



Organic Vegetable Storage in Wales – Opportunities and Constraints

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Executive summary

There is a growing interest in buying local produce, but there is insufficient produce available in Wales to meet this demand. One problem is lack of storage. Much organic vegetable produce in Wales is lost by poor storage

ADAS has undertaken this study on behalf of Organic Centre Wales under the Farming Connect Scheme, to assess opportunities for improving storage and increasing the available quantity of Welsh vegetables.

The number of organic vegetable producers in Wales in 2006 was estimated to be 118. (Horticultural Network, 2006)

The main crops stored in Wales are potatoes, carrots, squash, onions, cabbage and celeriac.

Many factors may contribute directly or indirectly to suitability for storage, these include length of life in store and quality of the crops in store.

Costs of storage are perceived to be high but investment in storage facilities can increase turnover and maximise marketable potential.

The majority of growers in Wales use field storage due to its simplicity, but there are disadvantages to field storage.

Alternatives to field storage include indoor and outdoor clamps and cold storage. Each method has advantages and disadvantages.

Recommendations

- A joint effort by the whole organic fruit and vegetable industry is required to increase the amount of organic produce produced within Wales.
- Processing and Marketing grants for improvement of storage for SME and or co-operatives are required to increase the amount of local produce produced and sold in Wales.
- Research is needed into the economic feasibility and issues involved with setting up and running storage facilities using alternative energy
- The practicalities and costs of using biodegradables needs to be investigated
- Best storage practices should be established

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1 Introduction

There is a growing interest in buying local produce amongst consumers, multiple retailers, box scheme providers and public procurers.

There is, however, insufficient produce available in Wales to meet this demand. There are a number of reasons to explain this under supply. One of them is lack of storage. Much organic vegetable produce in Wales is lost by poor storage. ADAS conducted this study to assess opportunities for improving storage and increasing the amount of Welsh vegetables available for the different outlets.

This study looks at how farmers' practices have developed in recent years and provides an overview of the latest developments in storage practices. It also investigates a number of storage methods that may be appropriate to use by Welsh growers.

2 Methodology

To assess the opportunities for improving storage, a literature review and a survey in the form of stakeholder interviews (20) were conducted.

2.1 Literature review

The desk research aimed to identify opportunities and constraints on storage of organic produce and furthermore to assess alternative storage methods (for example, as used elsewhere in the UK and other countries in Europe).

Published data and a number of reports on storage of (organic) vegetables were consulted. Much of the information on field and clamp storage dates back many years. Many articles and reports concerning vegetable storage refer to the ADAS publications of 1979.

As the organic vegetable market influences greatly the need for storage and the economic feasibility of storage, its development has been reviewed as well.

2.2 Survey

In order to assess storage technology/ methods and to build on the literature review, it was important to find out:

- what crops farmers and growers store and envisage to store in the future,
- problems encountered during storage,
- methods of storage

and in the case of growers not storing, the reasons why they do not store at present.

Fourteen interviews were conducted with organic vegetable producers and 6 interviews were conducted with experts. Through these interviews, views on the key issues relating to storage of organic vegetables and supply development were obtained.

A structured discussion guide for all stakeholder interviews, with the same set of questions asked of each interviewee was developed. The discussion guide is included in Appendix 1 of this report. See Appendix 2 for an overview of the people consulted. The majority of the interviews were conducted over the telephone, but three of them were face-to-face.

3 Results

3.1 Development of vegetable production in Wales and UK

The Soil Association estimates that the area of organic horticultural production in the UK increased from 7,083 in 2003 to 8,522 hectares in 2006. The main increase was found in the area of green vegetables, salads and protected crops (1,598 to 2,805 hectares between 2003 and 2006) (Soil Association, 2006).

Horticulture Network Wales estimated the number of organic vegetable producers at 118 in 2006.

Elm Farm Research Centre is conducting an organic fruit and vegetable market report at the time of writing this report.

According to the Soil Association's Market Report 2006 there were 588 hectares used in Wales for organic horticulture. The most recent estimates (Haward and Green, 2004) for cropping areas in Wales are as follows:

Table 3.1 Total area in organic production in Wales

<i>Crop</i>	<i>Total area (ha)</i>
Alliums – Onions	7
Brassicas	64
Green veg – other	86
Roots – Carrots	20
Roots – Other	21
Potatoes	138
Squash	
Other	
Total	394

Horticultural Network Wales (2006) estimate that Wales is only 20% self sufficient in fruit, vegetables and potatoes; with Cardiff wholesale market sourcing only approximately 5% from Wales, retailers sourcing no more than 10%, and the public procurement sector sourcing around 17.5% of fruit and vegetable from within Wales.

A survey undertaken in 2006 by Organic Centre Wales, suggested that 52% of the respondents expect to increase production over the same period (WDA, 2006).

In terms of self sufficiency, the situation varies widely from crop to crop but overall, levels of UK self-sufficiency are increasing. According to the WDA inward investment study in 2006, (WDA, 2006) it is highest (70% plus) for main crop potatoes, carrots, parsnips, leeks, swedes, cauliflowers and cucumbers, and lowest (less than 40%) for onions, celery and sweet corn.

According to Helen Browning (QLIF study, pers comm, 2007) imports of potatoes will continue to UK due to:

- insufficient production in UK (early and salad potato) and problems of storage
- Quality specifications – skin finish and problem of deterioration on storage Charlotte and Maris Piper can be stored to March, but must be produced on good storage land (light silts) to ensure shiny skin
- Storage is inadequate. She suggests that deterioration on storage (both skin finish and sprouting) sprouting could be prevented through use of ethylene

- High storage costs (£1/tonne/week, or £40/tonne/season)
- Risk of Isopropyl N-(3-Chlorophenyl) Carbamate (CIPC)residues from conventional stores requires that a dedicated store for is organic essential (it is not adequate to designate and clean out a store previously used for conventional potatoes.)
- During period February to April – UK potato ex-store are cheaper than imported salad/early, but imports are attractive in terms of quality (size, texture, taste, skin finish) and hence give uplift in sales, however, they are available only at higher cost, thus there is a trade off.

Calon Wen (pers. comm, 2007) reports that at present 80% of their organic fruit and vegetables are sourced from Wales in the summer dropping to 10% in the winter.

3.2 Growing for storage

3.2.1 Introduction

The main crops stored in Wales are potatoes, carrots, squash, onions, cabbage and celeriac. Furthermore, Calon Wen suggest that garlic is one of the products which could be produced and stored.

Many factors may contribute directly or indirectly to suitability for storage, the length of life in store and quality of the crops in store. These include the method of growing, harvesting and handling, store management and storage method.

Helen Browning suggests in her report that 50% of the UK organic potato growers produce potatoes that are not suitable for storage, growing on poor quality land and thus need to get the crop sold as soon as possible (QLIF pers. comm).

Some general guidelines for producing vegetables that are suitable for storage are the following:

1. Plants that have been grown in optimum conditions produce the best crops for storage. Immature crops or those that have struggled to survive through lack of water, nutrients or pest and disease damage will not keep well. (HDRA, 2007).
2. Avoidance of nutrient oversupply,
3. use of disease free seed and suitable varieties,
4. Use of strategies to avoid pests and diseases including crop rotation (Bevan et al.).

Crop rotations can prevent some soil-borne diseases, such as Sclerotinia and Centrospora, which can cause deterioration in store, particularly of root crops and celery kept for long period. (ADAS, 1978).

Care at harvesting is very important. Only top quality produce should be stored, according to ADAS (1978). Bruising of crops during harvest can lead to serious problems in store. The damage may not show up immediately, but the chance of rots getting in later is greatly increased (HDRA, 2007).

Air circulation is important to provide oxygen and carry away the heat and moisture produced. Crops have different requirements for temperature and humidity (see appendices 2,3 and 4). Checking stored produce regularly, preferably weekly, is very important. Anything showing signs of decay should be removed to prevent rots from spreading. (HDRA, 2007)

3.2.2 Economics of storage

Organic growers perceive costs of storage to be high. The interviews with growers undertaken for this study showed that the main reason for not using storage other than field storage is the cost involved. Whether an individual producer can meet the costs depends on a number of things such as the type of market outlet supplied. Improvements in production and marketing can impact on the profitability of storage positively. Investment in storage facilities can also increase a grower's turnover of if it allows a higher proportion of crops to be marketed as a result of better crop quality, or to be able sell at a time of year when prices are higher.

Case study examples

- *Growing with Nature*, a vegetable box scheme in North-West England was able to improve storage enormously after receiving a Processing and Marketing grant from DEFRA in 2005. They converted a pack shed into an ambient storage facility. A great deal of effort and capital was put into providing good insulation to prevent frost entering the building. They have improved their storage and in addition reduced their storage costs (as they no longer depend on cold storage) (Alan Schofield, pers comm. 2007)
- Puffin Produce Ltd received a Processing and Marketing Grant which was delivered by the WDA using Welsh Assembly and EU funding. A new 1500 sq. m cold storage and processing facility has turned a largely seasonal business into one that is secure all year round (CALU, 2006)

Table 3.2 Annual costs of storage (per tonne)

COSTS (£/t)	1	2	3	4	5	6	7	8	9
	Field storage carrots	Outdoor clamp	Dickie Pie	Clamp in a barn	Refrigerated container	Small cold store	Small ambient store	Large cold store	Large ambient store
Building Depreciation				5.75	1.3	2	13.96	10.6	13
Interest on capital				3.45	0.78	0.6	8.37	6.4	7.8
Electricity			1.5		2.12	2.66	1.5	10	1.6
Repairs/maintenance				0.87	1	0.2	2.5	3.33	1.95
Boxes									
Straw	21	1.5	2.25	1.5					
Polythene sheeting	13	0.27	0.2						
Ducting fans			2.7						
Earthing up		0.5	0.5						
TOTAL COST £/TONNE	34	2	7	12			26	30	24

Bevan et al. (1997) have undertaken research into costs of storage and have conducted a number of case studies. See table 1 for a general overview of the findings.

3.3 Storage methods review

The table above shows some differences between storage methods. This paragraph will outline the differences in more detail. Organic crops are generally stored using the same methods as conventional crops. According to Bevan et al (1997), the difference is that sometimes organic crops have higher storage losses as a result of not using pesticides and sprout suppressants.

Relatively few organic producers interviewed store vegetables but the majority recognise that in order to maintain supply of good quality UK produce throughout the year, more long term cold storage is required.

3.3.1 Field storage

Field storage is used by the majority of growers in Wales. Harvest is delayed until the crop is required.

The main advantages are:

- simplicity
- low costs involved
- better skin finish

According to Guy Watson of Riverford Organic Vegetables Limited¹, a large box scheme, parsnips and Jerusalem artichokes are best left in the ground and lifted when needed.

The main disadvantages of field storage mentioned by growers interviewed are:

- exposure to frost,
- exposure to pest and disease attack. According to ADAS (1979) evidence suggests that carrot fly damage can be severe over winter even when routine measures have been taken
- weather can make harvesting impossible
- land cannot be used by new crops or at least there are delays to planting a new cash crop or fertility building crop.

Furthermore, not all soil types are suitable for field storage. Heavy soils such as clay are unsuitable as the crop may come in contact with water as soils may become waterlogged and produce will start rotting.

One of the arguments given by the growers interviewed for using field storage is that the temperatures in winter are continuously increasing which makes other methods of storage unnecessary.

Some research has been undertaken to look at over wintering crops in the field making use of crop covers (See 3.4). Bevan et al (1997) suggest that the use of shelter belts or hedges at the field boundaries helps to prevent cold winds sweeping across the field. Guy Watson of Riverford mentions that carrots field stored under the insulation afforded by lots of straw between two layers of plastic is a good option for organic growers. He says that this technique allows them to be washed and graded for the supermarket shelves

¹ <http://www.riverford.co.uk/>

3.3.2 Cellars

The opportunity of using cellars was discussed at a workshop on vegetable storage organised by Glass. Cellars are either below or partly below ground and as a result are well insulated.

The main advantage of cellar storage is:

- Temperature remains fairly stable (approximately 11°C), which protects the stored crop from freezing or excessive warmth (Bubel & Bubel, 1979).

The main disadvantages are:

- Loading and unloading below ground is complicated
- Ventilation (Bubel & Bubel, 1979).

According to Bubel and Bubel (1979) it is unlikely that any grower would build a cellar. They say that the expense of building a structure below ground (requiring strong retaining walls and a strong roof) are high. However when the structure is already present it can provide new opportunities

It is possible to fit ventilation or refrigeration equipment to a cellar, but there are again costs involved to set it up. Bevan et al (1997) mention that drying out of produce can be a problem if floors are made of stone or concrete. Alternatively, when the floor is made of earth this is less of a problem.

The storage method is suitable for small farmers storing small quantities of crops such as cabbages, onions and potatoes (also pumpkins as long as the temperature is kept above 10°C) over the winter. Produce can be stored successfully until March, or for a few weeks during the summer.

For more information about this method see "Root cellaring" (Bubel & Bubel, 1979).

3.3.3 Pits

Storage in pits or trenches has not been researched very well but might offer opportunities. Bevan et al (1997) say that you can store crops in bulk or in boxes until March. The pit is covered with straw or other organic material, then filled with the crop and then covered with soil (up to 25cm thick for cold climates) or a layer of organic material such as straw.

The main problem with pits is lack of ventilation, which can lead to rotting. Ventilation can be achieved by digging ventilation trenches down to the base of the store or leaving ventilation holes at the top. The ventilation holes need to be covered with straw in such a way as to allow air through but not rain (Thompson, 1996).

The disadvantages of using pits to store vegetables is the high labour requirement for construction, loading and unloading (which can only take place in good dry weather).

Bevan et al (1997) suggest that the high humidity and contact with soil could possibly be an advantage in using pits rather than clamps for storage of carrots as it might help maintain good skin finish. They do recognise that this has not been proven by scientific research nor practice by growers.

An adaptation of the pit is to load root vegetables (e.g. carrots & potatoes) into bulk plastic bags (e.g. silage bags) and place these in a semi-permanent pit. This has been experimented by a few small-scale growers in Wales and was demonstrated at a Glasu storage workshop. It has however not yet been used or trialled on a large scale.

3.3.4 Clamps

58% of the Welsh organic growers interviewed use indoor clamps. The majority of these, 71%, store the produce loose - covering it with straw. The rest use crates or boxes to store the vegetables

Simple clamps have been used for storage of vegetables and fruit for centuries. The use of clamps has been largely replaced by cool storage in conventional production. Some of the growers interviewed mentioned that use of clamps is very labour intensive and therefore costly. They could however provide a suitable form of storage for some organic growers if value could be added.

The most suitable crops to store using clamps are hard vegetables, such as potatoes, carrots, beetroot, turnips, swedes, celeriac and parsnips. Potentially, crops that do not tend to sprout can be stored reasonably successfully by many growers up until March or even April, if weather conditions are favourable.

Andy Johnson of Riverford mentions that one has to take care with humidity when using clamps. Humid climates, according to him are not appropriate for clamping.

Bevan et al. (1997) identify a number of clamping methods. These are the following

- Crop covered with soil alone (traditional, unvented)
- Crop covered with loose straw only (traditional, unvented).
- Clamp walls made with straw bales, bales or netting and straw used to cover top (improved, unvented)
- Crop covered with loose straw or if risk of frost polythene, lined sides and straw (improved, unvented).
- Crop stored in pallet boxes lined with polythene sheets covered with straw bales by making use of the pallet base to form air channels for ventilation (improved, vented).

The main advantages of using clamps are:

- Flexibility; the decision to build a clamp can be made at harvest time. This provides a certain degree of flexibility to a producer. The need to store might only be identified near to harvest. Ensuring high crop quality is essential.
- Low capital cost; relatively minimal quantities of materials are needed however straw needs to be applied annually.
- Ease of construction; it is not technically difficult to build.

The main disadvantages of using clamps are:

- Temperatures in unvented clamps can rise sometimes above 10°C for short periods providing suitable conditions for many diseases to develop.
- Frost and rodent damage is likely.
- Reasonably high labour requirements for construction of clamps as they need to be built every year and re-made during loading and unloading of produce.

The main problems mentioned by the growers interviewed using clamps to store their produce were:

- Dehydration,
- Potatoes breaking dormancy,
- Blight occurrence
- Frost.

Much of the information available on clamps is relatively old. There is interest amongst organic growers interviewed to know more about storage in clamps.

Storage in clamps is practised by vegetable growers in Southern Germany, for example. Clamps are excavated using mechanical diggers and lined with polythene. Crops are covered with soil, straw and sheeting. Current use of clamps and modern methods of construction needs to be further researched, or exchange visits arranged for Welsh growers to learn from farmers in other areas where clamping is still common practice.

3.3.5 Ambient storage

Controlled ambient storage was not used by any of the organic growers interviewed. Alan Schofield of *Growing with Nature*, a medium-sized vegetable box scheme, has converted a pack shed into an ambient store. By investing in good insulation he managed to create a store which required relatively low investment and has low running costs. Alan Schofield suggests that ambient storage is the best storage method for growers in Wales. According to him there are two reasons for this:

- Storage is needed because of the high rainfall in Wales
- Ambient storage is effective and relatively cheap to construct.

According to Bevan et al.(1997) high depreciation costs of the building make the cost related to this storage method still high. They obtained economic data from Scottish Agricultural College.

3.3.6 Cold storage

Only 15% of the Welsh organic growers interviewed use cold storage. The main reason mentioned for not using cold storage is the high investment costs.

ADAS (1979) advises growers to consider the following issues before investing in a cold store:

- What types and varieties of crop are to be stored? (Not all product are suitable to be cold stored and/or need to be cold stored. For example some potatoes change taste when cold stored. Onions that are cold stored have a higher risk of bolting after removal of produce from cold store For what time period do the crops need to be stored? If storage is only needed for a few months, other storage methods might be better/ sufficient
- What market do you supply? Jim Cross of Bellis brothers, with a large farm shop, mentions that some years ago when they were selling to a wholesaler they used a cold store but since they started selling all produce via the farm shop they mainly use indoor clamps with only a small percentage cold stored. Some produce is bought in via a wholesaler.
 - Is the storage method appropriate for the scale of enterprise?

The main problems mentioned in relation to cold storing carrots are:

- Splitting of carrots after removal of produce from the cold store.
- Softening of carrots within a few days after removal of cold store

Andy Johnson of Riverford, where cold storage is used, advises growers wanting to store and maintain a good quality product to ensure that field heat is removed before storing produce. It is essential to do this within a short timespan. Doing so results in

an extended storage potential, especially for produce such as lettuce, spring greens, Brussel sprouts, calabrese and fruits.

3.3.7 Alternative methods

There is some research being undertaken on the following methods:

- Heat treatment/ Warm water treatment. This method can reduce rot in a number of vegetables. Heat treatment/ use of warm water however does not **always** give good results (Applied Plant Research, PPO, <http://www.ppo.wur.nl/UK/>; Bevan et al. 1997)
- Use of bio degradable crop covers for protecting crops stored in the field. Opportunities for over wintering field stored carrots by covering them with a bio degradable cover is being investigated in a DEFRA funded project . (pers comm John Birkenshaw, 2007; <http://www.hdc.org.uk/index.asp>)
- Use of beet juice for providing energy for a cold storage. This bio- energy is being used by one organic grower in the Netherlands. There is no detailed information available about this method. (pers. Communication Andy Johnson of Riverford, 2007)
- Use of alternative energy sources for cold storage; Use of “alternative/ green energy for cold stores” can be an alternative as it might lower the costs involved . However no research has been done in this area. According to Bevan et al (1997), the use of renewable energy sources such as wind and solar power is probably only financially justifiable on either a very large scale or on a very small scale where there is no existing electricity supply. They relate this to the high investment costs
- Use of heat from cold storage for heating ‘warm’ storage for storing e.g. squash. This technique is used by a number of organic growers in the Netherlands (pers. Communication Andy Johnson of Riverford, 2007)

3.4 *Increasing local produce supplied into public and private sector in Wales*

One of the questions asked during the interviews was “What is the best way forward in supplying local produce the whole year through?”. The answers, ranked in order of importance were:

1. More co-operation between growers, including in vegetable storage
2. Increase consumer awareness of seasonality
3. Increase the volume of organic vegetables produced within Wales
4. Improve storage methods used
5. Increase protected cropping
6. Use appropriate (Welsh) varieties
7. Lack of suitable land available

4 Conclusions

- There is a market for supplying organic vegetables the whole year through. (EFRC, unpublished. Organic fruit and vegetable market review)
- Currently storage is little used by growers in Wales. This is confirmed by Garry Smith of Horticultural Network Wales and Mike Westrip, who is a facilitator of a producers' group in Powys.
- Field storage and clamp storage are the main storage methods used by the organic industry. The majority of growers cease to have produce available after December. There is lack of organic produce from Wales from January onwards. (Calon Wen, pers communication).
- Cold storage and secondly clamps are perceived to be the best way forward. The majority of growers interviewed stress the need to cooperate to bear jointly the costs of cold storage.
- While it is recognised that storage needs to be improved in order to supply all year round, the majority of the interviewees are not investing in storage.
- There is resistance to increasing the scale of vegetable production among Welsh organic growers. The Organic Growers' Alliance has started an apprentice scheme which gives young people the opportunity to learn new skills and might increase interest to grow organic vegetables.
- Interest was expressed to co-operate to obtain supply levels which make it worth investing in storage. Andy Johnson of Riverford says that their members (growers) use eachother's stores. As different growers specialise in different crops, by sharing storage they can optimise storage methods. Different crops have different storage requirements. In addition, this results in fuller stores helping to spread costs.
- Improvement of storage has shown to increase market opportunities (Alan Schofield, pers. Comm; CALU inward investment horticulture).
- In general, storage is perceived to be too expensive by the growers interviewed.
- There are a number of alternatives available such as covering field stored produce with bio degradable covers and use of alternative energy for running cold stores. However more research is needed into these methods.
- Use of tunnels is seen as another opportunity to extending the season.
- As energy costs are increasing rapidly the costs of storage will increase as well. A good balance between benefits and cost of cold storage needs to be obtained.

5 Recommendations

- A joint effort by the whole organic fruit and vegetable industry is required to increase the volume of organic fruit and vegetables produced within Wales.
- Processing and Marketing grants for improvement of storage for SME and or co-operatives are required to increase the volume of local produce produced and sold in Wales.
- Research needs to be conducted into the economic feasibility and issues involved in setting up and running storage facilities using alternative (green) energy
- The practicalities and costs of using bio-degradables should be investigated
- Opportunities for sharing cold storage/ ambient insulated storage should be investigated
- Establish best storage practices

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- <http://www.hdc.org.uk/index.asp>)

Annex 1: The survey

General background of the farm:

1. Total area of farm
2. Area under vegetable production
3. Type of vegetables grown.
4. Vegetables stored
5. What vegetables are you looking at storing in the future
6. Market supplied.
7. What are the storage requirements on your farm.(Length of storage, etc)
8. Storage methods used at present

Type of vegetable (e.g. Carrot, potato, etc)	Type of storage used	Quantities stored

9. Storage methods used in the past: used for which vegetables? Why stopped using these methods
10. What problems do you encounter during storage?
11. Advantages/ disadvantages of using the storage methods mentioned below

	Advantage	Disadvantage
Field storage		
Cellar		
Pits		
Clamp		
Cold storage		
Cold refrigerated storage		
Other		

12. What were the main changes on farm over the last 5 years?
13. How important is storage for your business?
14. How important is storage for growers in Wales?
15. What is the best way forward in supplying local produce the whole year through?

Annex 2. List of people interviewed

Overview of growers and experts interviewed

Growers

Penpont
Old Hall Organics ,Llwynderw
Mentro Llest
Llest growers
Blaencamel
Organics To Go
Nantclyd Organics
Crynfryn organic produce
Llwynhelyg farm shop
The Wild Carrot
Northop Organics
Plas Einion
Long Meadow Organic Vegetables
H.E. Hall and Son Ltd.
The plantation
Offa Farm
Hooton home-grown

Experts

Name
Garry Smith, Horticulture Network Wales
Phil, Sumpton, HDRA
Jim Cross, Bellis brothers
Alan Schofield, Growing with Nature
Andy Johnson, Riverford
David Frost, Frost Fresh Organic

Annex 3. Storage of vegetables by consumers (adapted from Riverford Organic Vegetables²)

Onions

Cool and dry is best but dry is most important. One of the few vegetables that can be readily stored in a centrally heated house. In the autumn they will keep for months but after Christmas and as spring approaches they will show an increased tendency to sprout. Never put them in a plastic bag.

Carrots

Carrots are living organisms adapted to storing energy as starch generated in one season, for use in flowering and seed production the next. They keep best in conditions similar to those they evolved for: dark humid, 1 to 4 degrees C and covered in soil. The carrot's skin is its protection from bacteria. Washing severely damages the protective skin of the carrot allowing bacteria in, first impairing flavour and then causing decay.

Unwashed carrots should last for weeks or even months during autumn and early winter in a paper or perforated plastic bag. A cool vegetable rack is normally OK but as spring approaches and they would naturally be preparing for flowering, it is worth putting them in the bottom of the fridge to delay the sprouting of root hairs and leaves.

During May and June, imported carrots, normally from Andalucia in Spain, arrive washed. Keep them in the fridge and don't expect them to keep more than a week. To avoid bunched carrots dehydrating and going rubbery twist off the tops and store in a bag in the fridge.

Celeriac

Cool and damp is best so, an outdoor shady vegetable rack is good and the bottom of the fridge even better. If healthy they should keep for several weeks without any significant loss of quality. Technically speaking they are a corm and as such a natural starch store which would be used to produce a seed head in the second year if given a chance.

Parsnips

Parsnips lose moisture more quickly after harvest than carrots and most other roots. With some soil on and without the damage caused by washing, they will keep for two or three weeks in a cool vegetable rack or the bottom of the fridge.

From February onwards parsnips are preparing for spring, which means throwing up a seed head from their central core. In preparation they start re-growing root hairs and sprouting leaf, and the core can start to go tough and woody. From February it is worth keeping them in the fridge to slow down the clock.

Potatoes

New potatoes, normally harvested from May to early July, before the skin is set, will not keep in good condition for more than a week and should be eaten as soon as possible. Once the skin is set the potato has equipped itself to be the plants natural storage organ for starch and should keep for weeks or even months provided kept in

² <http://www.riverford.co.uk/>

the dark and cool but free from frost. If potatoes come in a plastic bag it is worth putting them inside a heavy paper bag straight away to protect them from the light.

From Christmas onwards the potatoes are starting to prepare for spring and might show signs of sprouting at temperatures above 4 degree C. This is normally prevented in non-organic potatoes by using chemical sprout suppressants. The tuber is actually a modified swollen stem and the eyes are dormant buds from which new roots and leaves would naturally emerge. This is highly dependent on variety but the tendency increases later in the year. Sprouting can be stopped by putting the potatoes in the bottom of the fridge. Temperatures of less than 4 degrees C can cause the potatoes to accumulate sugar which will cause blackening during cooking.

Leeks

Leeks keep best at high humidity and 1 to 4 degrees C, so the best place is the bottom of the fridge where they should keep in good condition for at least a week. They should also be OK on a cool, outdoor veg rack for up to a week during winter. As spring approaches leeks tend to telescope out from the centre and may yellow a bit faster at the end of the leaves. This is caused by the leek preparing to throw up a seed head in its second year

Sweetcorn

It is important to keep the leaves on the sweetcorn for as long as possible to maintain freshness. A lot of fuss is made about "Getting the water boiling before you pick the cob" to get the sweetest corn. This is based on the fact that the sugar supply (photosynthesis) is cut off when you pick it and the sugars will soon be converted to starch. With the new super-sweet varieties this is less the case but it is still worth keeping the cobs in the fridge and using them as soon as possible.

Kohl rabi

This keeps fairly well but like most veg will last longer in the fridge. If it has leaves attached, these should be removed to avoid drawing moisture from the root. The leaves can be cooked as greens if in good condition

Squash and pumpkins

Squash, in general, keep for a long time. Many people store them decoratively on their kitchen shelves (although you should avoid placing them above a hob or anywhere with steam and heat). For optimal shelf life you can expect to get several weeks out of them if stored in a cool, dark, dry place with good air circulation

Courgette

Courgettes keep best at 4 degrees C and high humidity so the bottom of the fridge is ideal. They keep their appearance for two weeks or more but, certainly the flavour, and probably the nutritional value, declines much more rapidly. At the beginning and end of the season (June and October/ November) when the weather can be less suitable for flowering and pollination, poor pollination and blossom end rots can cause a tapered shape and sometimes rots setting in where the flower was attached.

Sprouting broccoli

Like its more highly bred cousin, calabrese, PSB keeps best at 1 degree Centigrade and high humidity, so in a plastic bag in the bottom of the fridge is ideal. It has a longer life than calabrese and does not have the tendency to yellow. It will normally keep for a week or more, but like most greens, is better as fresh as possible. If it is looking a bit old it is worth re-trimming the bases

Cabbage

Ideally 1 to 4 deg C and high humidity i.e. the bottom of the fridge. The hard white and red Cabbage should keep for several weeks. In Holland they are harvested in November and stored at 1 deg C through to June. Hispi, Savoy, Tundra and other round cabbages should keep for 7 to 10 days. Spring greens, available in March, April and early May will not last more than a few days and should be eaten as soon as possible.

Cauliflower

Cauliflowers keep best at 1 to 4 degrees C and high humidity, so the bottom of the fridge is the best place. For a flower they have a remarkably long shelf life and will keep in reasonable condition for as long as two weeks. An outside veg rack is OK during the winter if the fridge is full.

Kale

Kale will keep best at high humidity and 1 to 4 deg C. In a plastic bag in the bottom of the fridge is ideal. It should last for a week but as with all greens is best eaten as fresh as possible. Shelf life is likely to be lower at the beginning and end of the season (September / October and March).

Brussel sprouts

As with all the brassica vegetables the bottom of the fridge is the best place, ideally at about 4 deg C and high humidity

Romanesco

Ideally 1 to 4 degrees centigrade so bottom of fridge is ideal. Has a wonderful flavour when fresh but this is lost more quickly than a cauliflower so eat as early in the week as possible.

Tomatoes

The ideal storage for tomatoes is generally accepted to be 8 to 12 degrees C so the fridge is too cool and will not allow effective ripening while room temperature is too warm and you will find they do not keep for long. An old fashioned larder would be ideal, but in practice if fully ripe they should go in the fridge if not eating straight away, while if under ripe they will be OK at room temp for a few days. Always remove from the fridge a few hours before eating to get the best flavour.

Ethylene is given off by ripening fruit and also serves as a plant hormone by initiating ripening. The fastest way to ripen under ripe tomatoes is to keep them at room temperature, or just above, in a semi-sealed container which has the effect of concentrating the ethylene.

Annex 4. Storage of vegetables by producers

Annex 4A: Refrigerated storage of fruit and vegetables (ADAS, 1979)

Carrots

Optimum storage conditions: 0-1C RH 95-98 %

The maximum storage life of carrots is unlikely to exceed 6-7 months. Ideally, carrots should be grown for storage and not, as so often happens in practice, be put into store merely because they happen to be available and surplus to immediate requirements. For long-term storage hand lifting is the method recommended. Mechanically harvested produce of good quality may be acceptable but only if the roots are required before mid-March. Carrots usually are stored in bulk containers, of either 500kg or 1000 kg capacity. Storage in sacks is not recommended because the airflow is restricted making it difficult to keep the roots cool in store. This can result in dehydration.

Beetroot

Optimum storage conditions: temperature 3C, RH 95-98%

Red beet can be stored for six to eight months in temperature controlled stores. It can be kept in clamps or barn stored during the earlier part of the winter and moved later into temperature controlled chambers as outdoor temperatures rise. Red beet must be harvested during November before severe frost occurs. Temperatures of below 0C can result in sugar conversion resulting subsequently in loss of flavour.

Onions

Optimum storage conditions: temperature 0C, 70-80% RH

Onions can be stored in ambient ventilated stores from September until the end of March but for marketing during April- July, refrigerated storage is necessary. Onions should be selected from land known to be free of eelworm as infested bulbs are unsuitable for long-term storage. Onions stored in places with RH above 85 per cent will develop roots and shoots making them unfit for marketing.

Winter white cabbage

Optimum, storage conditions: temperature 0C, RH 95 per cent

Cabbages can be stored for up to eight months in cool stores with a weight loss averaging 1-1.5 per cent per month. It is essential that such cabbage should be harvested in advance of severe or prolonged frost. Resorting may be necessary during the storage period and diseased heads will need retrimming. Disease free heads should not be peeled until required for market. Peeling to remove senescent leaves and those infected with Botrytis or bacterial soft rots, and butt trimming will then be necessary. On average a total of four to six wrapper leaves are removed.

Cauliflower

Optimum storage conditions: temperature 1C, RH 95-98 C

Cauliflowers can be stored at 1C for a period of up to three weeks. Storage longer than three weeks leads to rapid deterioration and loss of shelf life.

Annex 4B: Storing the harvest, factsheet GG16 Henry Doubleday Research Association

Carrots, parsnips, celeriac, beetroot, turnip, swede, kohlrabi, horseradish, salsify:

These crops all require the same conditions. They usually last well, as most are the storage organs of biennial plants, so would naturally stay dormant in the soil over winter. Harvest carefully, taking care to avoid skin damage. Do not wash unless grown in very heavy soil or pest/disease damage is suspected. Harvest on a cool day or cool before storage. Remove leaves by twisting off close to crown. Place in layers in shallow crates/boxes separated with a damp packing material such as leafmould, sand, sieved soil, sawdust (from untreated wood only), coir.

Ideal temperature: 0°- 4°C.

Potatoes:

Require slightly different conditions from other root crops. They must be kept dark to prevent them turning green, and protected from low temperatures. If stored below 5°C the starch turns to sugar, giving them a sweet taste when eaten. Harvest in dry, cool conditions if possible. Remove any damaged tubers; store good ones in thick paper sacks closed at the neck to conserve moisture. Do not use plastic sacks - the humidity will be too high, which stimulates sprouting. Give extra insulation before weather becomes very cold.

Ideal temperature: 5°- 10°C.

Onions/garlic:

Lift garlic when only 4-6 outer leaves have turned yellow. Leave onions longer, until the tops have completely died away. Do not bend tops over prematurely. Both need to be dried until skins "rustle", either in the sun or under cover. Store in nets, old tights or make into strings, and hang in a cool, dry place where air can circulate.

Ideal temperature: 2°- 4°C.

Pumpkins/winter squash/marrows:

Being of sub-tropical origin, these store best at a higher temperature with lower humidity than most other crops. They are very affected by growing conditions, as they need a few weeks of warm sun in August/September to develop a tough skin for successful storage. Harvest before the first frost, leaving as long a stalk as possible. Check for skin blemishes, and store in a dry, airy place, preferably on slatted shelves or hanging in nets.

Ideal temperature: 10°- 15°C.

Annex 5. Storage of fruit and vegetables by retailers

	Pre Packing Min/Max (°c)	Storage pre Despatch Min/Max (°c)	Distribution Min/Max (°c)	Product Core Temperature Min/Max (°c)
Brassicas	1 to 4	1 to 4	1 to 4	1 to 4
Red beet	3 to 8	3 to 5	3 to 5	3 to 5
Carrots and Parsnips	1 to 4	1 to 4	1 to 4	1 to 4
Bulb onions	3 to 7	1 to 5	1 to 5	3 to 7
Runner and Dwarf Beans	5 to 8	4 to 7	4 to 7	4 to 8
Courgettes, Marrows	5 to 10	5 to 10	5 to 10	5 to 10
Asparagus, Rhubarb, Sweetcorn	1 to 4	1 to 4	1 to 4	1 to 4
	Pre Packing Min/Max (°c)	Storage pre Despatch Min/Max (°c)	Distribution Min/Max (°c)	Product Core Temperature Min/Max (°c)
Ware	6 to 10	2 to 8	2 to 8	2 to 8
Bakers	6 to 10	2 to 8	2 to 8	2 to 8
Salad Potatoes	6 to 10	2 to 8	2 to 8	2 to 8
Sweet Potatoes	10	8 -10	8 –10	8- 10
	Pre Packing Min/Max (°c)	Storage pre Despatch Min/Max (°c)	Distribution (Target 4°c) Min/Max (°c)	Product Core Temperature Min/Max (°c)
Tomatoes	6 to 9	7 to 9	7 to 9	6 to 9
Lettuce, Endive, Celery Watercress, Spinach	1 to 4	1 to 4	1 to 4	1 to 4
Cucumbers, Peppers	7 to 10	7 to 10	7 to 10	7 to 10

Product	Days at optimum temperature for long shelf life	Max	Min
Oranges	8 days @ 8c	10c	6c
Bananas	5 days @14c	25c	12c
Red apples	10 days @ 8c	10c	6c
Granny smith/ Red delicious	10 days @8c	10c	6c
Baking potatoes/ White potatoes	10 days @3-8c	10c	6c
Carrots	4 days @ 4c	5c	3c
Broccoli	4 days @ 3c	6c	2c
Iceberg lettuce	3 days @ 3c	7c	2c
Tomatoes	4 days @3c	6c	2c
Cucumbers	4 days @3c	6c	2c
Mushrooms	4 days @ 3c	6c	2c

Source: Information supplied by Nigel McDonald, ADAS Senior Horticultural Advisor, 2007.