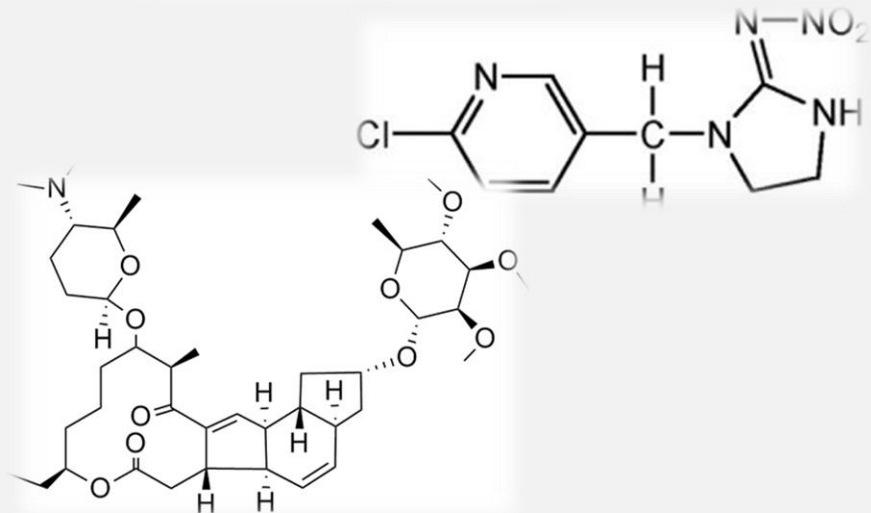
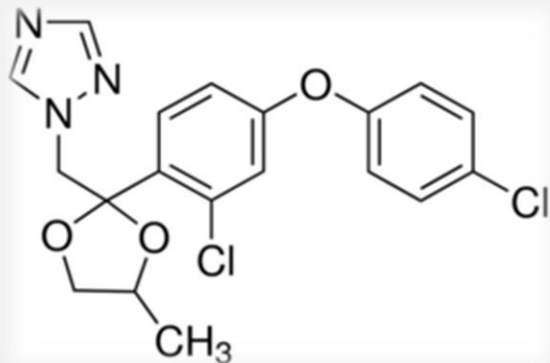
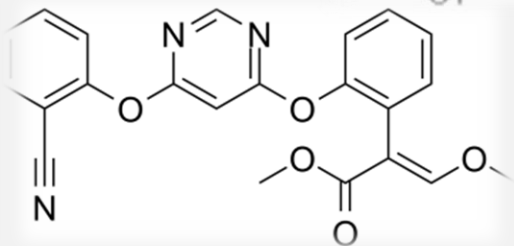


HOW TO DEFINE THE SCOPE?

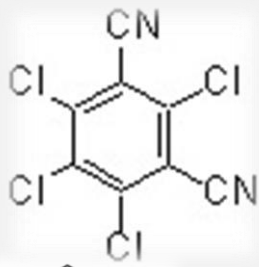


Insecticides

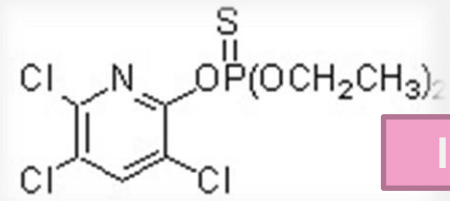
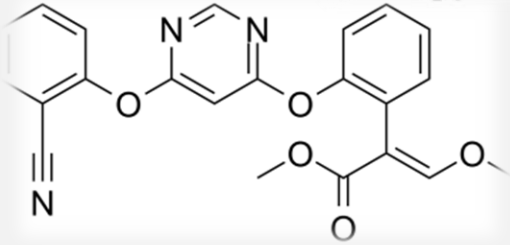
Fungicides



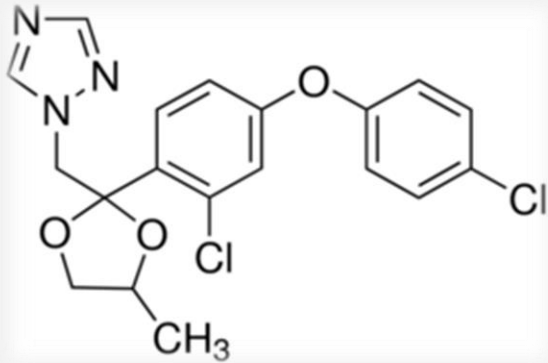
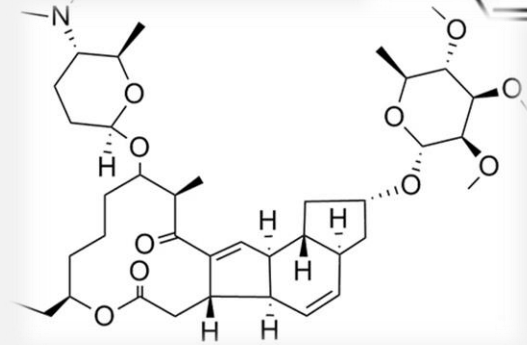
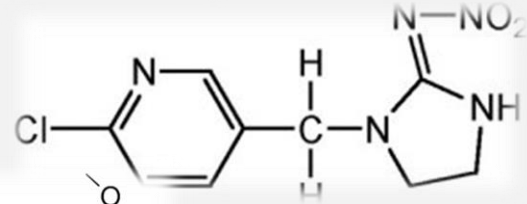
HOW TO DEFINE THE SCOPE?



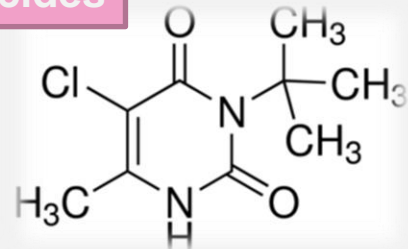
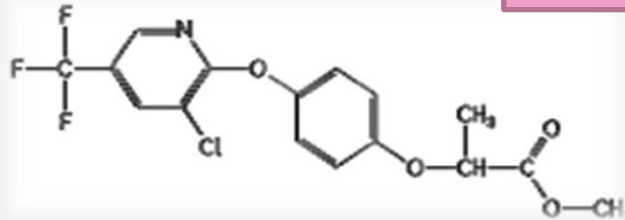
Fungicides



Insecticides



Herbicides



**Final
Scope**



Analytical methodology

10 g
strawberries +
MeCN



Hand shaken 2
min.



Buffer citrate
salts addition
and shake again.



Centrifuge 5
min. at
3500rpm



Clean-up with
PSA + MgSO₄.



Vortex 30 sec.
and centrifuge
again.



Filtered and
analyzed by
HPLC-MS/MS

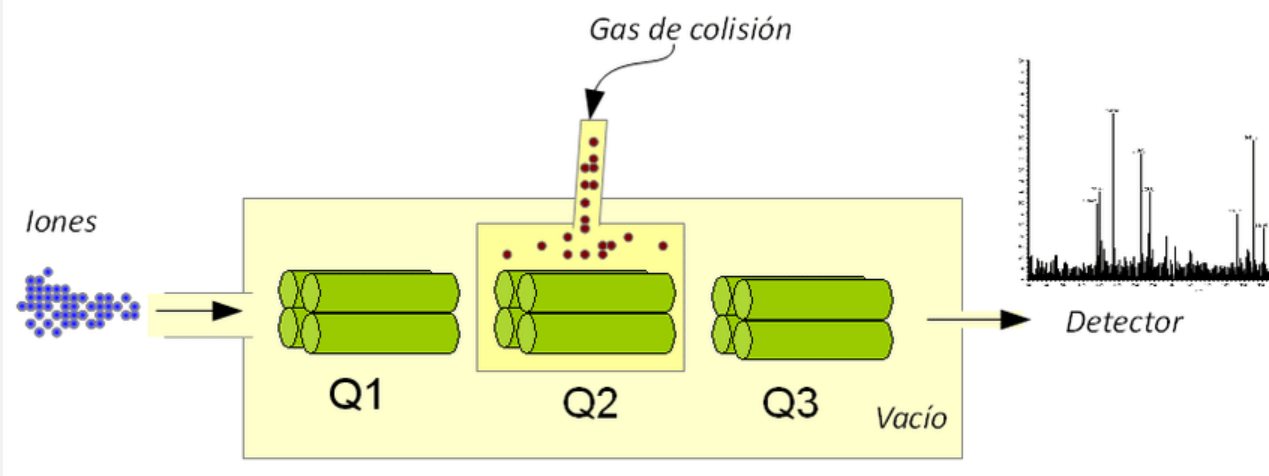


**QuEChERS citrate
method (CEN 15662)**



INSTRUMENTAL SYSTEM

QqQ WITH ACQUISITION METHOD: Multiple Reaction Monitoring (MRM)



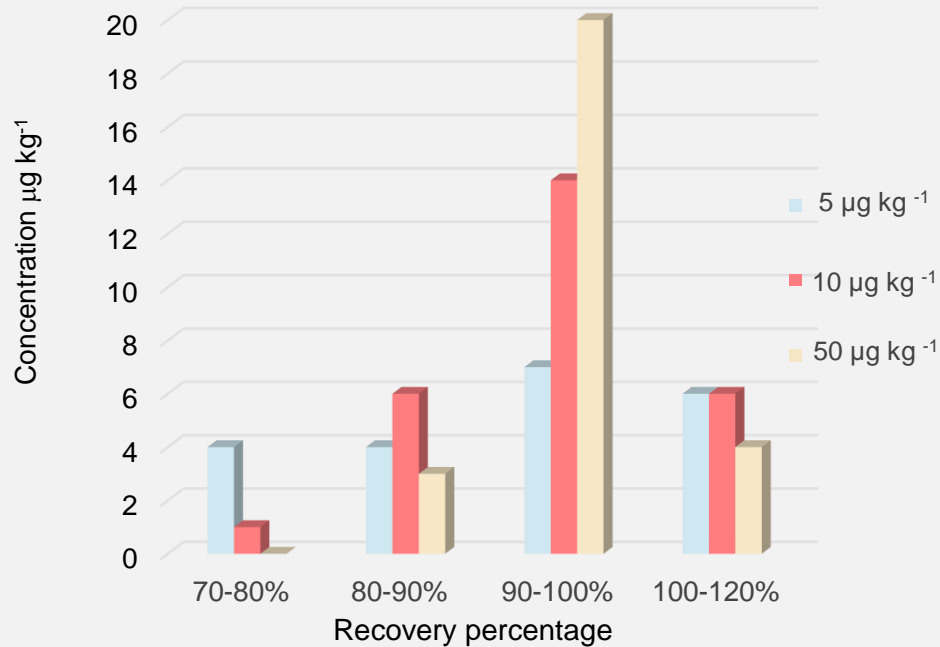
01

Analytical methodology

Validation parameters

Matrix matedched calibration curves were used for quantification

Recoveries percentages at 3 concentration levels: 5, 10 y 50 $\mu\text{g kg}^{-1}$ between 70 & 116% and DSR <20%.

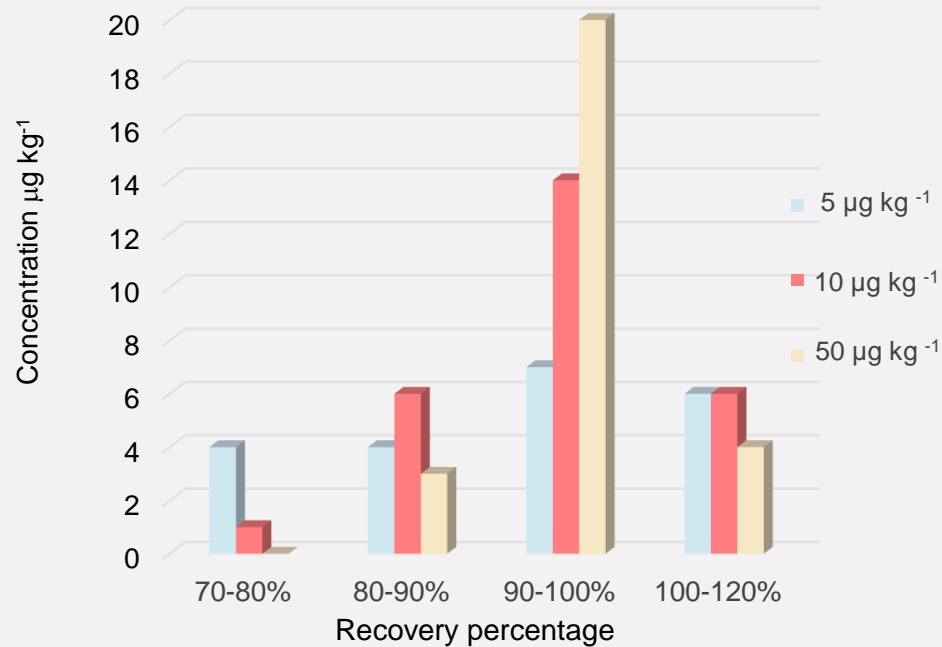


According to SANTE 12682/2019 criteria.

Matrix mated calibration curves were used for quantification

Recoveries percentages at 3 concentration levels: 5, 10 y 50 $\mu\text{g kg}^{-1}$ between 70 & 116% and DSR <20%.

Linearity range in matrix from 5 to 100 $\mu\text{g kg}^{-1}$ checked for five levels.



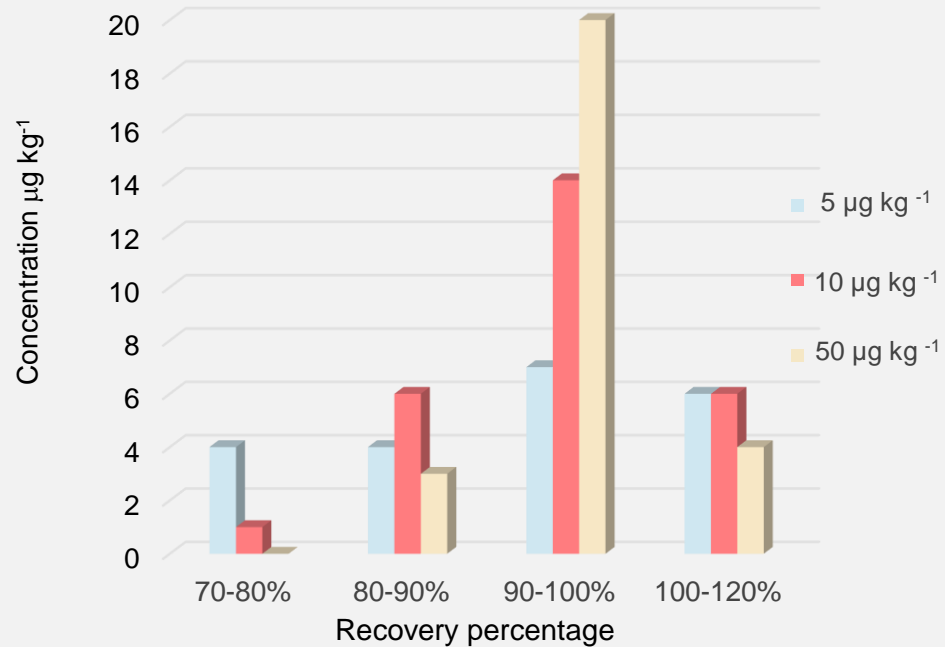
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The back calculated concentrations (BCC) were <20%.



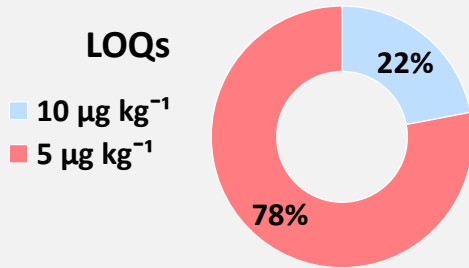
According to SANTE 12682/2019 criteria.

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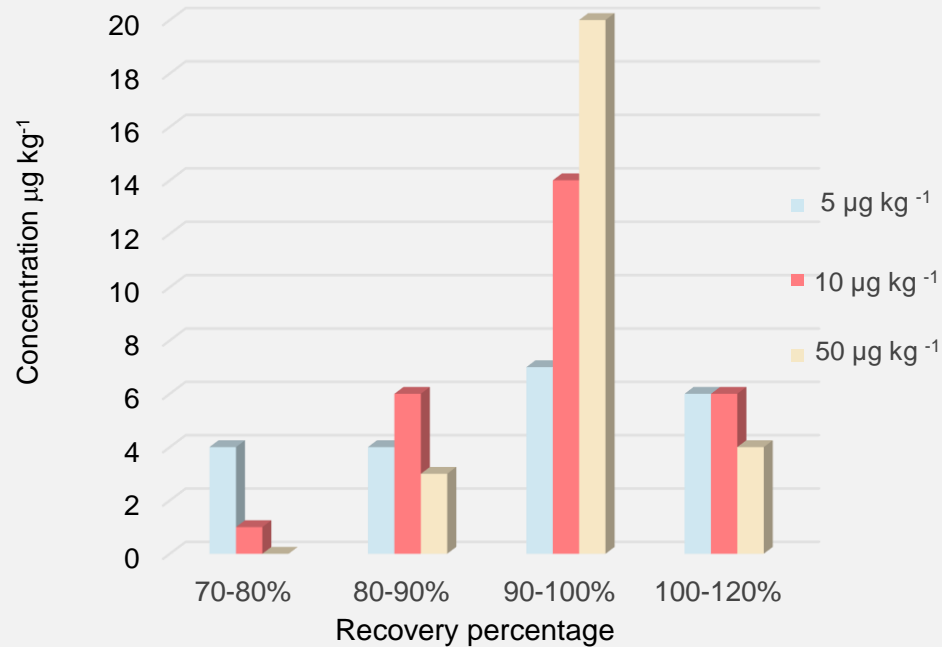
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Below the MRL's established in the Codex Alimentarius and the EU regulation.



According to SANTE 12682/2019 criteria.

02

Effect of minimal processing operations

Minimal Processing Operation evaluated



- Washing.
- Calyx removal.
- Disinfection with sodium hypochlorite for 5 minutes.
- Disinfection with peracetic acid for 1 minute.

Modified atmosphere packaging.

Minimal Processing Operations

Raw
strawberries
(with calyx)

Minimal Processing Operations

Raw
strawberries
(with calyx)



Raw
strawberries
(without calyx)



Sample for pesticide analysis
only

Minimal Processing
Operations

Raw
strawberries
(with calyx)



Raw
strawberries
(without calyx)



Sample for pesticide analysis
only

Washing



Minimal Processing Operations

Raw strawberries (with calyx)



Raw strawberries (without calyx)



Sample for pesticide analysis only

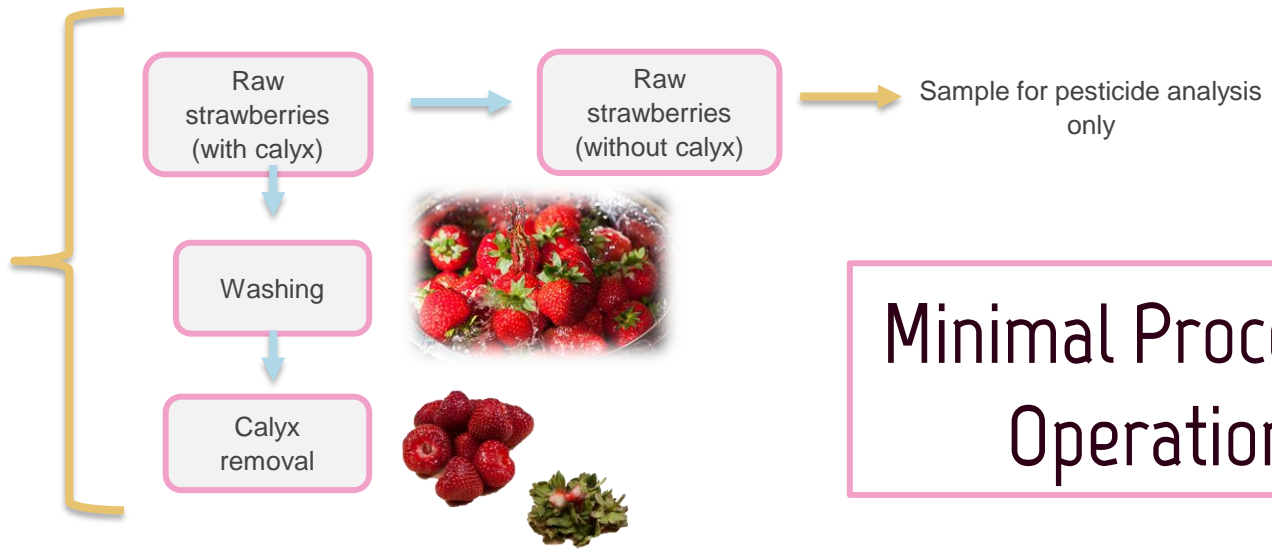
Washing

Calyx removal



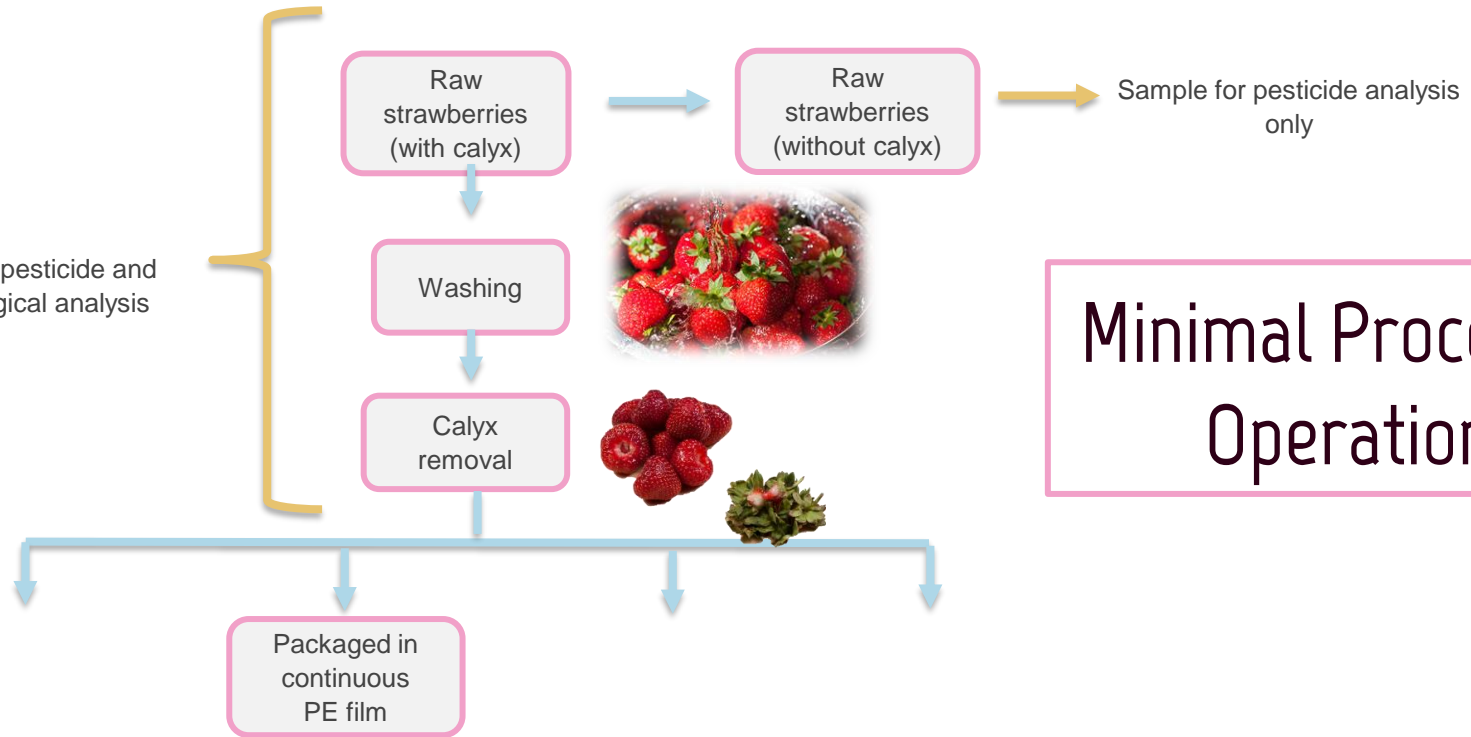
Minimal Processing Operations

Sample for pesticide and
microbiological analysis

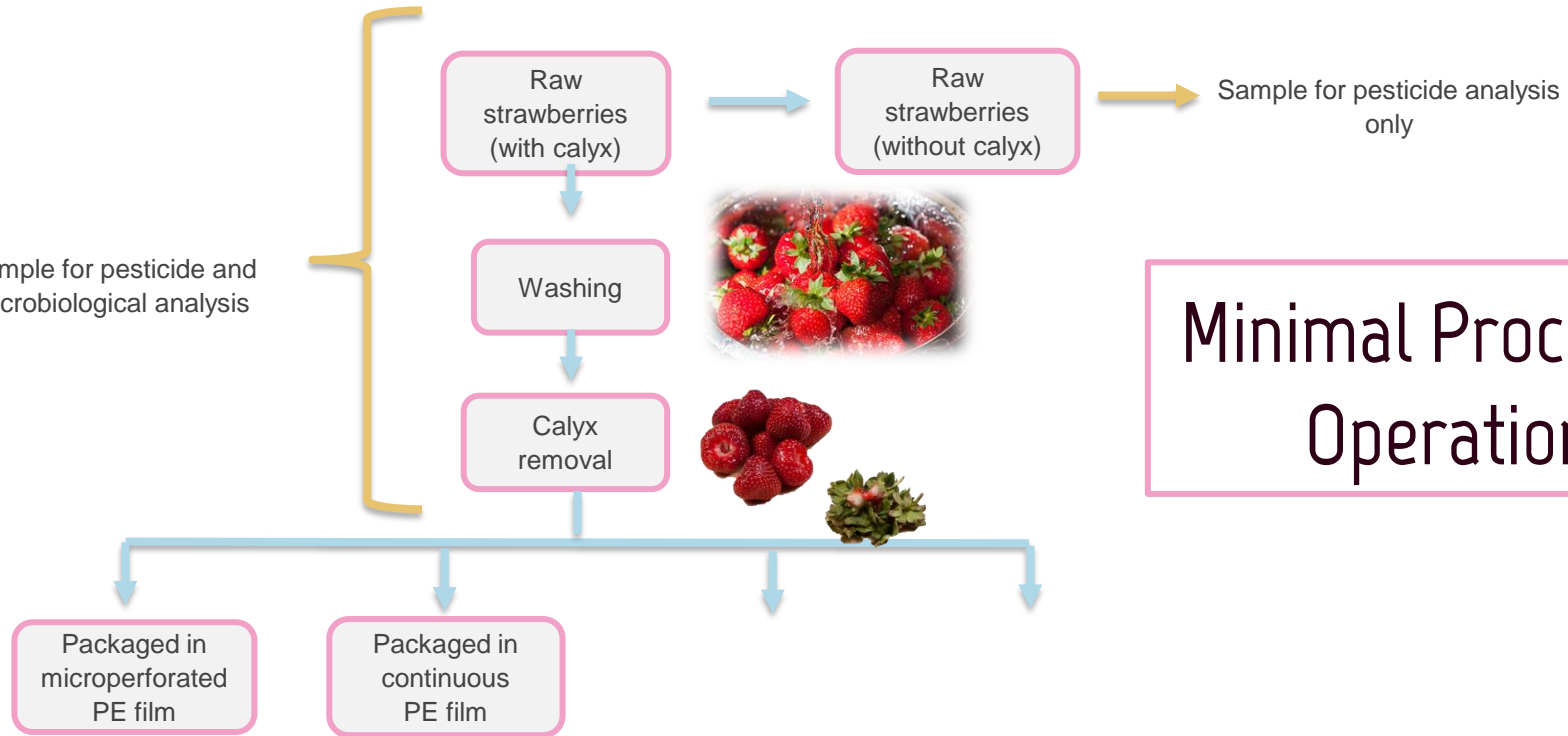


Minimal Processing
Operations

Sample for pesticide and
microbiological analysis



Sample for pesticide and
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Minimal Processing
Operations

Sample for pesticide and
microbiological analysis

Raw
strawberries
(with calyx)



Raw
strawberries
(without calyx)



Sample for pesticide analysis
only

Washing



Calyx
removal



Minimal Processing
Operations

Packaged in
microperforated
PE film

Packaged in
continuous
PE film

Disinfection
with NaClO for
5 min.



Sample for pesticide and
microbiological analysis

Raw
strawberries
(with calyx)



Raw
strawberries
(without calyx)



Sample for pesticide analysis
only

Washing



Calyx
removal



Minimal Processing
Operations

Packaged in
microperforated
PE film

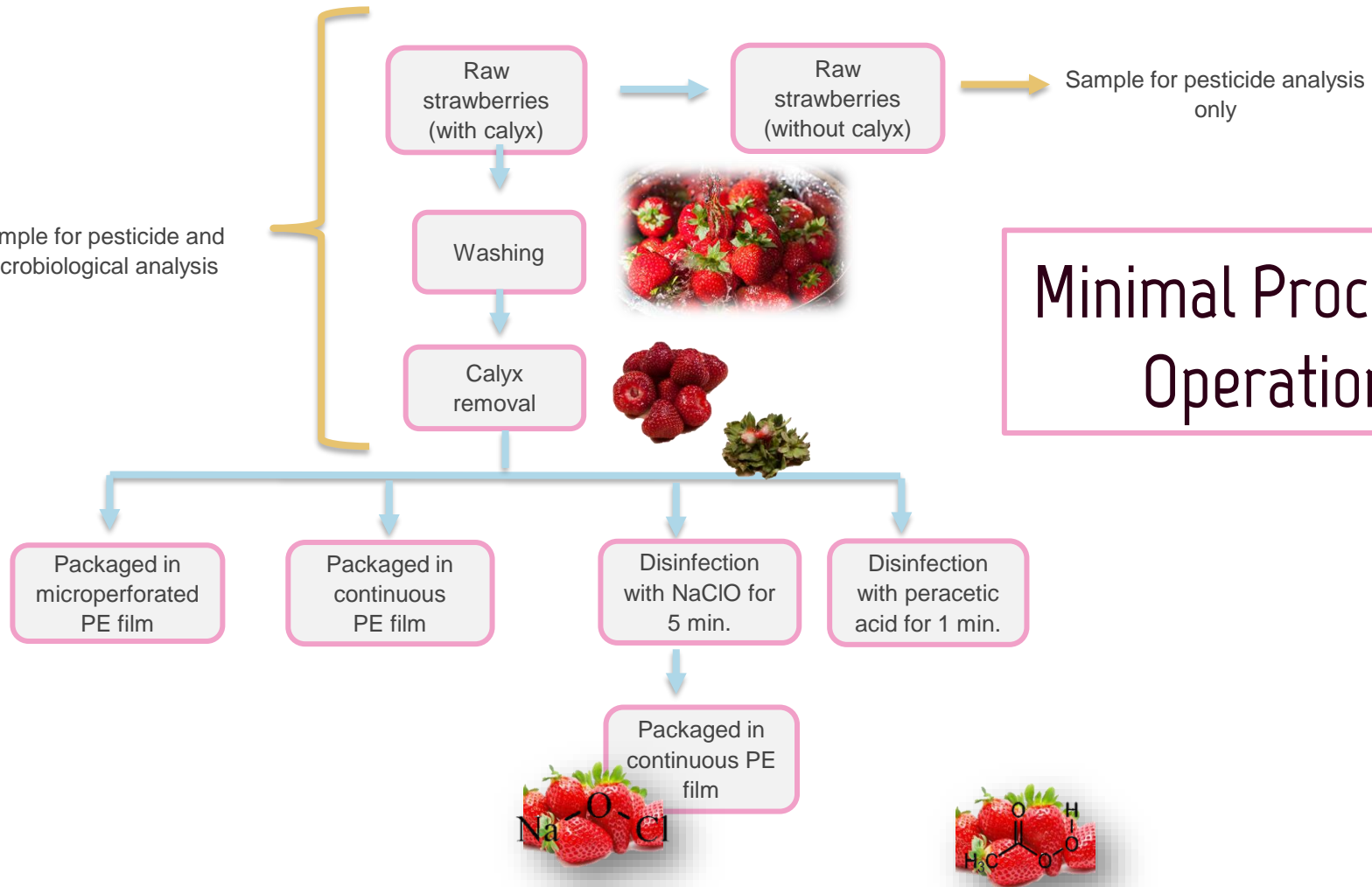
Packaged in
continuous
PE film

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with NaClO for
5 min.

Packaged in
continuous PE
film

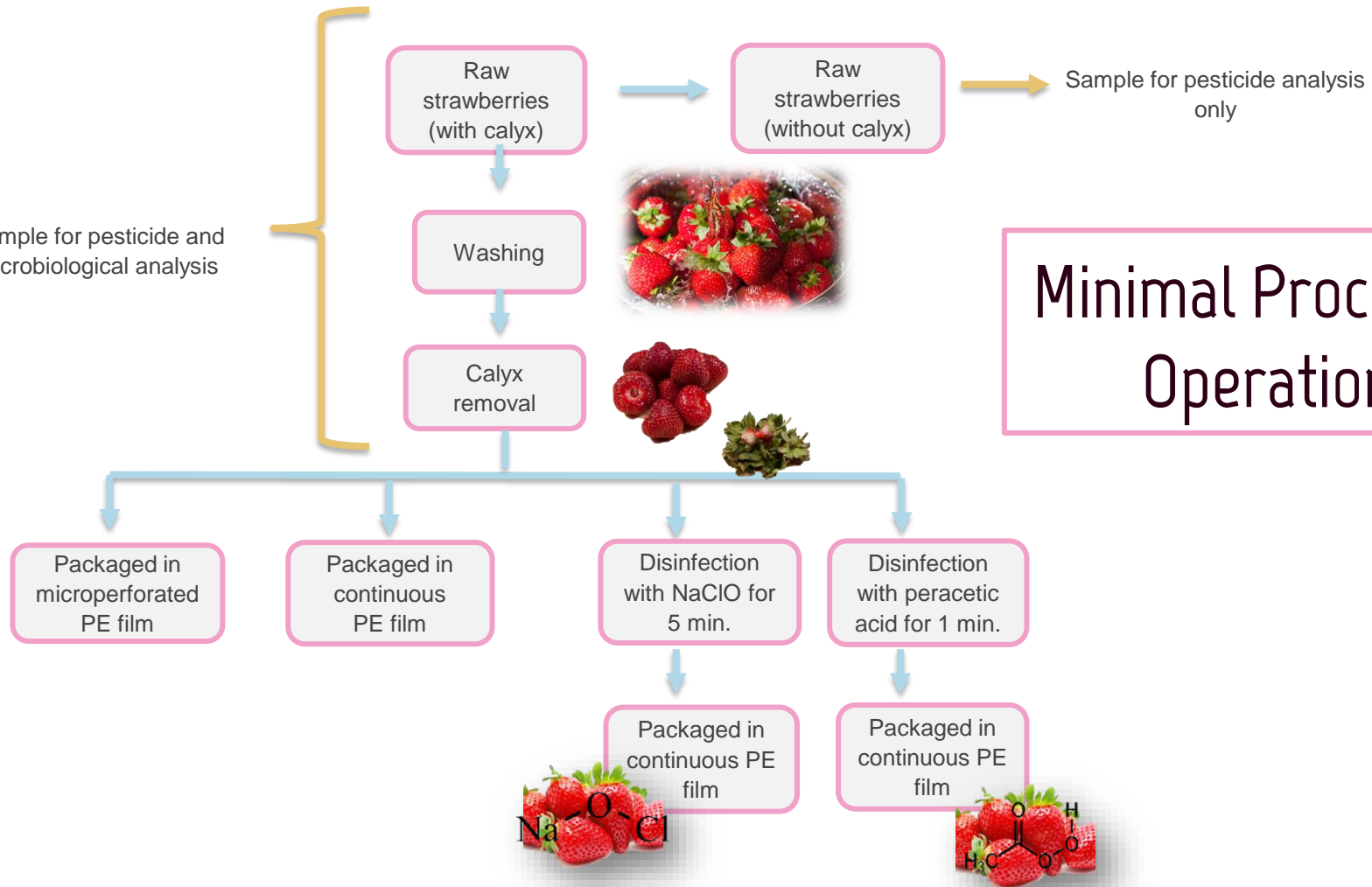


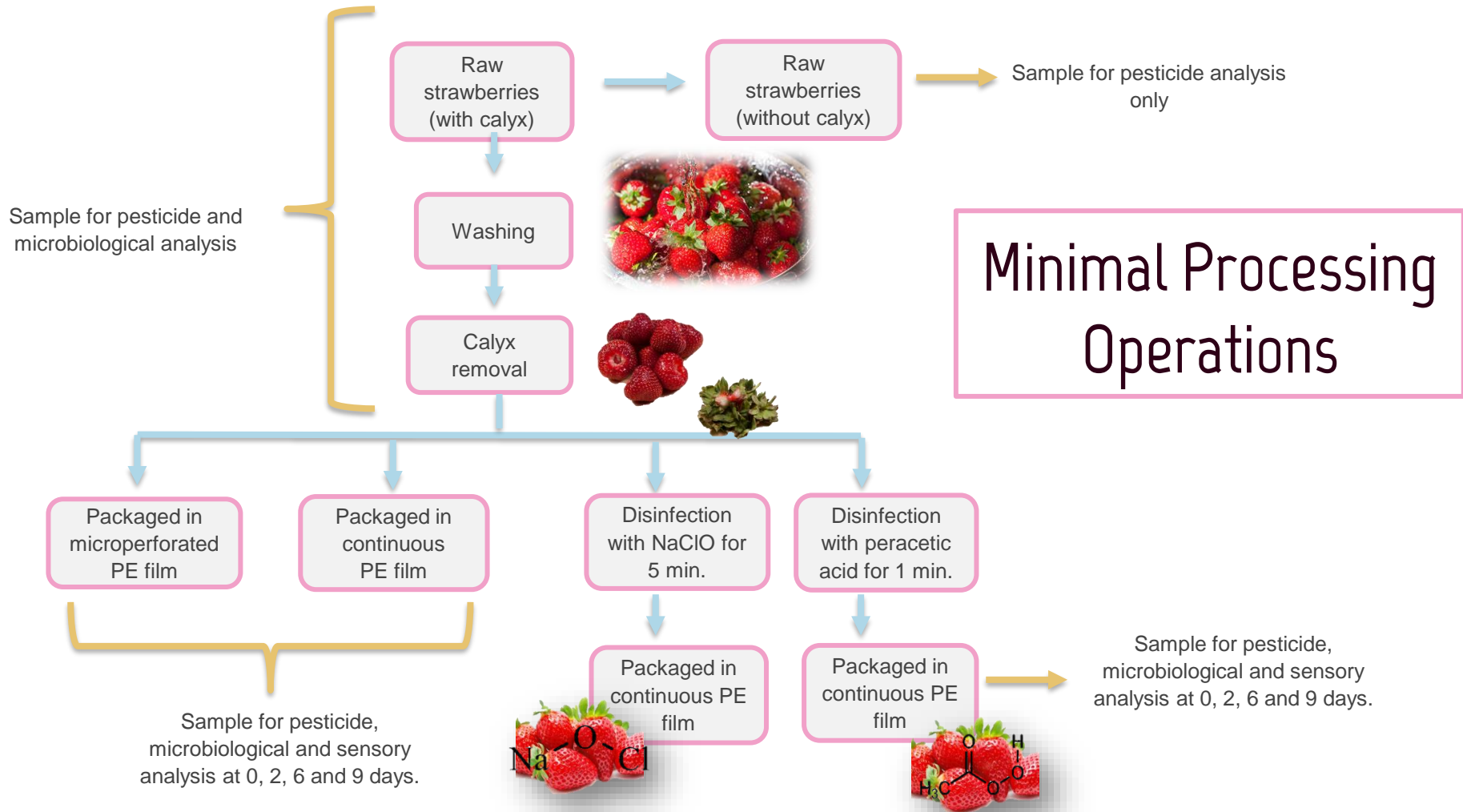
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microbiological analysis

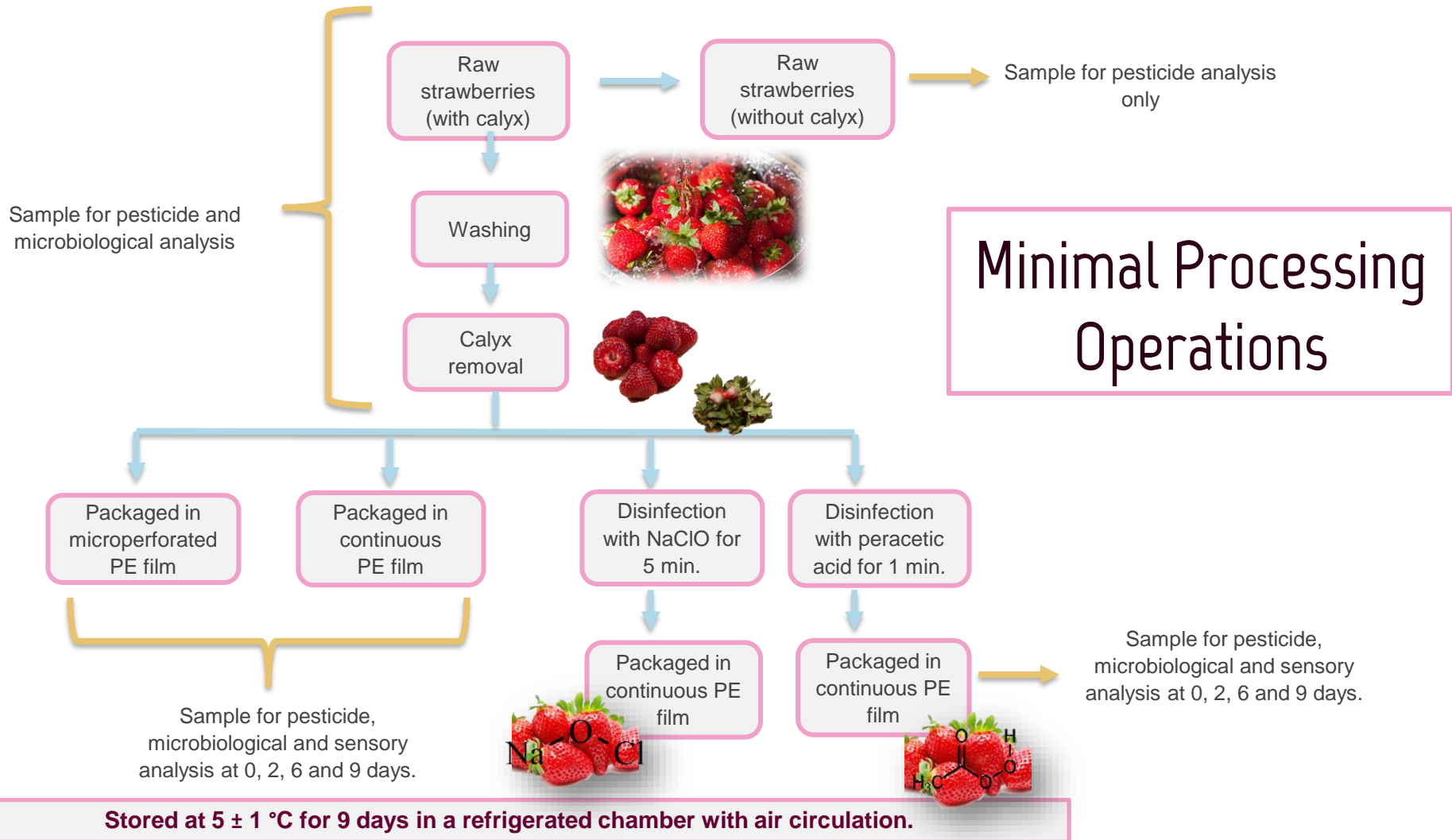


Minimal Processing Operations

Sample for pesticide and
microbiological analysis

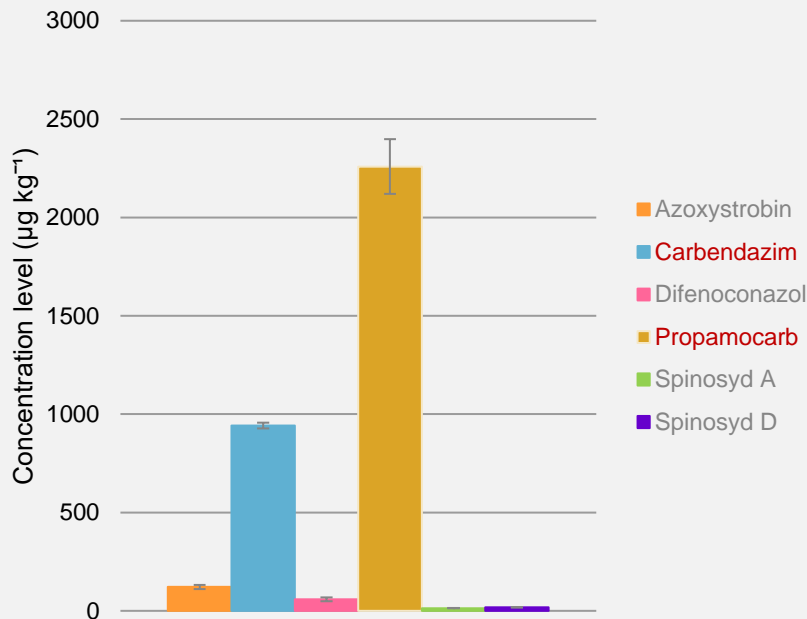






Strawberries used in this study were commercial strawberries, grown in a real field.

Pesticides found in strawberries



Pesticides found in raw strawberries

Azoxystrobin, carbendazim, difenoconazole, propamocarb and spinosad (sum of A and D) in concentration ranges of 0.005 to 2.2 mg kg⁻¹.

Only carbendazim and propamocarb exceeded the established MRL.

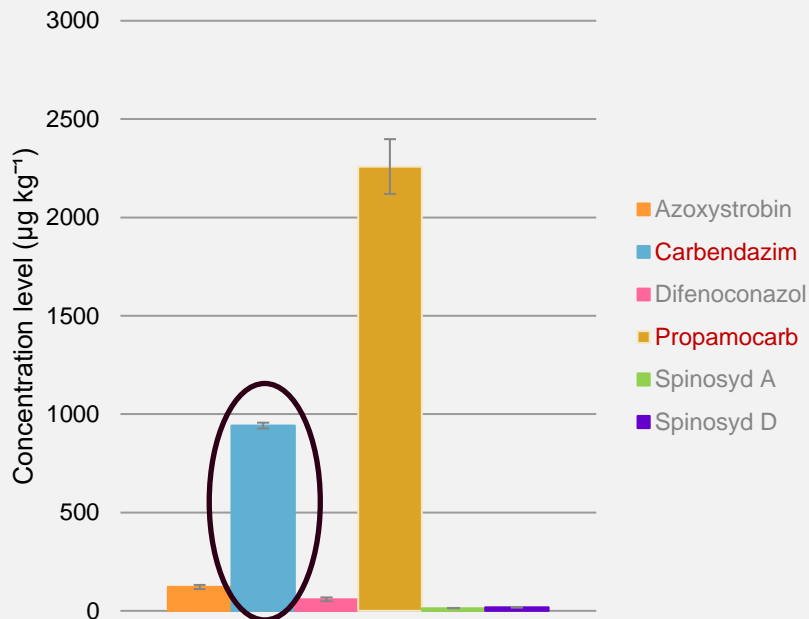
MRLs Codex Alimentarius and EU:

Propamocarb
0.01 mg kg⁻¹

Carbendazim
0.1 mg kg⁻¹

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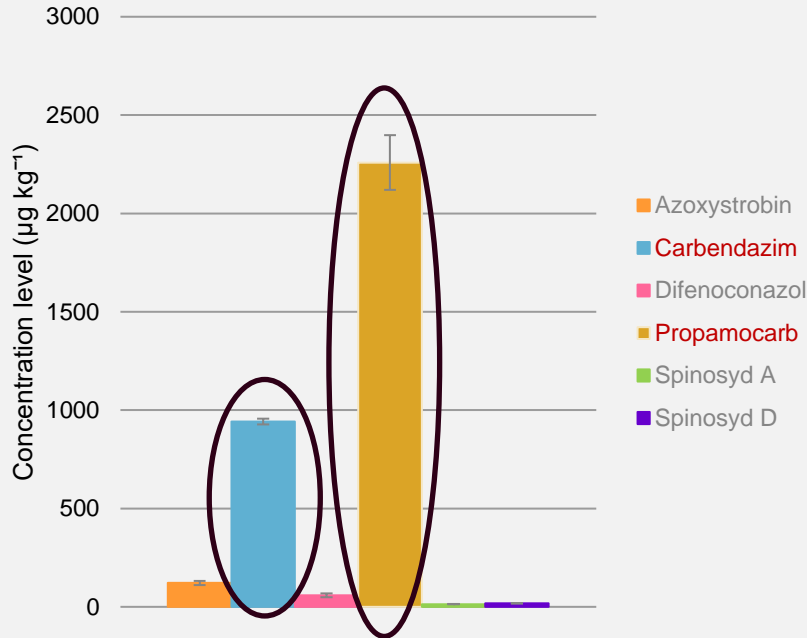
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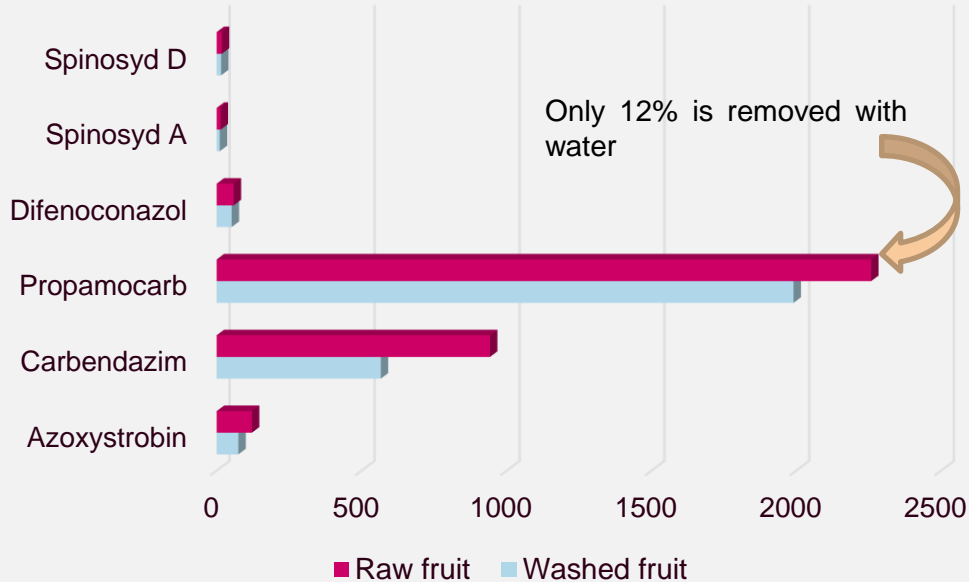
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Propamocarb
0.01 mg kg⁻¹

Carbendazim
0.1 mg kg⁻¹

Washing effects on the initial pesticide level in Strawberries



Effect of minimal processes on initial pesticide concentration

| | Pesticide Removal [%] |
|----------------|-----------------------|
| Azoxystrobin | 38.5 |
| Carbendazim | 39.9 |
| Propamocarb | 11.9 |
| Difenoconazole | 12.1 |
| Spinosyn D | 15.0 |
| Spinosyn A | 21.8 |

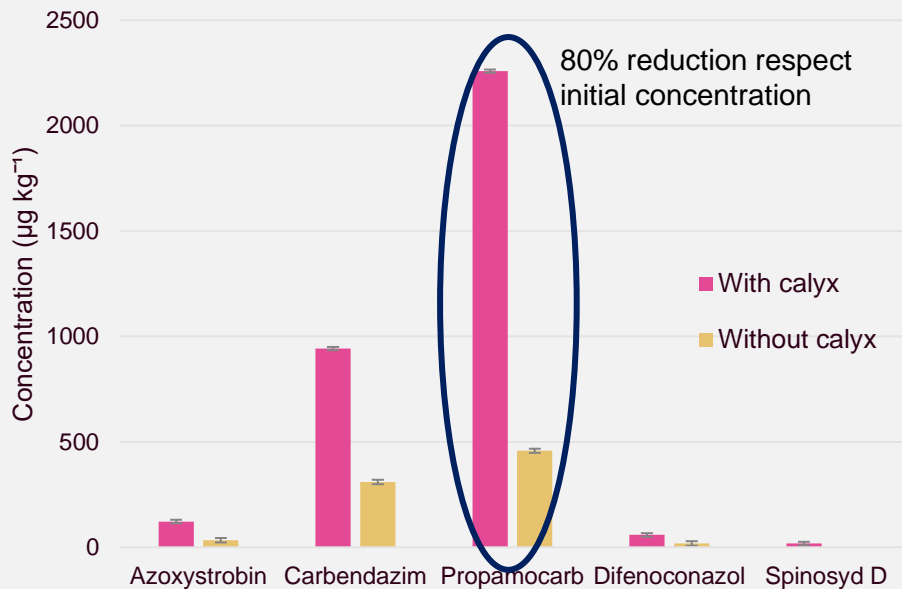


This step by itself did not show a significant change in pesticide concentration with respect to initial concentrations. Pesticide removal around 12 to 40% were registered.

Pesticides with a systemic mode of action



Calyx removal effect



Effect of minimal processes on initial pesticide concentration



| | Washing [%] | Removal calyx [%] | Washing + calyx removal [%] | Disinfection with NaClO [%] | Disinfection with peracetic ac. [%] |
|----------------------|-------------|-------------------|-----------------------------|-----------------------------|-------------------------------------|
| Azoxystrobin | 38.5 | 73.0 | 72.1 | 75.1 | 74.4 |
| Carbendazim | 39.9 | 67.2 | 76.0 | 84.2 | 80.4 |
| Propamocarb | 11.9 | 79.7 | 72.2 | 69.0 | 71.3 |
| Difenoconazol | 12.1 | 68.9 | 71.4 | 75.6 | 75.5 |
| Spinosyn D | 15.0 | 68.3 | 59.0 | <LOQ | 67.2 |
| Spinosyn A | 21.8 | <LOQ | 60.4 | <LOQ | <LOQ |

Strawberries' calyx concentrated the greatest number of pesticides. Pesticide level dropped 67 to 80% after its removal.

Effect of minimal processes on initial pesticide concentration

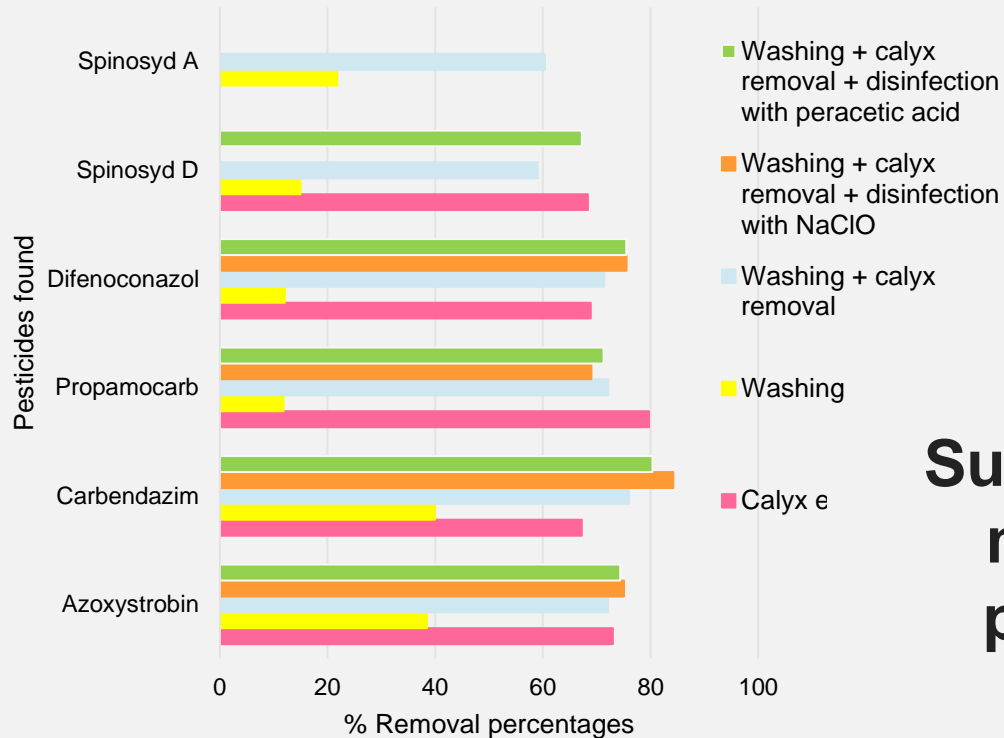
| Pesticides | Washing | Calix removal | Sanitization NaClO | Sanitization AcOOH |
|----------------|---------|---------------|--------------------|--------------------|
| | FP | FP | FP | FP |
| Azoxystrobin | 0,62 A | 0,45 B | 0,89 C | 0,92 C |
| Difenoconazole | 0,60 A | 0,40 B | 0,66 A | 0,82 C |
| Carbendazim | 0,89 A | 0,32 B | 0,85 A | 0,85 A |
| Propamocarb | 0,77 A | 0,32 B | 1,12 C | 1,04 C |
| Spinosid A | 0,76 A | 0,51 B | ND* | ND* |
| Spinosid D | 0,85 A | 0,48 B | ND* | ND* |



- **Calix removal yielded the best depletion of the initial concentration of propamocarb ($p < 0.05$)**

Effect of minimal processes on initial pesticide concentration

Pesticide removal after the different minimal processes assayed



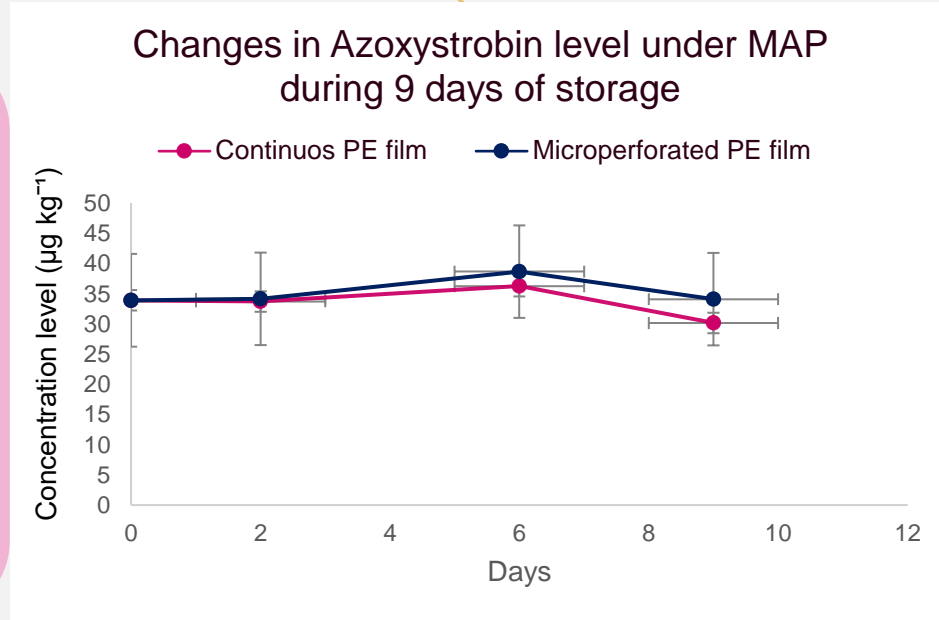
Sum of all treatments was the most efficient procedure for pesticide residues' removal.

03

Effect of modified atmosphere packaging

Effects of Modified Atmosphere Packaging

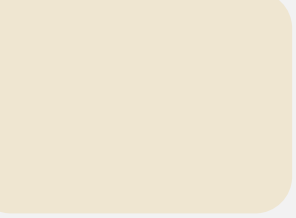
Pesticide residues' concentration remaining after minimal processing did not change throughout 9 days of storage.



MAP extended product shelf-life and did not concentrate pesticide residues.

04

Conclusions



**An analytical method was
validated to determine
pesticide residues in
strawberries
according to SANTE
Document 12682/2019**



**An analytical method was
validated to determine
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according to SANTE
Document 12682/2019**

**Residues of azoxystrobin,
carbendazim,
difenoconazole,
propamocarb and
spinosad were
determined in
commercial raw
strawberries.**



Residues of azoxystrobin, carbendazim, difenoconazole, propamocarb and spinosad were determined in commercial raw strawberries.

An analytical method was validated to determine pesticide residues in strawberries according to SANTE Document 12682/2019



Calyx removal had the highest incidence in decreasing the levels of the studied pesticide residues.

Residues of azoxystrobin, carbendazim, difenoconazole, propamocarb and spinosad were determined in commercial raw strawberries.

An analytical method was validated to determine pesticide residues in strawberries according to SANTE Document 12682/2019



Packaging under MAP conditions does not promote the variation of pesticide residues level during storage.

Calyx removal had the highest incidence in decreasing the levels of the studied pesticide residues.

Residues of azoxystrobin, carbendazim, difenoconazole, propamocarb and spinosad were determined in commercial raw strawberries.

Packaging under MAP conditions does not promote the variation of pesticide residues level during storage.

An analytical method was validated to determine pesticide residues in strawberries according to SANTE Document 12682/2019



Calyx removal had the highest incidence in decreasing the levels of the studied pesticide residues.

The whole sequence of minimal processes evaluated improved food safety and increased the final quality of RTE strawberries.



Safety
Quality
Traceability

THANK you for your
attention

cs@fq.edu.uy



I+D 2022

