UNIVERSITEIT VAN PRETORIA
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The African Academy of Sciences

Postharvest losses of Fresh produce

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UNIVERSITY PRETORIA

PRESIDENT OF THE AFRICAN ACADEMY OF SCIENCES

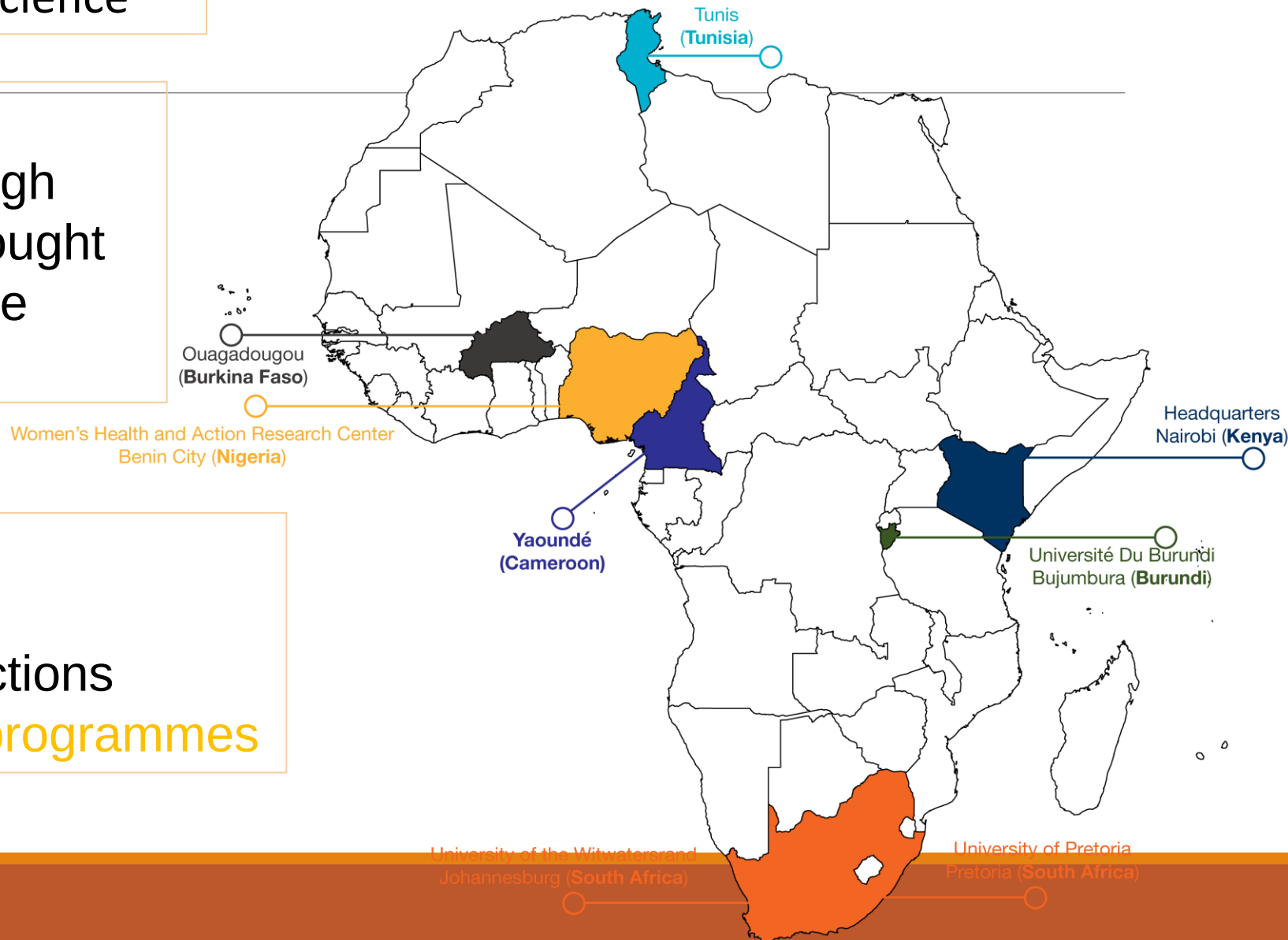
DSI-NRF
Centre of Excellence
in Food Security

About the AAS

Vision: Transform lives through science

Mission:

Leverage resources through research excellence and thought leadership for sustainable development



Tripartite mandate:

- Recognition of excellence
- Advisory and think tank functions
- Implementation of key STI programmes

ARISE

African Facts

1. More than 1/4 of the hungry in the world, live on the African continent.
2. 1/5th of people living in Africa are considered malnourished, the highest in the world.
3. South Africa ranked highest in the **food security** index in Sub-Saharan Africa 2022, (score 61.7)
4. In Africa, up to 52% of fruit and vegetables go to waste annually, the majority lost or wasted during **handling** and **storage** due to a lack of efficient refrigeration, transportation and storage facilities.
    1. But little is known about what is lost in the field.
5. **Climate change is intensifying food insecurity**
6. *If Africa can stop wasting food and reduce losses we can feed the world*

Produce Quality and Safety

Produce

Quality

Safety

Food Waste and Losses: Facts and Figures

1. The global focus of the SDG (12.3) have placed food waste and losses in the **middle of the Food Security table**.
2. Approximately 30% of fresh produce are **lost at the postharvest stage** - Is this a true reflection in SA?
   - **45% OF AVAILABLE FOOD SUPPLY** IN SOUTH AFRICA WASTED (CSIR STUDY, 2022).
   - **EstiMate 10.3 million tonnes** per annum of edible food, earmarked for human consumption is wasted.
   - This is equivalent to **34% of local food production**,
     - **But** SA is a net exporter of food, the losses and waste is thus equivalent to 45% of the available food supply in the country.
   - These results point to high levels of inefficiency in the food value chain.
     - **But** is this in the formal or informal sector
3. Mostly associated with quality parameters?
   - Physiology/ **diseases** / improper **handling or proper storage or inadequate cold chain management systems?.**
4. **Or Product recall food safety issues or regulatory aspects (SPS/ Quality etc).**

Introduction continue

Postharvest losses reduce **farmers income and food availability and affect the broader food system.**

SA FOOD WASTE FACTS

45% OF AVAILABLE FOOD SUPPLY IN SOUTH AFRICA WASTED (CSIR, 2021)

- 68% occur in early stages of production
- 19% occurring during post-harvest handling and storage,
- 49% during processing and packaging.
- 18% Food waste at the consumption

PER COMMODITY

- 50% Cereals contribute
- 19% fruit and vegetables
- 14% milk and 9% meat

https://www.eeetimes.org/2022/11/initiatives-to-generate-electricity.html

Prevalence of *Botrytis cinerea* at different berry developmental stages of table grape in South Africa

Symptoms of grey mould showing externally in table bunches at varaison in the field (A=early symptom; B=advanced stage in the field) and at the market (C)

Aim

To determine the prevalence of *B. cinerea* at different phenological growth stage (full bloom, pea size and fully mature berries)

Berries were sampled from 2 commercial farms Globalgap certified

Three vines located on the eastern and western peripheral-end and inside centre within the vineyard

For each vine three samples were collected

A total of 263 samples at:

- Full bloom (n = 47),
- pea size (n = 108)
- mature stages (n = 108)

PATRICIA C. CARMICHAEL
Previous PhD student

Results-presence of Botrytis

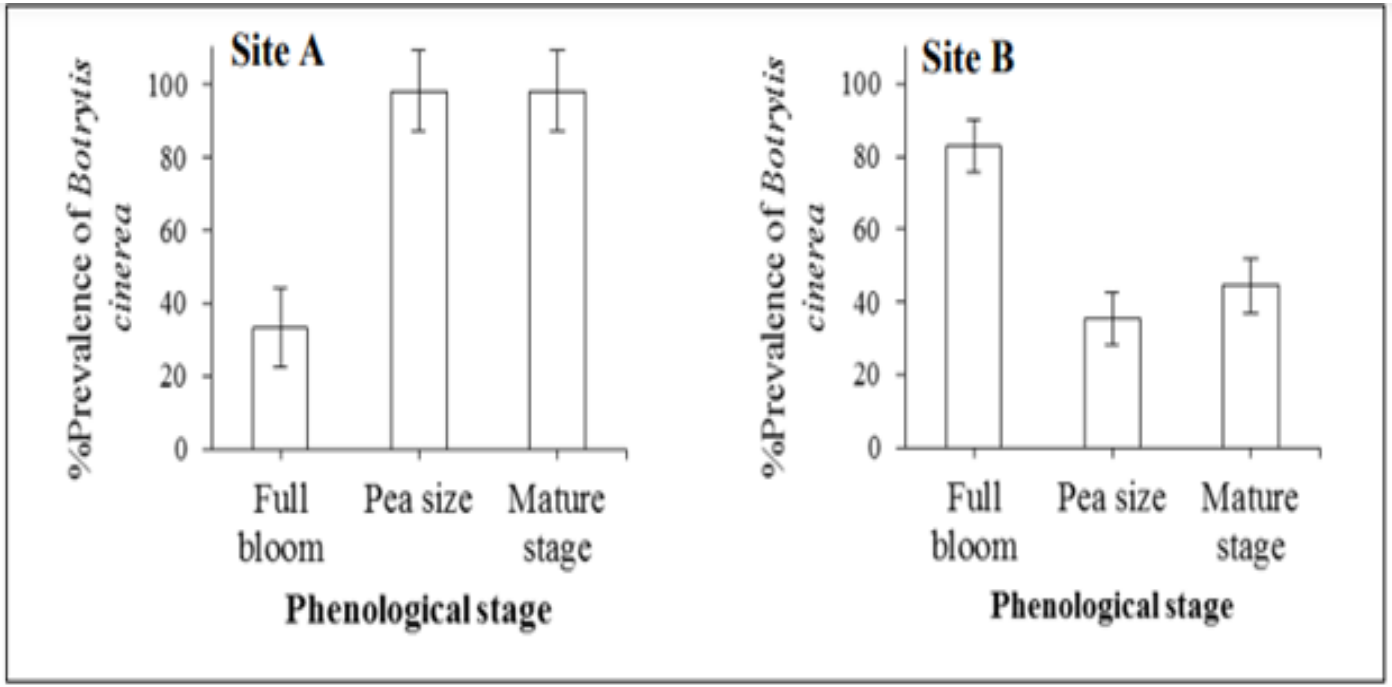


Figure 4. 1. Prevalence of *Botrytis cinerea* on table grape samples from two commercial farms at full bloom, pea size and mature stages. Error bars show standard error.

70.3 % (n=263) of the samples were positive for B. cinerea

Site A
Pea size and mature stage samples the highest prevalence (98.2 %) of B. cinerea
Bloom stage (33%)

Site B
Full bloom 83 %, pea size 35 % and mature 44 %

Prevalence of *Penicillium* species on symptomatic table grapes in South African Fresh Produce Markets

Three of the largest fresh produce markets in South Africa.
Two visits/ market

Active air sampling

Fungi was isolated and identified using ITS

The internal transcribed spacer region was amplified that includes the 5.5S rRNA gene (Schoch *et al.,* 2012).

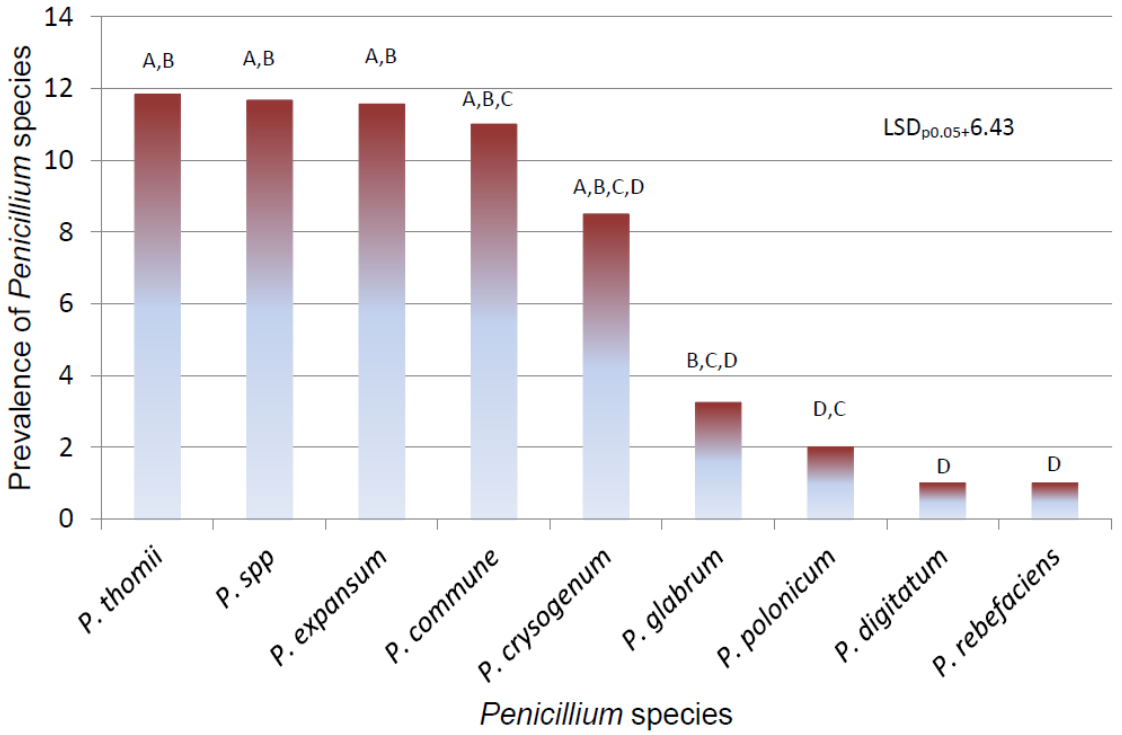
Aim

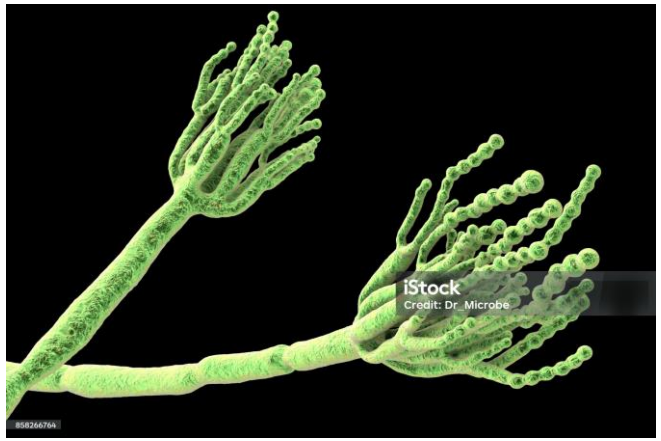
To determine the prevalence of *Penicillium* spp. in NFPM of South Africa.

Nadia Grobler
MSc graduate

Air samples

A total of **781 isolates** were purified and grouped including *Penicillium* spp. and other fungi as well as yeast colonies. In total 581 isolates were *Penicillium* spp. (74.39%).





Penicillium on table grapes

Prevalence of fungal species on symptomatic table grapes displayed in the three biggest National Fresh Produce Markets in South Africa

Genera	Species	Joburg FPM	Tshwane FPM	epping FPM
Penicillium	*brevicompactum*	+	+	+
	expansum	+	+	+
	crysogenum	+	-	+
	italicum	+	+	+
	glabrum	+	-	+
	crustosum	+	-	-
	polonicum	+	-	-
	schlerotium	+	-	-
	repensicola	-	-	+
	digitatum	-	+	-
	commune	-	+	-

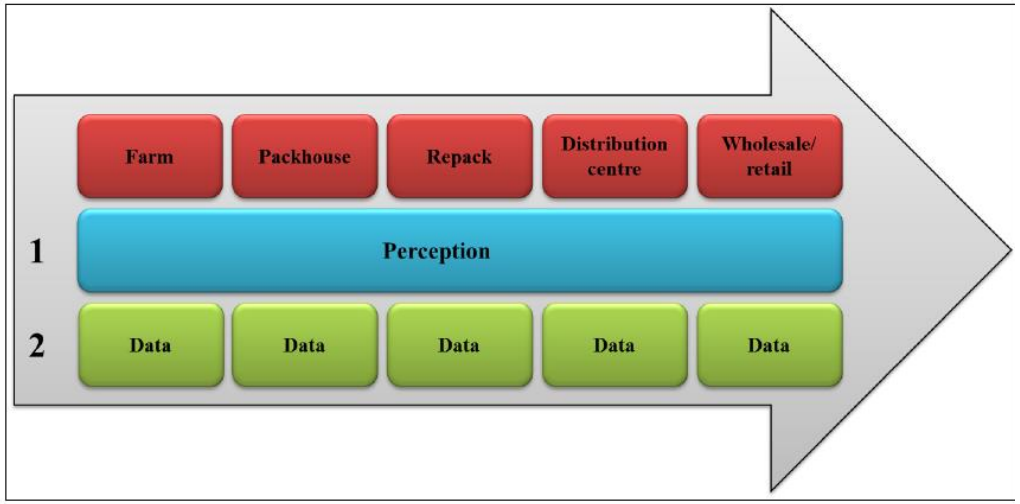
240 swabs was taken in total in the three local markets

A total of **781 *Penicillium*** and other dominant fungal colonies were counted over the one-year sampling period.

119 isolates used for further studies.

These isolates were grouped into 26 groups and 11 of these were identified as Penicillium

OPERATIONAL ANALYSIS OF FOOD LOSSES AND WASTE IN THE TABLE GRAPE EXPORT SUPPLY CHAIN



Quantitative and qualitative approaches

Data collection point	Data description

Farm	• Total production volume
	  ○ Local and export market volumes
	  ○ Waste

Pack house	• Total production received
	• Total packed
	  ○ Export market volume
	  ○ Local market volume
	• Total pack house waste

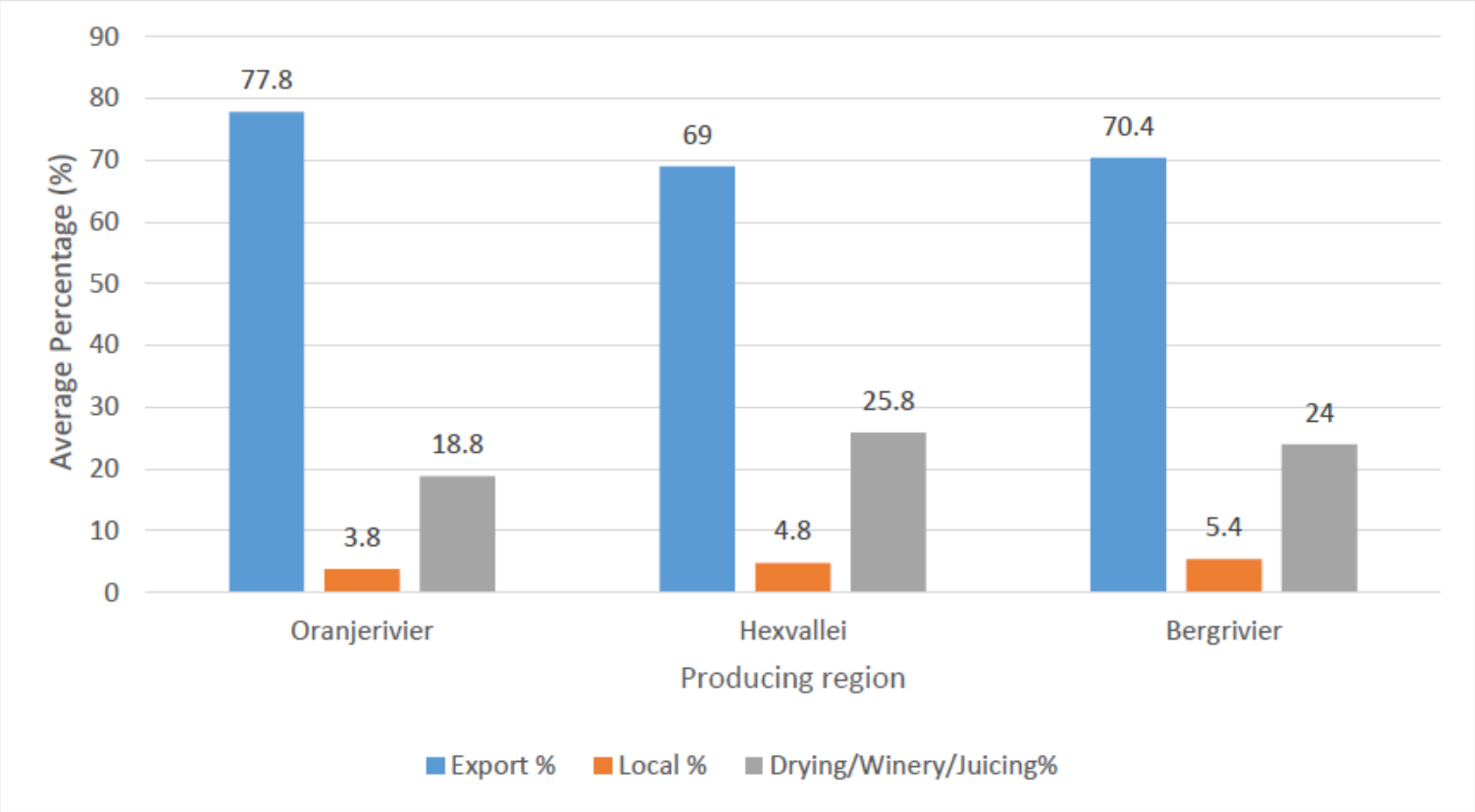
Exporter	• Total export volume inspected • Total rejections ○ Reason for rejections
Importer	• Total volume received • Total volume rejected (write-offs) • Total volume rejected for repacking

Repack	• Total repack volume received
	• Total volume repacked
	  ○ Reasons for repacking
	  ○ Waste
	• Total volume distributed to distribution centres

Distribution centre	• Total volume received • Total volume that failed inspection ○ Reasons why it failed inspection • Total volume distributed to retailers
Wholesale/Retail	• Total volume received at retail • Potential losses and waste that occurred at retail ○ Reasons for losses and waste

Lianda Louw

OPERATIONAL ANALYSIS OF FOOD LOSSES AND WASTE IN THE TABLE GRAPE EXPORT SUPPLY CHAIN

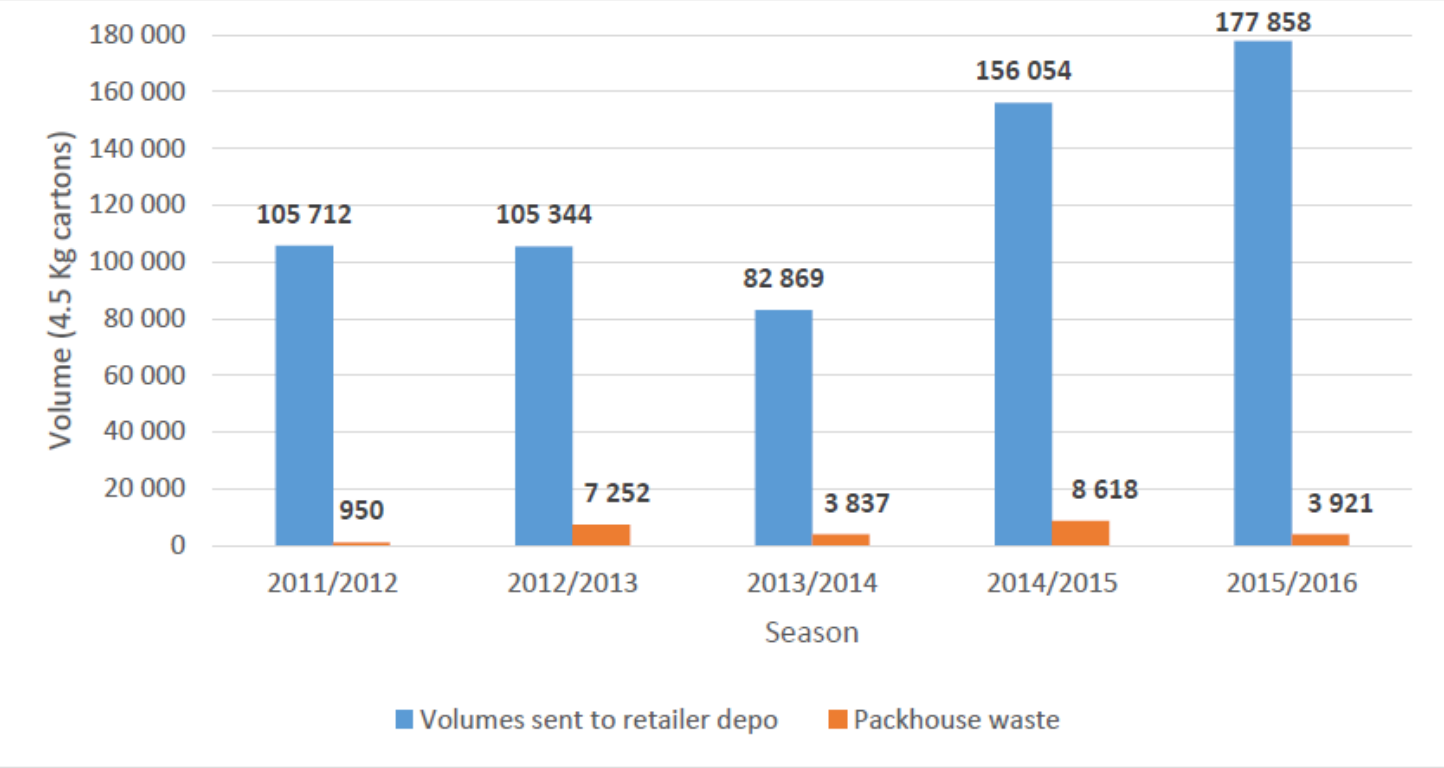


Cape producing regions, 5-year average

Losses and waste in the Food Security context

Lianda Louw

OPERATIONAL ANALYSIS OF FOOD LOSSES AND WASTE IN THE TABLE GRAPE EXPORT SUPPLY CHAIN



Importers' volumes handled for retailers

Who pay the ultimate prize for waste?

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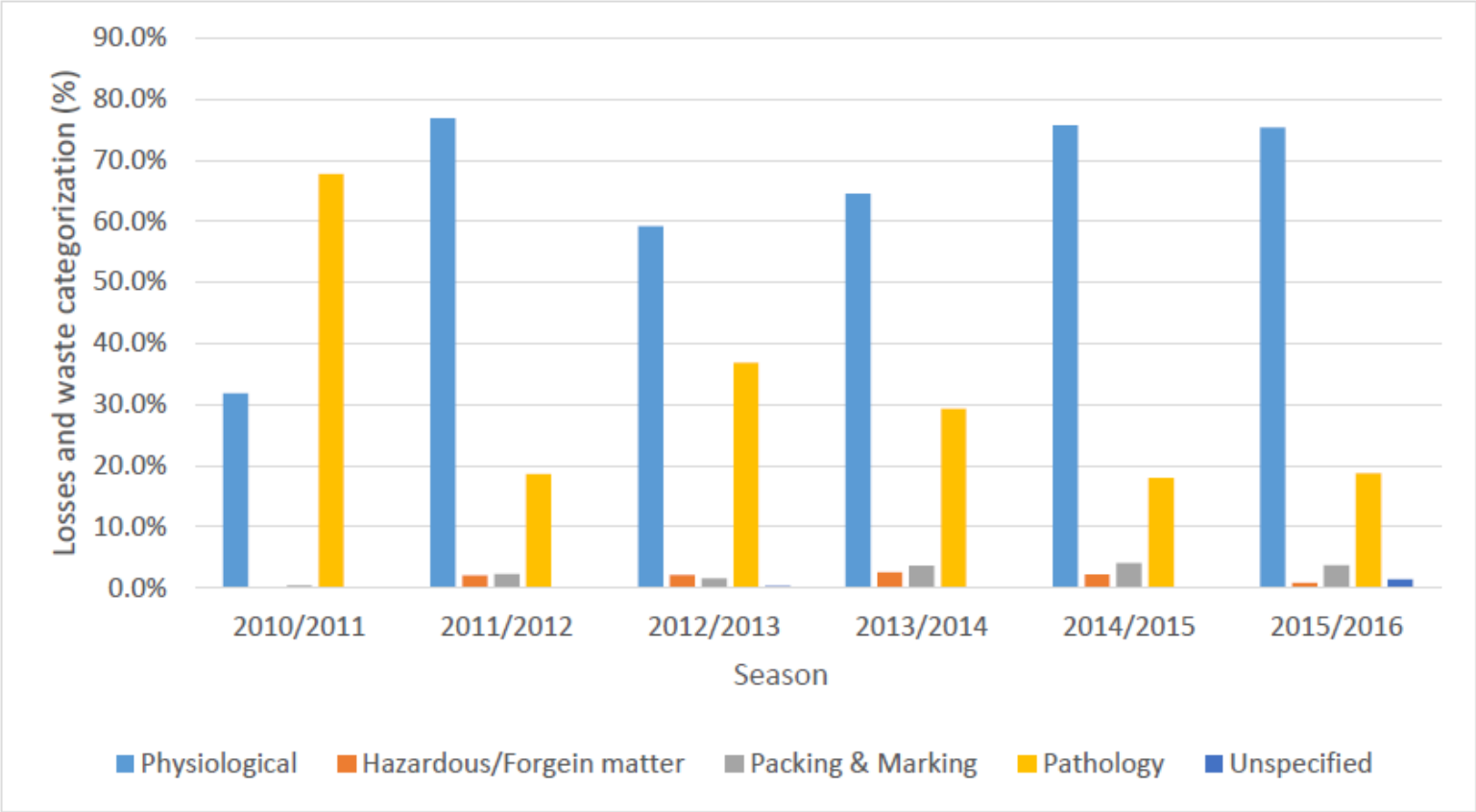


Percentage losses and waste according to categorization (PPECB 2015)

An economists perspective

A regulator perspective

A Farmers perspective

Dualistic
Food Supply in South Africa

Formal Sector Supply Chain: Commercial Farmers/ Major Processors/ Big Retail

1. Photo credit Loandi Richter

Informal Sector Supply Chain: Small scale farmers

2. Photo credit Degracious Kgoale

Prevalence and characterisation of antimicrobial resistant Enterobacteriaceae in fresh vegetables from farm to retail

AMR

Informal vs Formal Markets

How Safe is our Food?

- Dominant species identified included:
  E. coli, *E. cloacae*, *E. asburiae*, and *K. pneumoniae*
- 40.3% Multidrug-resistant generic *E. coli*

545 Fresh produce samples

J Food Sci. 2021 Jan;86(1):161-168. doi: 10.1111/1750-3841.15534. Epub 2020 Dec 8.

High prevalence of multidrug resistant Escherichia coli isolated from fresh vegetables sold by selected formal and informal traders in the most densely populated Province of South Africa

Loandi Richter [1, 2], Erika Du Plessis [1], Stacey Duvenage [1, 2], Lise Korsten [1, 2]

Affiliations + expand

PMID: 33294974 DOI: 10.1111/1750-3841.15534

Foodborne Pathog Dis. 2019 Jun;16(6):421-427. doi: 10.1089/fpd.2018.2558. Epub 2019 Feb 20.

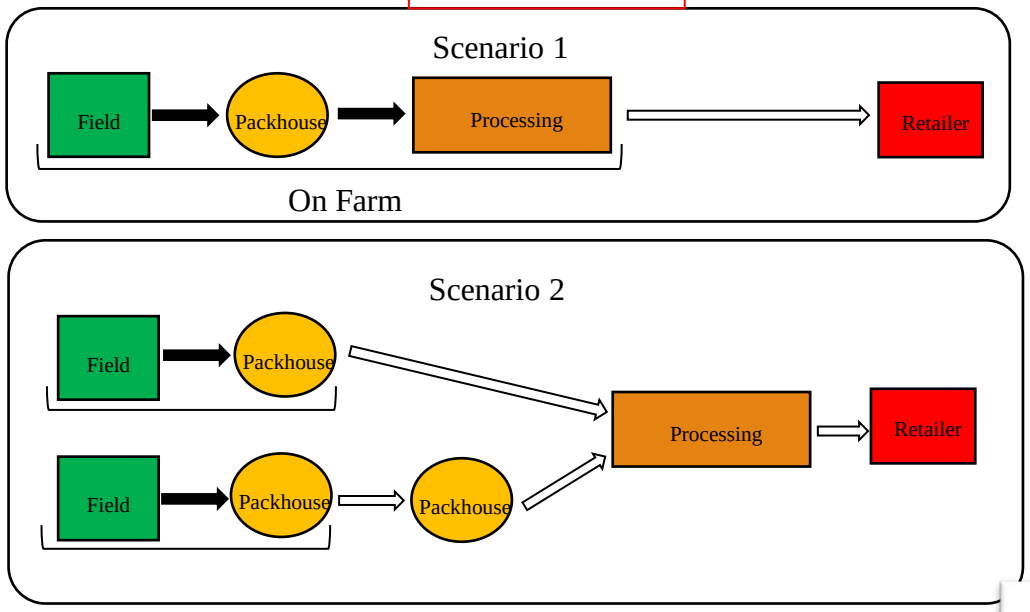
Occurrence, Identification, and Antimicrobial Resistance Profiles of Extended-Spectrum and AmpC β-Lactamase-Producing *Enterobacteriaceae* from Fresh Vegetables Retailed in Gauteng Province, South Africa.

Richter L[1], Du Plessis EM[1], Duvenage S[1], Korsten L[1].

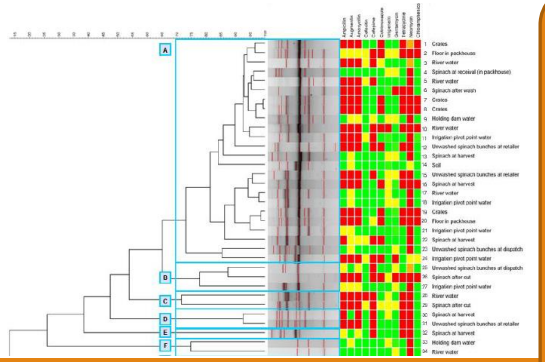
Prevalence and characterisation of antimicrobial resistant Enterobacteriaceae in fresh vegetables from farm to retail

AMR

288 Samples



Spinach Supply Chains



Results + highlights:

- ESBL-producers in the commercial fresh produce production environment
- Multidrug resistant potential pathogens in the water-plant-food nexus
- Irrigation water: an important source of contamination in vegetable production
- Source tracking: link between *E. coli* in source water, irrigated crop, and produce at the point of sale (ERIC-PCR)

J Appl Microbiol. 2022 Mar;132(3):2389-2409. doi: 10.1111/jam.15357. Epub 2021 Nov 29.

Microbiological safety of spinach throughout commercial supply chains in Gauteng Province, South Africa and characterization of isolated multidrug-resistant Escherichia coli

Loandi Richter [1 2], Erika M du Plessis [1 2], Stacey Duvenage [1 2], Lise Korsten [1 2]

Foodborne Pathog Dis. 2019 Jun;16(6):421-427. doi: 10.1089/fpd.2018.2558. Epub 2019 Feb 20.

Occurrence, Identification, and Antimicrobial Resistance Profiles of Extended-Spectrum and AmpC β-Lactamase-Producing *Enterobacteriaceae* from Fresh Vegetables Retailed in Gauteng Province, South Africa

Loandi Richter [1], Erika M Du Plessis [1], Stacey Duvenage [1], Lise Korsten [1]

Bacterial profiles and foodborne pathogens in leafy greens from informal supply chains

426 Samples

Observed practices in the informal supply chain

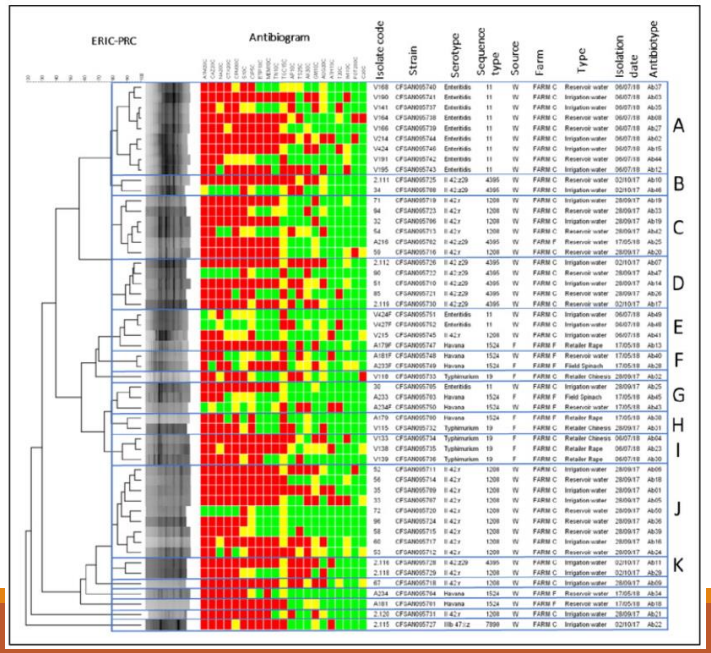
J Food Prot. 2024 Jan;87(1):100195. doi: 10.1016/j.jfp.2023.100195. Epub 2023 Nov 15.

Serotype Distribution, Antimicrobial Resistance, Virulence Genes, and Genetic Diversity of Salmonella spp. Isolated from small-scale Leafy Green Vegetable Supply Chains in South Africa

Degracious M Kgoale [1], Stacey Duvenage [2], Erika M Du Plessis [1], Jarishma K Gokul [3], Lise Korsten [4]

Affiliations + expand

PMID: 37977503 DOI: 10.1016/j.jfp.2023.100195



Results + Highlights

- **ERIC-PCR:** high diversity among the *Salmonella* spp., with water and fresh produce isolates clustering together, suggesting water as a potential contamination source.
- **92.45%** Multidrug resistant

Assessment and mitigation of fresh produce (tomato and pepper) postharvest losses among small-scale farmers in the Gauteng Province

Region	Tomato	Peppers
Tshwane	3 farms -1 open -1 netted -1 tunnel	2 farms -1 netted -1 semi-covered tunnel
WestRand	4 farms -all tunnels	1 farm -tunnel
Germiston	1 farms -tunnel	1 farm -netted

Rot related losses

- After 14 days of storage, between 13 % to 25 % with an average of 21 % of the total stored fruits were lost due to fungal rot.s
- ANOVA analysis showed no significant difference on losses across the farms.

Table 1: Percentage of fruit loss at storage due to fungal rot pathogens

FARMS	N	$\bar{x}$±SEM
RP01	6	23.3±4.2ab
GP01	6	19.2±1.6ab
TP02	4	12.8±0.6b
TP01	9	24.7±2.5a
$F_{3,21}$		*2.975*
p Value		*0.055*

N-total number of sample sets per farm.

- The majority of the rots across the farms were caused by *Alternaria* and *Fusarium* species

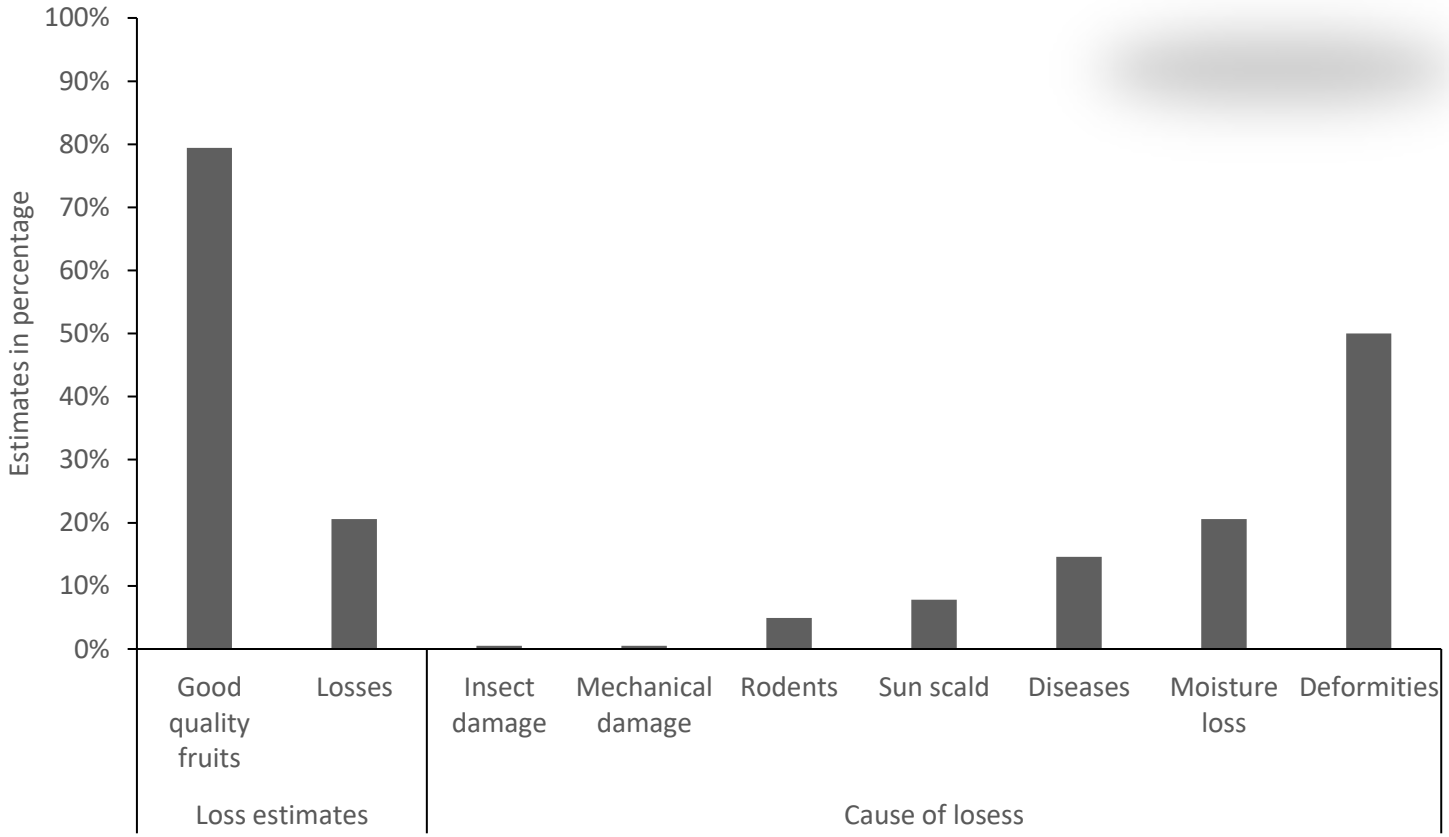
Alternaria species isolated from symptomatic bell pepper fruit

Bell pepper losses and causes of losses

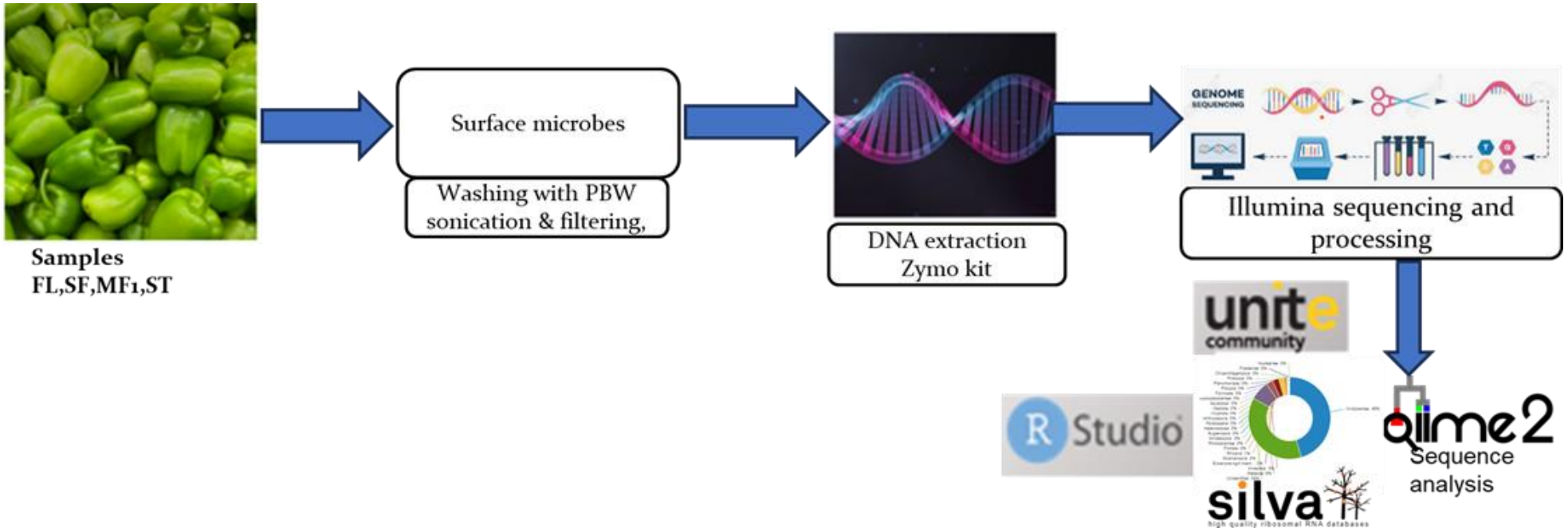
About 21% of the bell peppers produced are lost at a postharvest level.

Major causes of losses:

- Deformities
- Moisture loss
- Diseases



Linking Microbiome knowledge with waste and losses



Fungal community structure on bell pepper fruit developmental at: Preharvest stages, Harvest and Storage

Relative abundance –Phylum level

- Total sample size-24
- Total ASV yield-1778

Community structure

- 4 phyla, 23 classes, 63 orders, 159 families, and 344 genera.

- Phyla **Ascomycota and Basidiomycota** were the most abundant accounting for 84% and 14 % of the total organisms.

Relative abundance-Genus level

Most abundant genera:

- *Cladosporium* (41%)
- ***Alternaria*** (17%)
- ***Fusarium*** (5%)

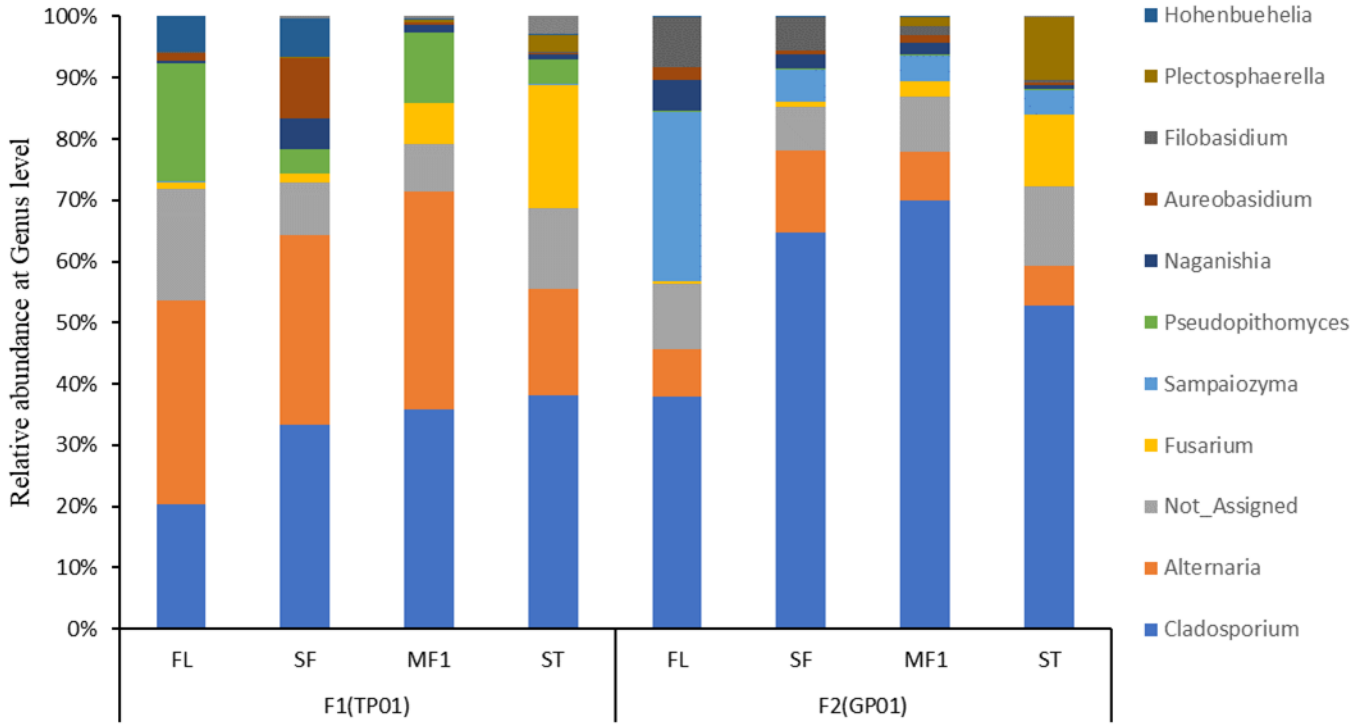


Figure 1: Bell pepper fungal community structure across the different fruit developmental stages

Postharvest rot Isolate prevalence

Fusarium-34%

Alternaria-31%

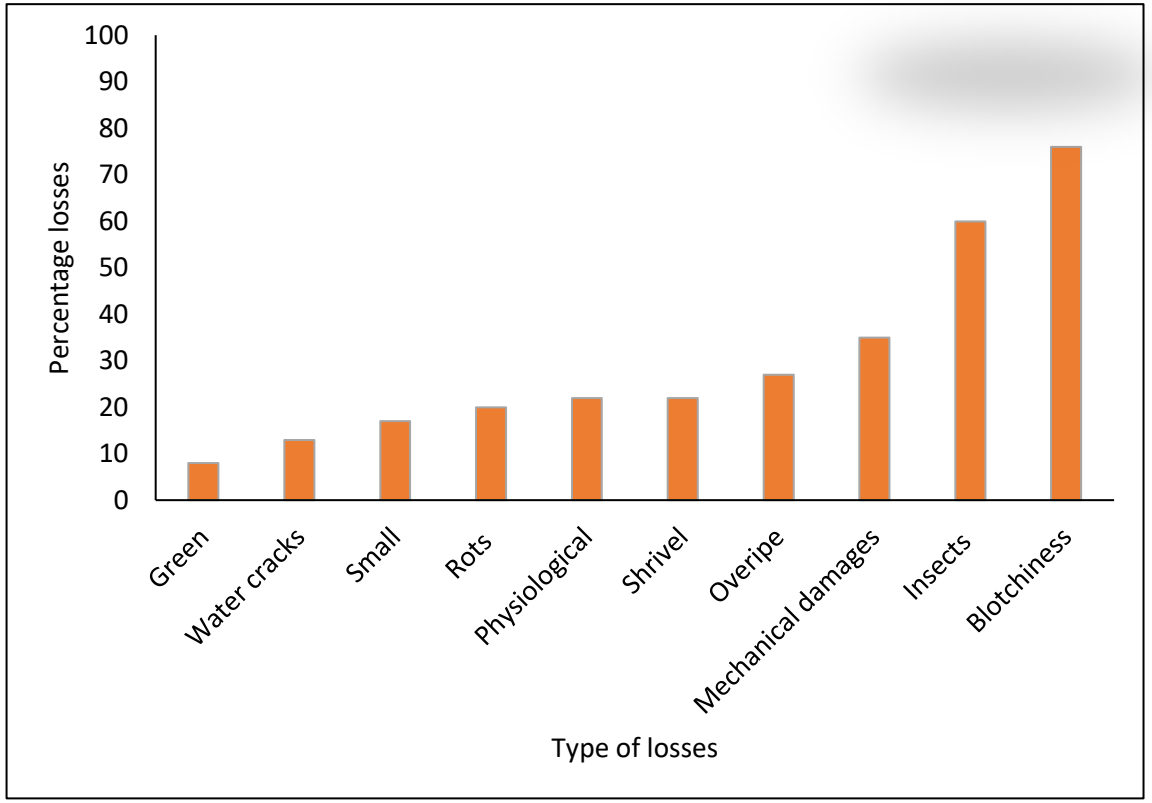
Tomato losses and causes of losses

Losses on farm:

Losses at market:

Major causes of losses-

- Mechanical damages
- Diseases
- Uneven ripening
- Overripe



Postharvest losses- Tomato

Physiological disorder (mostly open field)

Postharvest diseases (all farms)

Chilling injury (1/8 farms, cold storage)

Shriveling (after 7 days storage in 4/8 farms)

Physical damage (all farms, worse in open field)

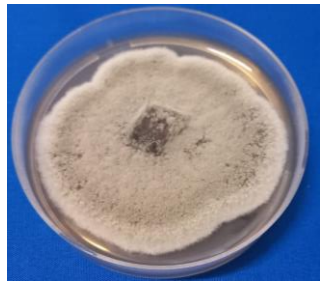
Cracks (seen in 4/8 farms)

Unripe fruit (3/8 farms)

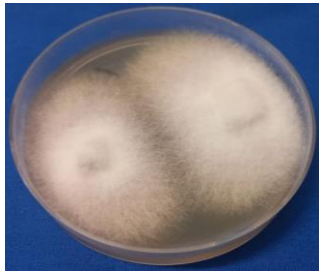
Sunburn (2/8 farms)

Potential pathogens prevalent in tomato production (8 FARMS)

Open field (N=1)

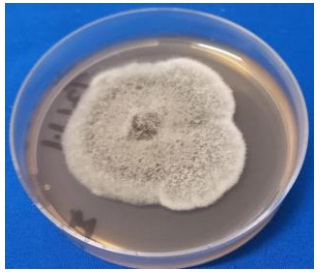



Alternaria spp.

Fusarium spp.

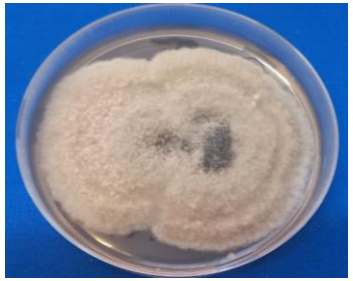
Nets (N=1)

Alternaria spp.

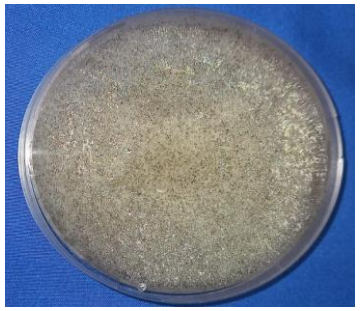

Alternaria spp.

Closed tunnels (N=6)

N=6 *Alternaria* spp.


N=4 *Fusarium* spp.

N=6 *Rhizopus* spp.

Disease losses were the highest- after 15 day

Increase in the number of food items recalled in 2022

Food Safety News: Coral Beach March 15, 2023

- The total number of "units" recalled under FDA increased by **700% in 2022** compared to 2021
- The FDA oversees 80 percent of the country's food supplies with the USDA responsible for the other 20 percent.

Sedgwick reports that the number of FDA food recalls rose marginally at a rate of 2.2 percent from 414 recalls in 2021 to **423 recalls in 2022**.

However, the number of "units," such as individual bags of salad, went up 700.% .
There were 52.1 million recalled units in 2021 with an average size of 125,796 units compared to 416.9 million units in 2022 with an average recall size of 985,658 units.

https://www.foodsafetynews.com/2023/03/report-finds-enormous-increase-in-number-of-food-items-recalled-in-2022/

Plate Waste

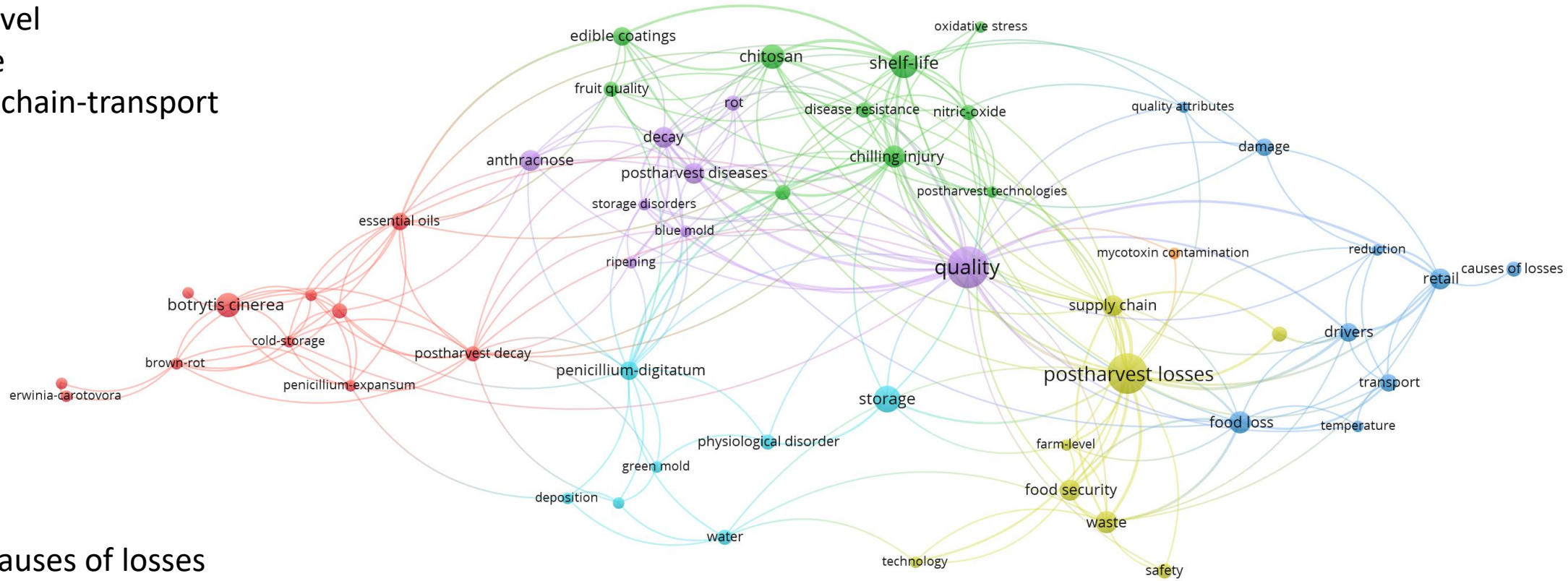
Lucy Bennett, February 3, 2022

- Plate waste is any food wasted direct from plate or to-go box. It can be an indication of overly-large portions (or simply over-ordering).
- Plate waste makes up a total of **41% of food waste in canteens**, according to the EPA's Food Waste in Canteens
- Fact Sheet. **38% of food waste from the typical Irish food service establishment is attributed to plate waste**. So, plate waste is a real problem.

https://www.toogoodtogo.com/en-ie/blog/what-is-plate-waste

Postharvest losses network analysis

Postharvest losses mainly occur at
-farm level
-storage
-supply chain-transport



Major causes of losses
-Diseases/rots
-physiological disorder
-Temperature/chilling injury

VOSviewer

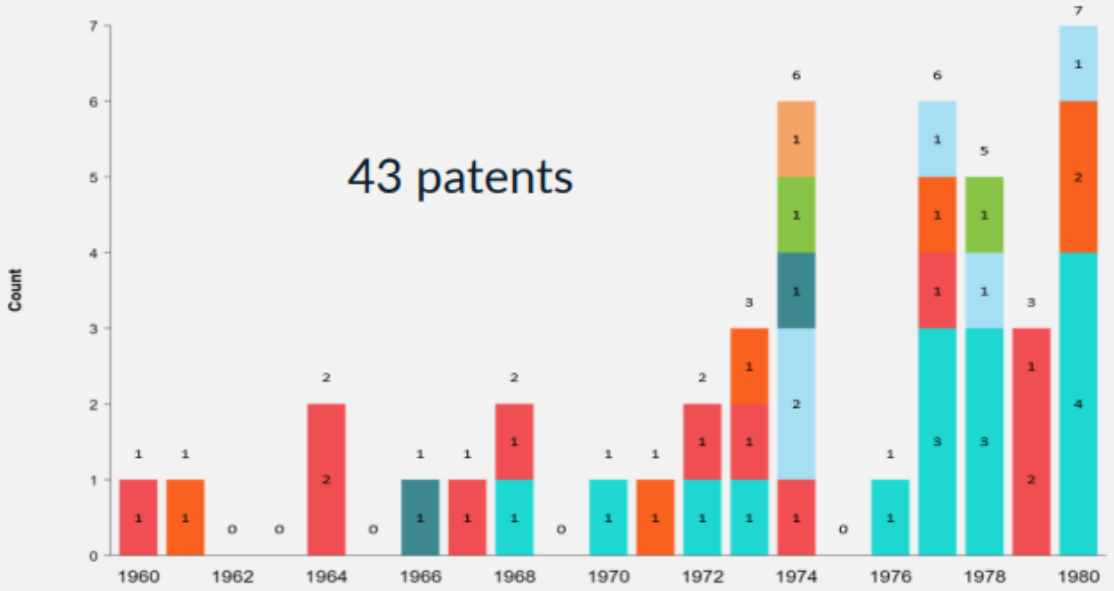
Patent Timeline | Post Harvest Technologies

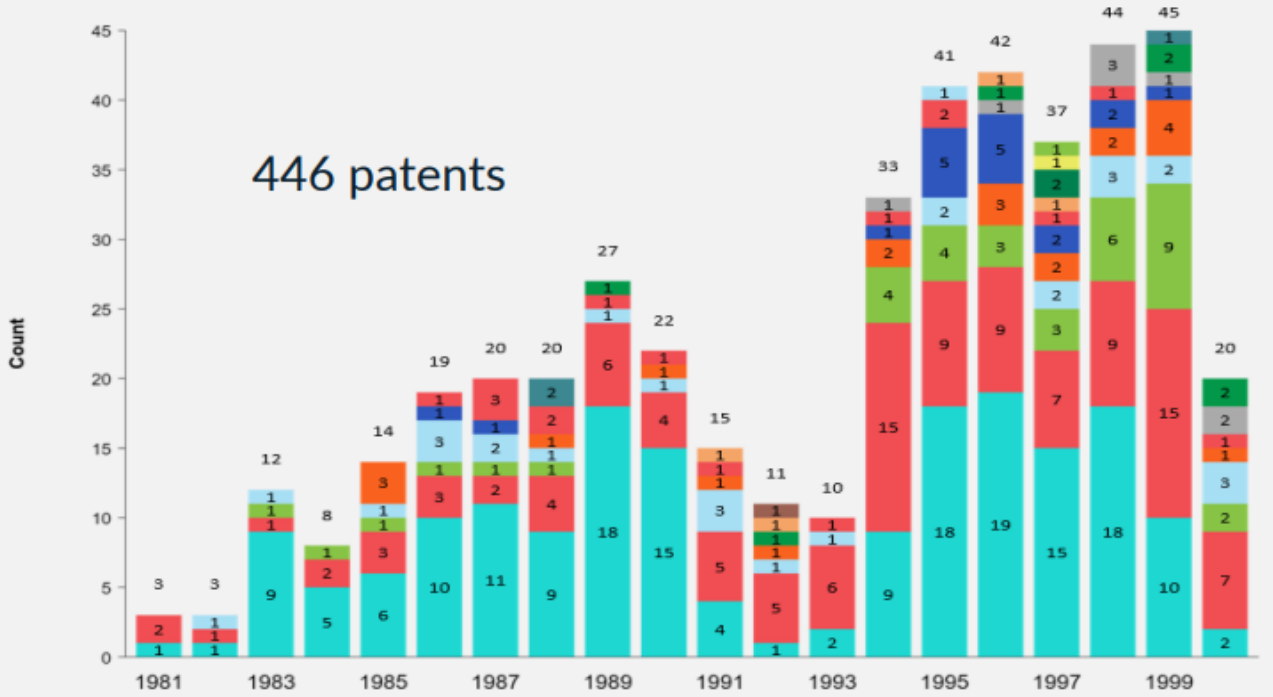
Patent filings are increasing at an annual growth rate of 51% from 2000.

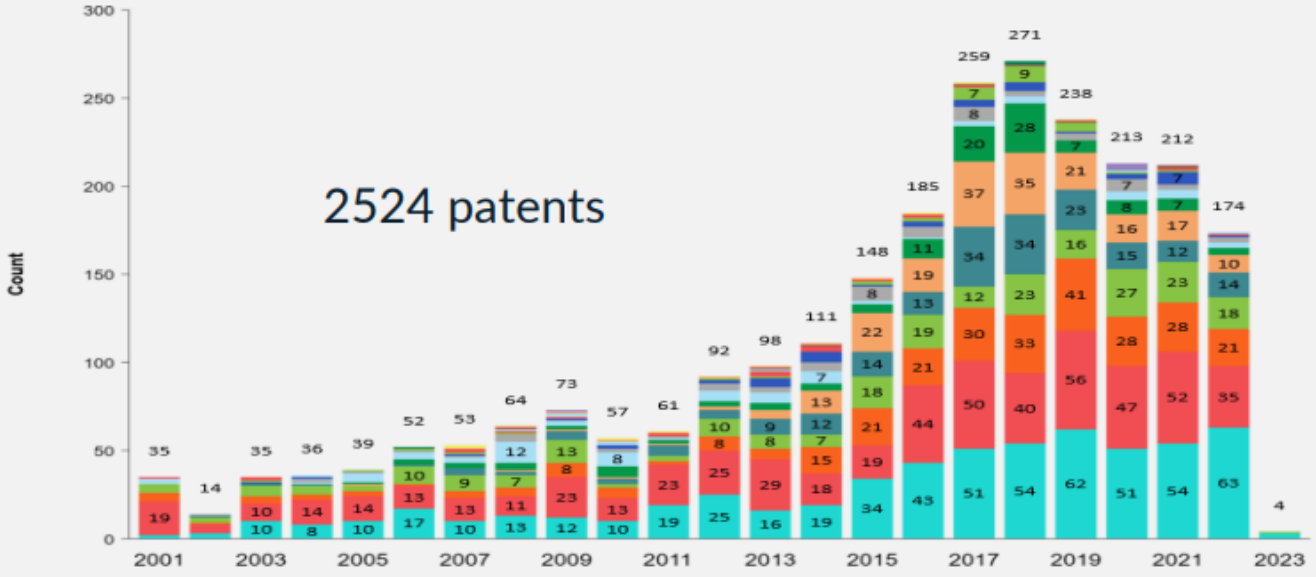
After 2010, the annual number of patents filled is more than 100

The steep growth after 2014 coincides with the Paris Agreement

Patent Timeline







Clusters

Machines, Devices, Apparatus, Harvesters, Grading Devices	26%
Formulation, Antimicrobial, Pathogens, Biological & Biobased Data, Fungicides	23%
Refrigeration System, Freezing, Cold Storage, Fresh Keeping	10%
Module, Sensors, Robotics & IoT	9.5%
Pruning	7.1%
Seedbed, Field Management, Sandy Loam	6.7%
Tea, Harvesting Garlic, Juice	4.3%
Ethylene	3.8%
Sweet Potato	2.1%
1-6C Alkyl	1.3%

Loadshedding-food loss and waste (South Africa)

93% of South Africans have been forced to throw away food that spoiled in refrigerators amid load shedding.

38% have had to replace their fridge due to power outages,

Acknowledgement

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NRF National Research Foundation

GAUTENG PROVINCE
AGRICULTURE AND RURAL DEVELOPMENT
REPUBLIC OF SOUTH AFRICA