Fruits and vegetable resource maps

Waste not want not

SCI headquarters

5th March 2013

Prof Leon A. Terry
l.a.terry@cranfield.ac.uk

Cranfield UNIVERSITY

http://www.cranfield.ac.uk

Resource mapping

Cranfield UNIVERSITY

wrap Material change for a better environment

Final report

Fruit and vegetable resource maps

Mapping fruit and vegetable waste through the retail and wholesale supply chain.

Methodology

Cranfield UNIVERSITY

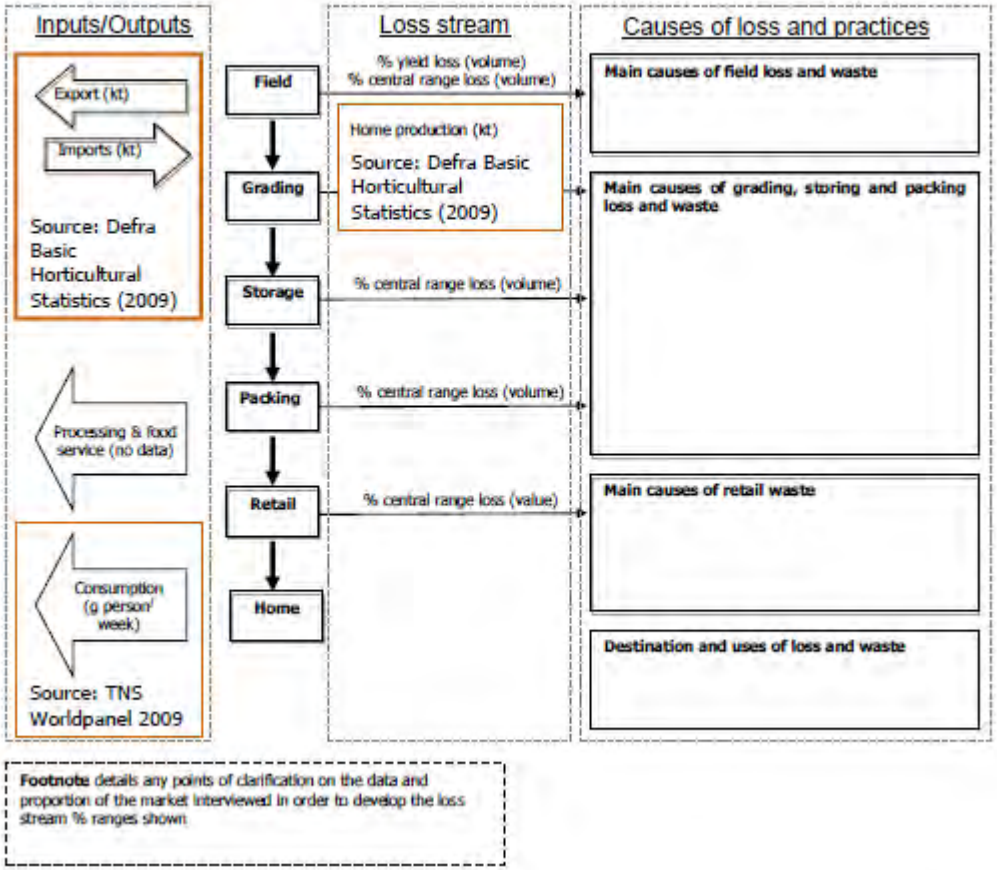
Table 9 Summary of number of suppliers who participated in data collection and total market share for each fresh product type

Product	Number of Suppliers	UK Market Share (%)
Strawberry	3	75
Raspberry	3	70
Lettuce	3	75
Tomato	3	70
Apple	6	60
Onion	4	81
Potato	6	60
Avocado	3	70
Citrus	3	60
Broccoli	3	55
Banana	4	85

Methodology – resource maps

Cranfield UNIVERSITY

Figure 7 Outline resource map. 'Consumption' is defined in its 'economic' sense, i.e. the purchase of fruit and vegetables by consume



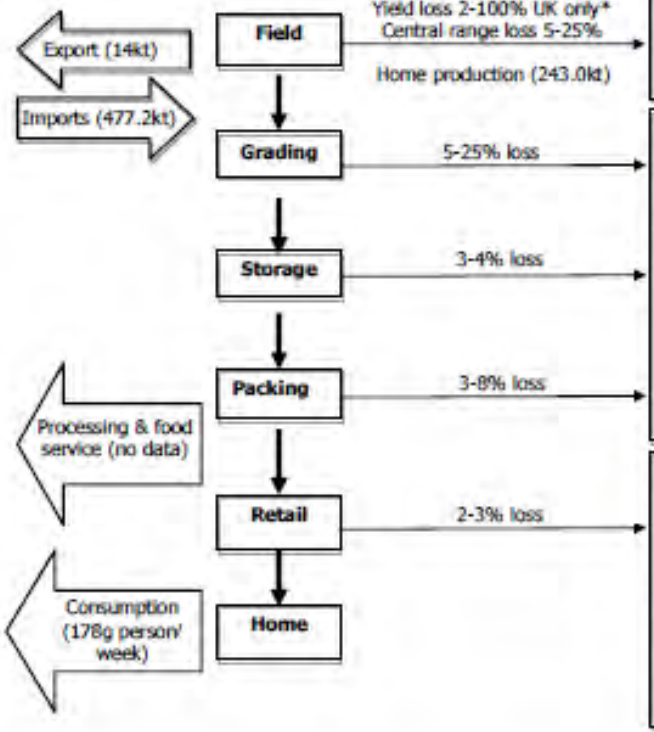
Apples

Key supply chain characteristics include:

- Post-harvest life typically ranges from 0-365 days, but is reliant not only on variety, but also on storage regime (e.g. temperature, controlled atmosphere, ethylene control/suppression [DPA (diphenylamine), 1-MCP, $KMnO_4$, Platinum group metal-based ethylene removal etc.]). The best crop is stored longest with optimal storage regime (e.g. early harvest cv. Queen Cox for controlled atmosphere (CA)). Mean storage is 50 days.
- Lead times range from 6-24 hours. Stock levels range from 0.5-60 days, but are commonly between 7-21 days (variety dependent).
- Shelf-life is again very variety dependent and can range between 4-12 days.
- Out of specification product arising in the field is diverted from landfill and sent for juicing, typically resulting in just <0.01% going to landfill. However, the data shows that loss levels can be catastrophic resulting in 100% of the crop not making it to the retail shelf.
- There can be quite high levels of loss and waste at grading and packing as well, as product is rejected due to not meeting prescribed specifications, though this is also usually diverted from landfill and juiced.
- The level of final mean product waste is 3%, which will likely go to landfill or energy recovery.
- Suppliers commented that waste for imported fruit can be as high as ca. 5-8%.

Apples

Resource map: Apples



Main causes of field loss and waste

1. Preharvest factors (e.g. hail) can be catastrophic.
2. Climate change may be affecting storage potential.

Main causes of grading, storing and packing loss and waste

1. Storage losses due to water loss, disorders (e.g. superficial scald, bitter pit) and loss in firmness.
2. Compared to other fruits the impact of forecasting is less because demand tends to be more predictable and can buffer using storage.
3. Packaging is designed for transit not for retail
4. Packing design changes have increased especially for labels (problem with end of reel and minimum order requirements).
5. Sea freight: poor temperature control and delays can increase waste.

Main causes of retail waste

1. Over-stacking of displays can increase waste.
2. Waste sometimes increased by cannibalism due to promotions on other fruits.
3. Post-promotional sales fall and can increase waste.
4. Consumer handling in store (riffling) increases waste.
5. Value lines may encourage larger purchases and increase waste.
6. Conditioning of consumers increased waste and cost to supply.

Destination and uses of loss and waste

Different market: primary wholesale, processing for juice and other products (e.g. mince meat and cider) and animal feed.
Alternate market: not used (but one supplier uses AD facility).
Physical waste: minimal landfill/EfW by some suppliers but prevalent at retailer level.

Footnote: % ranges given in the loss stream were sourced from six principal apple suppliers which make up ca. 60% market share.
* little data on field or other losses associated with imported apples.

Technical recommendations

- Continue to invest in improved storage regimes (e.g. ethylene control and modern controlled atmosphere).
- Improve control over post-climacteric senescence.
- Reduce frequency of packaging design changes (especially labels) and improve communication between retailer, packaging supplier and produce supplier to decrease packaging waste and/or consider generic labelling.
- Explore the use of more flexible Brix and pressure tolerances to help reduce waste.
- Continue with specification changes on size to utilise more apples for the fresh market (NB: though there was some disagreement between suppliers on this point and it is important to improve the understanding of how this will affect overall waste/crop utilisation).
- Improve temperature control during distribution on ships (for imported produce) and in-store.

Apple

Case study - impact of 1-MCP

Cranfield UNIVERSITY

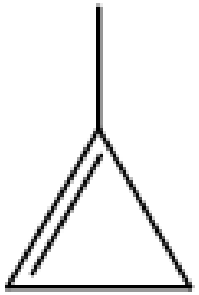


Table 10 Storage regimes employed for UK-grown and imported apples.

Variety	Storage-Marketing Period	RA-storage *	CA-storage or SmartFresh *
Discovery	2-4 weeks	All RA	not applicable
Worcester Pearmain	6-8 weeks	All RA	not applicable
Spartan	4-6 weeks	All RA	not applicable
Royal Gala	6-7 months	2 months	4-5 months
Cameo	6-7 months	2 months	4-5 months
Cox's Orange	6-7 months	2 months	4-5 months
Kanzi	6-7 months	2 months	4-5 months
Pink Lady	5-6 months	2 months	3-4 months
Red Delicious	5-6 months	2 months	3-4 months
Egremont Russet	3-4 months	All RA	not applicable
Braeburn	7-8 months	2 months	5-6 months
Golden Delicious	11-12 months	2-3 months	8-9 months
Granny Smiths	11-12 months	2-3 months	8-9 months
Jonagold	AYR *	2-3 months	9-10 months
Bramley's Seedling	AYR *	2-3 months	9-10 months

Source: courtesy of anonymous supplier

** RA = regular atmosphere (air); SmartFresh = 1-MCP; CA = controlled atmosphere, AYR = all year round*

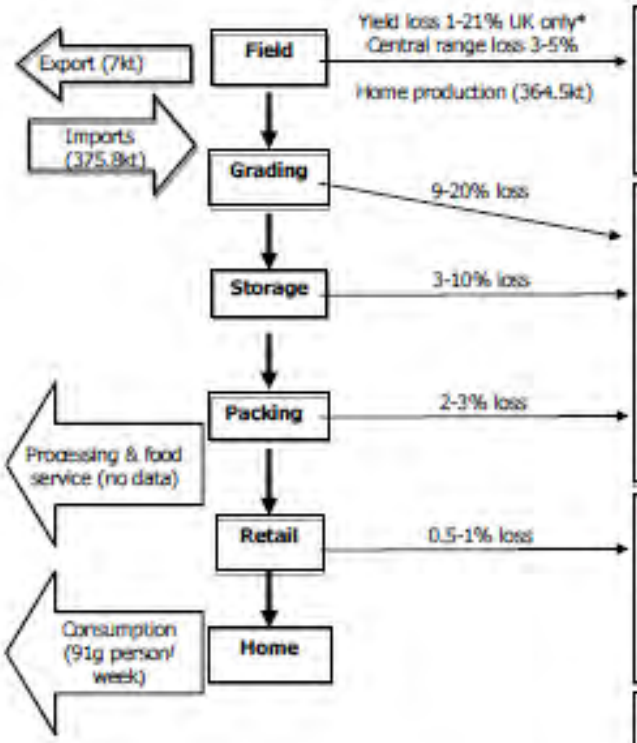
Onions

Key supply chain characteristics include:

- Post-harvest life typically ranges from 21-300 days, but is reliant on not only variety (innate dormancy, period of sprout suppression, dry matter), but also on storage regime (e.g. curing, storage temperature, CA, sprout suppressants (e.g. maleic hydrazide (MH), exogenous ethylene supplementation). Mean storage life is between 120-160 days. The best crop is stored the longest with optimal storage regime (e.g. cold with CA and ethylene).
- Lead times range from 3-30 hours. Stock levels range from 1-7 days, but are commonly between 2-4 days for volume lines.
- Shelf-life ranges between 7-10 days, but can be reduced to five days at the end of the season.
- Yield losses can be high (at 21%) but on average there is less loss in the field for onions than for some of the other products in this study. There are, however, high losses at grading as product that does not meet specification is rejected.
- Storage also represents a significant proportion, due to water loss and internal defects.
- The level of final mean product waste at retail is 0.5-1% but can be even lower and the majority will be disposed to landfill or energy recovery.

Onions

Resource map: Onions



Main causes of field loss and waste

1. Harvest damage - affected by weather – small window of opportunity to harvest (N.B. wet weather during 2008 harvest inhibited access unto fields with heavy machinery) but no problems in 2009.
2. Weather affects storage potential.

Main causes of grading, storing and packing loss and waste

1. Specifications (especially visual) are too high and lead to high wastage during grading.
2. No market for small red bulbs (<less than 40 mm diameter).
3. Storage losses due to water loss (increases with duration but dependent on storage regime) and internal defects (bacterial rots).
4. Reliance on storage to cope with small fluctuations in forecast and demand.
5. Much of loss is unavoidable e.g. skins, roots, tops and soil.

Main causes of retail waste

1. Colder weather slightly increases demand. Hot weather reduces shelf life and increases home waste.
2. Vertical-fill films may actually be increasing waste (at home) due to 'sweating' [too higher RH%], yet in-store damage is minimal due to robustness of product.

Destination and uses of loss and waste

Different market: primary wholesale, processing (e.g. ready meals) and animal feed (principally for cattle, but mixed with other foodstuffs due to possible risk of meat taint).
Alternate market: composting (>70% of waste, used on arable land not onion land).
Physical waste: minimal (retail only).

Footnote: % ranges given in the loss stream were sourced from four principal onion suppliers which make up ca. 81% market share.
* no data on field or other losses associated with imported onions.

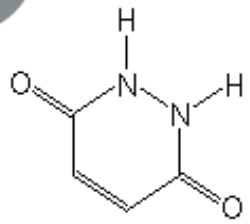
Technical recommendations

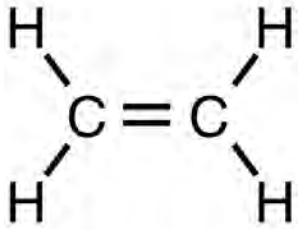
- Greater tolerance of aesthetic appearance and size grades would vastly decrease loss. Such tolerances would need to be coupled with consumer education that colour, skin finish and size have no impact on eating quality. This would mean undersized bulbs, for example, which are currently composted, could be eaten.
- Reduce incidence and impact of internal defects, potentially finding an alternative to destructive testing to monitor this.
- Improve storage by, for example, optimising use of ethylene supplementation.
- Improve temperature control in-store.
- Investigate whether netted bulbs reduce waste in comparison to vertical form-fill films, particularly given they provide more ventilation and lower relative humidity for the product.
- Investigate the impact of variable and high relative humidity on skin finish and disease incidence

Onion

Case study – ethylene supplementation

Cranfield UNIVERSITY





Plant Physiology®

Ethylene and 1-Methylcyclopropene Differentially Regulate Gene Expression during Onion Sprout Suppression[1][W][OA]

Katherine Cools, Gemma A. Chope[2], John P. Hammond[3], Andrew J. Thompson, and Leon A. Terry*

Plant Science Laboratory, Cranfield University, Bedfordshire MK43 0AL, United Kingdom (K.C., G.A.C., L.A.T); and Warwick Horticulture Research International, University of Warwick, Wellesbourne, Warwick CV35 9EF, United Kingdom (J.P.H., A.J.T)

Sprouting

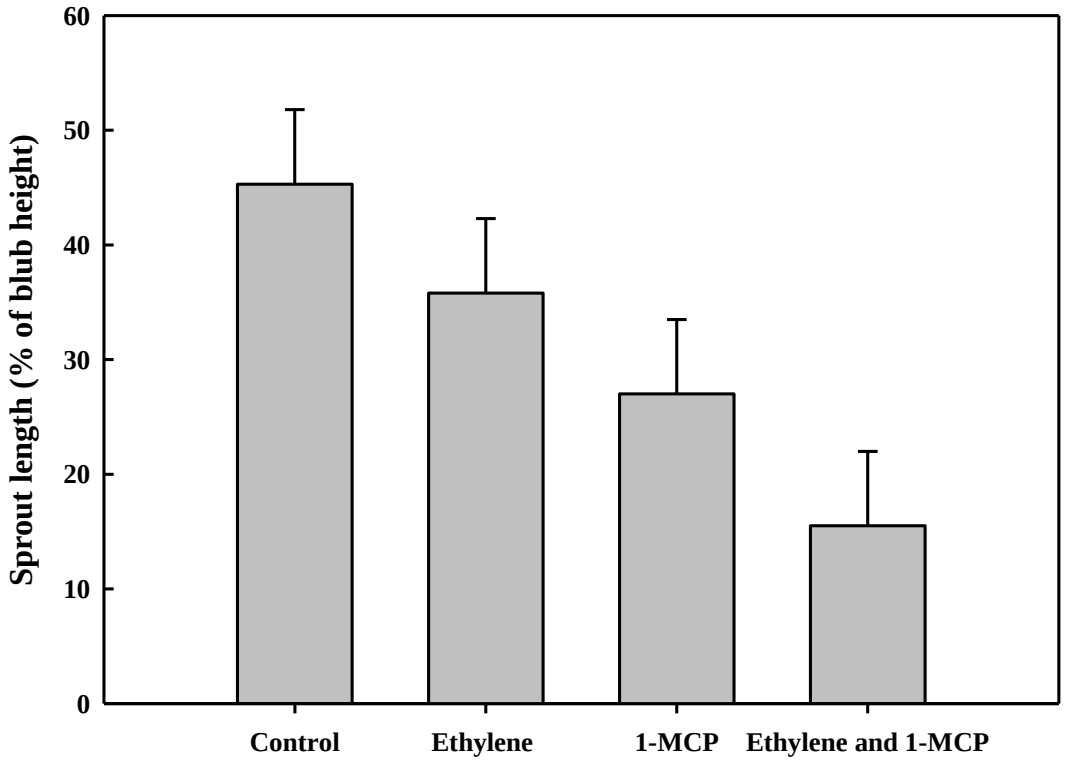


Figure 1 Average sprout length (% of the bulb height) of onion bulbs after 25 weeks of storage treated before or after curing with 1 µl l^{-1} 1-MCP or 10 µl l^{-1} ethylene or with both in combination (Error bar = SE).

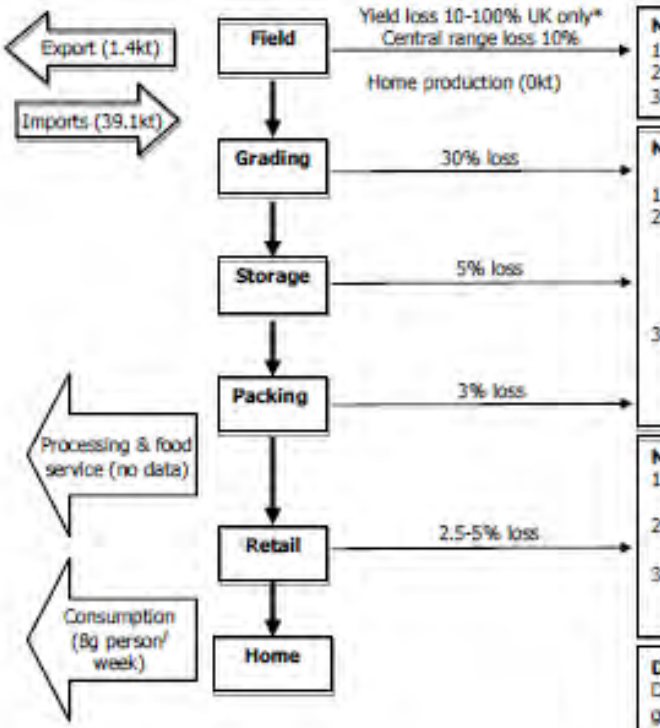
Avocado

Key supply chain characteristics include:

- Storage life (transit) ranges from 6-40 days (dependent on controlled atmosphere and ethylene control strategies and country of origin – 'time on the water'), but can be extended beyond this.
- Lead times range from 12-24 hours. Stock levels range from 4-10 days but are typically 4-5 days.
- Shelf-life ranges from 2-4 days and is related to whether or not fruit have been conditioned/ripened.
- One of the principal sources of waste occurs at quality control where as much as between 1-5% of the consignment does not meet the specification. Most product waste is sent for animal feed with <1% going to landfill or energy recovery.
- The level of final mean product waste at retail is ca. 2.5-5%, with the majority of this going to landfill or energy recovery.
- Waste arising prior to receipt in the UK has not been measured.

Avocado

Resource map: Avocados



Main causes of field loss and waste

1. Product heterogeneity is main reason of loss.
2. Physical damage.
3. More data required.

Main causes of grading, storing and packing loss and waste

1. Storage losses due to water loss and internal defects.
2. Market for RTE fruit results in more waste during ripening due to fragility of product (susceptibility to damage) and heterogeneity in quality even within the same consignment [greater variability in quality for South African and Peruvian fruit].
3. Overstocking due to poor forecasting can increase waste as fruit cannot be held for long when climacteric has been induced using higher temperatures (18-22°C).

Main causes of retail waste

1. Long transit times for some fruit so forecast can have large impact.
2. Difficult to schedule promotions as fruit availability can be variable.
3. RTE increases waste due to less shelf life (yet better returns).

Destination and uses of loss and waste

Different market: primary wholesale and processing (e.g. guacamole), compost and animal feed.
Alternate market: not used.
Physical waste: minimal from suppliers but prevalent at retailer level.

Footnote: % ranges given in the loss stream were sourced from four principal avocado suppliers which make up ca. 70% market share.
* no data on field or other losses associated with imported avocado.

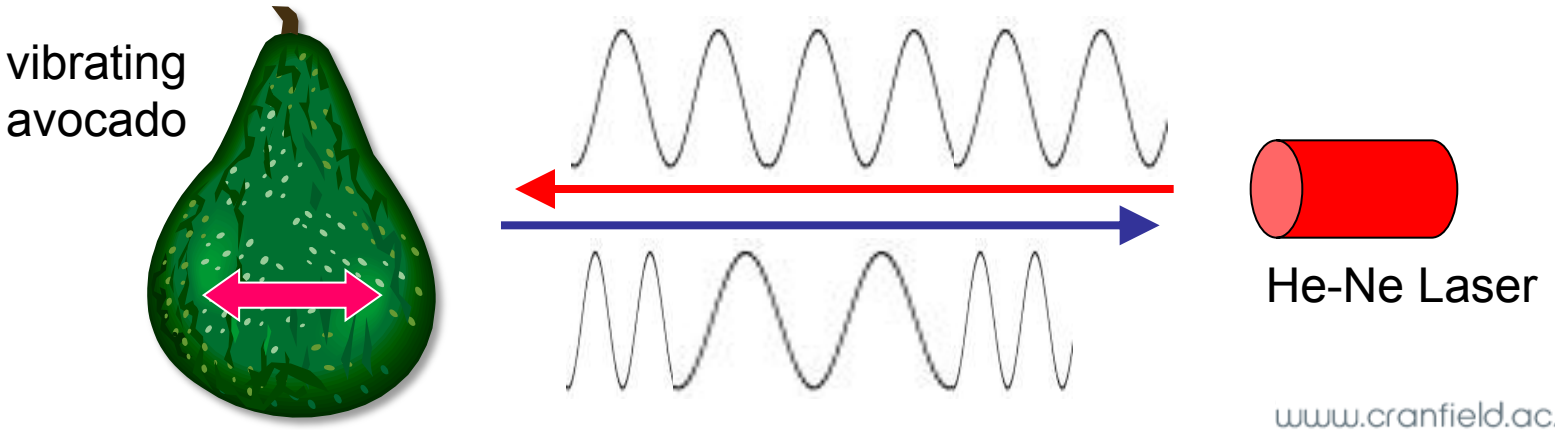
Technical recommendations

- Improve non-destructive quality control to reduce losses associated with destructive testing.
- Continue to reduce heterogeneity in quality of supply especially for early season fruit.
- Improve real-time forecasting of field production and picking cycles to better inform promotional activity and match supply with demand fluctuations.
- Agronomic management will become increasingly important and thus requires better vertical integration between supplier and growers.
- Re-educate consumers that aesthetic defects (scarring and other superficial defects) do not affect the eating quality.
- Improve understanding of effects of transit time, and storage/ripening regimes on product quality and damage.
- Develop a better understanding of the impact of ethylene across the whole supply chain.

Laser Doppler vibrometer (LDV)

- LDV = precision optical instrument used for determining vibration velocity and displacement at a single point

- Senses the frequency shift of back scattered light from a moving surface: Doppler-effect



Summary

Table 11 Summary of resource maps, detailing percentage loss and waste by product for eleven different fruits and vegetables through the supply chain.

Product	Field loss (Central range)	Grading loss	Storage Loss	Packing loss	Retail waste
Strawberry	2-3%	1%	0.5%	2-3%	2-4%
Lettuce	5-10%	No data	0.5-2%	1%	2%
Raspberry	2%	No data	No data	2-3%	2-3%
Tomato	5%	7%	No data	3-5%	2.5-3%
Apple	5-25%	5-25%	3-4%	3-8%	2-3%
Onion	3-5%	9-20%	3-10%	2-3%	0.5-1%
Potato	1-2%	3-13%	3-5%	20-25%	1.5-3%
Broccoli	10%	3%	0%	0%	1.5-3%
Avocado	No data	30%	5%	3%	2.5-5%
Citrus	No data	3%	No data	0.1-0.5%	2-2.5%
Banana	No data	3%	No data	0-3%	2%

Recommendations

- Improve data on waste and loss
- Improve supply chain communications
- Review consumer specifications
- Work to optimise packaging
- Promote technology development and knowledge transfer
- Increase use of production planning systems

Managing quality in chains - MQUIC 2013

Cranfield UNIVERSITY

ISHS

Book online – Early bird discounts and ISHS membership discounts apply.

2 – 5 September 2013

www.mquic2013.com

l.a.terry@cranfield.ac.uk

Acknowledgements

l.a.terry@cranfield.ac.uk