

# MASTER

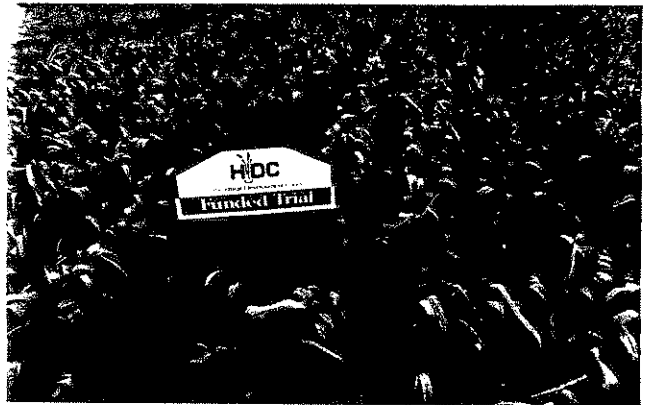
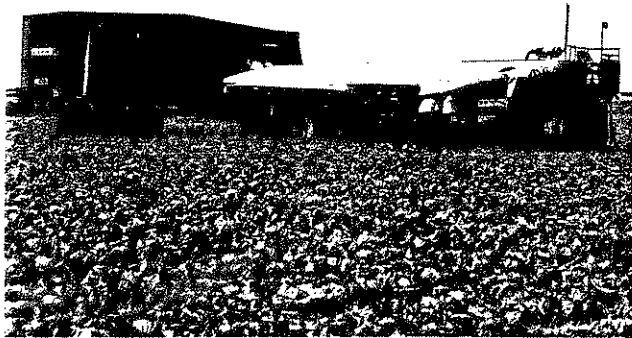
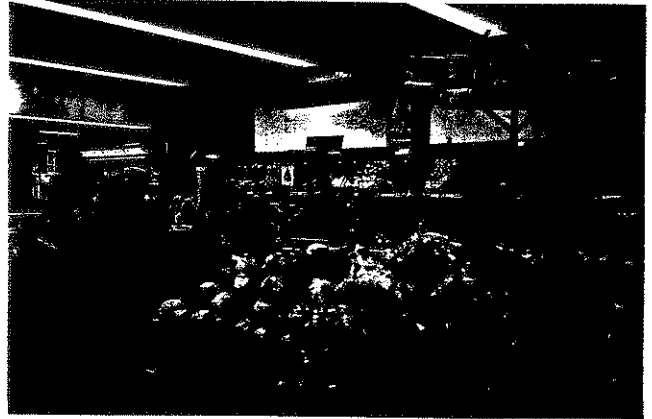


**HORTICULTURAL DEVELOPMENT COUNCIL**

## QUALITY VEGETABLES

A review of the factors affecting the quality and shelf life of UK field vegetables for the fresh market.

*Written by John Love for the Horticultural Development Council*



# MASTER.

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# ABBREVIATIONS USED IN THIS REPORT

- B.O.P.A. \_\_\_\_\_ British Onion Producers Association.
- C.F.D.R.A. \_\_\_\_\_ Chipping Camden Food and Drink Research Association.
- F.R.I. \_\_\_\_\_ Food Research Institute.
- H.D.C. \_\_\_\_\_ Horticultural Development Council.
- H.R.I. \_\_\_\_\_ Horticulture Research Institute.
- N.I.A.B. \_\_\_\_\_ National Institute of Agricultural Botany.
- N.F.U. \_\_\_\_\_ National Farmers Union
- P.G.R.O. \_\_\_\_\_ Processors and Growers Research Organisation.

# QUALITY VEGETABLES

## A Review of the Factors Affecting the Quality and Shelf Life of UK field

### Vegetables for the Fresh Market

The intention of this review is to bring together the practical knowledge, experience and to a certain extent the opinions of a wide range of individuals involved with the growing, marketing, breeding and selection of a range of field vegetables. Some reference is made to research work but this is not a comprehensive survey. It is hoped that the review will shed some light on the quality and shelf life problems, their probable causes and possible solutions, if any. Everyone involved in the chain of events from plant breeding through to retailing should gain a better understanding of the situation in the quest for better quality and extended shelf life for the benefit of not only the consumer but everyone involved in the industry.

For the purpose of this review the definition of quality is that given in the introduction to BS 5750, i.e. quality is the requirement necessary to meet the customer's needs. One of the major problems encountered is that of specifying what are the customer's needs and, if known, how well are they understood and how consistent are they? Several aspects are discussed for each crop studied but in general terms there are factors common to all crops or products.

#### The physical and visual aspects

Most of these are laid down in the EC Quality Standards and extended in the supermarket specifications. Where no supermarket specification exists the relevant EC Class is generally adopted and must in all circumstances be complied with. The **physical criteria** e.g. size, weight and shape of product are dependent on plant density, varietal choice and cultural techniques (e.g. irrigation and fertiliser rate),

these are generally well understood by growers. The emergence of the demand for smaller or mini vegetables can be met by choice of variety, increased plant population or harvesting the crop at an immature stage with consequent effects on its flavour and shelf life. The alternative of selecting out the small portion of a normal crop defeats the image of mini vegetables being young, fresh and tender, if in fact this is the marketing objective. Special dispensations from the EC quality standards are given for some baby/mini vegetables by the Ministry of Agriculture but agreement on such dispensations must be obtained from the Horticultural Marketing Inspectorate. Currently cauliflower and leeks are included in the agreement provided they meet Class I and are in packs not exceeding 5kg.

The **visual factors** of colour, shape, degree of blemish are again well understood and documented although concern has been expressed regarding the degree of blemish which may be acceptable to the average customer, if in fact such a person exists. This concern applies mainly to some supermarket specifications which demand a degree of visual excellence achievable at a cost not always reflected in the price received. In general the EC Quality Standards are reasonable and practical on this aspect with the possible exception of onions where the question of skin finish and cleanliness is subject to debate. To overcome these difficulties many supermarkets sell the product as Class II.

In considering blemish a clear distinction must be made between defects which are progressive and those that are non progressive e.g. slight mis-shapes, surface scarring or acceptable healed damage which is easily removed on preparation.

Progressive defects are those such as rots, disease and physiological breakdown. The EC Quality Standards and their interpretation by horticultural marketing inspectorates on this aspect of blemish is again generally acceptable although the nil tolerance in Class I for bolting or flowering in celery, and to a certain extent in leeks, is not practical and is therefore not adhered to on occasions.

In almost every discussion the problem of pest and disease control linked with reduction in pesticide usage was raised. It is particularly serious in Brassica crops, especially Brussels sprouts, where the increased acreage of oilseed rape has led to a build up of leaf diseases. The problem of violet root rot in carrots was highlighted as needing more attention.

## Quality Issues Important to the Consumer

The industry, and supermarkets in particular, are paying much attention to the issues of pesticide usage and residue testing. The NFU and a number of leading retailers have got together to prepare joint protocols on Integrated Crop Management (ICM). Two of these, for cauliflower and carrots, have already been issued and others are in preparation. Supermarkets are particularly vulnerable to adverse publicity and legal action because of the Food Safety Act 1990. This has been interpreted as having more serious consequences for them by removing the warranty defence and replacing it with a requirement to show due diligence. It has perhaps not been sufficiently appreciated that the due diligence requirements apply to all food products and not just to those supplied to supermarkets.

A major concern expressed by producers is the increasing limitations on the range of pesticides approved for use on horticultural crops. The activities of HDC in actively supporting the necessary work to register new pesticides and obtain off-label approval for existing pesticides on horticultural crops should be recognised. There is also concern about the use of post

harvest chemicals and it was interesting to note the complete ban on the use of these in Holland on stored white cabbage, and onions. The UK industry should therefore be preparing itself for similar restrictions.

The flavour and texture of fresh produce was the cause of much discussion. **Flavour** is very difficult to determine and agree upon. One is left with the conclusion that between the absolutely tasteless and the positively repulsive product there is a wide range of acceptable flavours. Bitterness in sprouts raised the subject to the forefront and it was encouraging to note the activities of HDC and NIAB and some leading growers who, in conjunction with CFDRA (Chipping Camden), have regular tasting sessions with their own panels to assess their crops. Many supermarkets already run regular tasting sessions and the Dutch plant breeders and State Organisations such as the Central Bureau of Auctions and TNO Food Research Institute are putting considerable effort into flavour assessment. This contrasts with the rather casual approach of some plant breeders and growers, very few of whom carry out regular or organised tasting sessions.

**Texture** came up in discussions on celery, beans, cabbage greens and broccoli particularly where stringiness or high proportions of inedibility occurred. Apart from varietal considerations, which are discussed for each crop, important factors are the maturity of the product at harvest and the effect of stress on the crop e.g. poor growing conditions, lack of moisture, and extremes of temperature.

**Nutritional** value of the product was never considered particularly important although most supermarkets include this data on their packaging. One major Dutch breeder however is very active in this area and lists varieties of Brussels sprouts with high vitamin C content. The carotene levels in carrots was another area of interest to plant breeders and several comments are covered in the crop section. The dangers of irresponsible misinterpretation of the chemical analysis especially with respect to

naturally occurring compounds which could be toxic at high levels must be carefully addressed.

## Shelf Life

There is a lack of concern among some breeders and growers with regards to shelf life. This however has been challenged by the supermarkets not only because of the financial implications to them but also with respect to customer satisfaction.

The first requirement in discussing shelf life is to agree a definition of what is meant. To the supermarket it normally means the length of time that the product is considered to be of a saleable standard under the conditions of handling and display. This will take into account the transport and holding of the product under refrigeration at 6-10°C with subsequent display, normally at ambient, and customer holding, generally at ambient, although more domestic refrigerators are now being provided with special storage areas for produce. This definition of shelf life assumes the product is prepared and packed on the day of delivery to depot. Shelf lives quoted here are expressed as two figures e.g. 2+2 days, indicating 2 days at retail level (the display until figure), plus two days customer usage. Shelf life as indicated by a "**display until**" date on pre-packs indicates freshness to the consumer and serves as a management tool in ensuring product rotation on the shelf. It does not however tell the customer how much longer the product will remain in an acceptable condition as this will depend on how the product is kept (e.g. temperature). The supermarket will assume a customer life of 1-5 days, dependent on the product display at retailing. If there is complete **cool chain** from depot to retail display the period of display can be extended by 2-3 days, again dependent on product. However few field vegetables can justify the expense of refrigerated display which is normally, but not always, restricted to salad lines.

While fresh fruit and vegetables are not legally required to be labelled with an indication of their "shelf life" or durability most supermarkets will

do so. **Loose produce**, once it is put on display, generally does not carry any indications of its "shelf life". The situation is made worse when poor management and inadequate training allows staff to "top up" displays by putting fresh product on top of old. Brussels sprouts and carrots were quoted as the worst examples of this. The shelf life of loose produce is adversely affected by customer handling and selection thus increasing the proportions of old, bruised, broken, dehydrated and discoloured product on a display. There may be very little that can be done by plant breeders, growers and packers to overcome deficiencies in the wholesaling and retailing of fresh produce but this is no excuse for not providing the customer, whether it be retailer or consumer, with good acceptable product to begin with. The development of slow ripening, long life varieties of tomatoes although not directly applicable to vegetables, is an indication of how breeding can affect shelf life.

Prepared, ready to eat, produce such as salad packs must be clearly labelled with an indication of its total safe life by the use of wording such as "**use by**" together with instructions on its refrigeration. It must be distributed and displayed under refrigeration at temperatures not exceeding 8°C.

Most of the work on shelf life in the UK has included the removal of **field heat** from the product as quickly as possible after harvest. This ensures a cool chain, simulating distribution and holding conditions. Trials run at NIAB during 1990-1992 held the product in a temperature controlled room at 20°C with a relative humidity of 50% to simulate supermarket conditions. The effect of light on displayed product has not been studied but conditions were simulated using fluorescent "day light" tubes (1,200 lux for 12 hours with 12 hours darkness). It has been difficult to reproduce the effect of customer handling or the environment of bulk displays but a reasonable estimate of the time for a product to become unsaleable has been obtained. Similar shelf life rooms are used at HRI Kirton, Stockbridge House and Efford. Packers supplying the major supermarkets have



designated shelf life rooms in which they retain samples of their production for a period equivalent to an average customer purchase. This is often a condition imposed by the supermarket.

The estimation of when a product is no longer acceptable for the market is somewhat more difficult. Only workers at FRI (Norwich) use an objective assessment for shelf life. This is based on the percentage water loss in the product before it becomes unsaleable. This ranges from 4% for sprouting broccoli, 5% for runner beans, 7% for leeks, parsnip, cauliflower and cabbage, 8% for carrots and 10% for celery. Post harvest product life at the retail level is not considered by Dutch workers or plant breeders.

A literature review of the factors affecting the shelf life of cauliflower, calabrese, Brussels sprouts and leeks has been undertaken by HDC in project FV137 and this has been extended into further work at HRI Kirton on these crops. Some of the observations and results from this project are alluded to in this review.

Very little work appears to have been done on the changes in flavour and nutritional value of stored products, especially after shelf life testing. The effect of storage on the flavour of carrots is however well documented and is referred to in the crop section.

## CARROTS

For the UK to be the largest producer of carrots in Europe says much for the expertise and energy of the industry which also produces the best quality carrots over the longest period. Nature has lent a hand in providing some good sandy soils, adequate rainfall and relatively mild winters. Carrot production is concentrated in the Fens, Norfolk, Suffolk, Lancashire, Lincolnshire and Scotland. However this still leaves unexploited areas of fertile sand lands especially in the South and South West. The opening up of export markets underpins this current production position and maintains the quality standards achieved to date.

## Specifications

Much of the current carrot specifications have developed from the supermarket and multiple buyer's need for an easy to pack, attractive product. This means cylindrical types 10.5-15cm (4-6") in length and 2-2.5cm ( $\frac{3}{4}$ -1") diameter capable of being handled without breaking and suitable for uniform in-line packs. A guide to **root size** for various pack weights and marketing requirements is as follows:

MARKETING UNIT	ROOT LENGTH	ROOT DIAMETER
Small pre-pack 450g (1lb)	100-150mm (4-6")	10-20mm (0.4-0.8")
Medium pre-pack 500g (1.1lb)	100-150mm (4-6")	20-30mm (0.8-1.2")
Large pre-pack 1kg (2.2lb)	150-175mm (6-7")	25-35mm (1-1.4")
Loose	115-200mm (4.5-8")	25-40mm (1-1.6")

These size ranges fall within the EC Class I grades where maximum root diameter or weight of the carrot without foliage is taken as the criteria:

	Min. diam.	Max. diam.	Min. wt.	Max. wt.
Early carrots & small rooted varieties	10mm (0.4")	40mm (1.6")	8g ( $\frac{1}{4}$ oz)	150g (5oz)
Main crop & larger rooted varieties	20mm (0.8")	none	50g (1.8oz)	none

No maximum diameter or root weight is laid down for main crop or large rooted varieties in Class I although they are stipulated for Extra Class. The maximum here is 45mm ( $1\frac{1}{2}$ ") and maximum weight of 200g (7oz). It is therefore feasible for all supermarket carrots to come within the Extra Class for size. A comment made

by one supermarket representative was that there had been too much emphasis on cosmetic appearance and that standards of the best UK supermarket carrots already attained Extra Class! A relaxation of standards would not be universally welcomed however.

The quiet revolution in carrot varieties with the introduction of F1 hybrids based mainly on Nantes types has met the customers needs in appearance, shape and size. The work on seed rates and plant population emanating from Wellesbourne in particular, has improved the yield of marketable sizes. A glance at the NIAB Descriptive List for fresh market carrots shows how well modern varieties fall within the preferred size ranges and the high scores for flesh and core colour, skin smoothness and uniformity of shape show how well the modern varieties meet the specifications.

## Defects

Defects still lead to 20-30% of a crop being unmarketable as recorded in the NIAB over-wintering trial for 1992/93. Some growers have quoted much higher figures mainly as a result of roots being over and under the stipulated size range for their market, twisted, split or broken roots. **Splitting** and **breakage** of roots either during growth or as a result of handling, washing and packing is now the subject of HDC research at HRI Wellesbourne (Project No 46.46a). Much has already been written on the subject and varietal, cultural and climatic factors all combine to complicate the picture. The relationship between the mechanical strength of the root and its flavour and texture should not be forgotten in these studies. More than one comment was made of varieties which had good field and handling characteristics but fell down on texture, colour and taste. The UK preference for cylindrical carrots derived from Nantes and Berlicium types which are susceptible to breakage and splitting has not helped European breeders. Their USA counterparts have been overheard to comment that such varieties would not survive the American methods of harvesting and handling. HDC project FV46 looks at

pre-harvest treatments to reduce damage during handling. From the retailing point of view much of the crop's problems are left in the field or pack-house although **hair line splitting** often occurs after packing and even when being placed on the supermarket shelf. Here turgidity of the roots linked with mechanical pressure in rough handling has been quoted as being the main cause. **Discoloration** of the skin especially at the root tip, occurs with early harvested, immature carrots. This is more widely seen on imported product especially if there is inadequate post harvest cooling. The fact that almost all carrots are washed, even for the wholesale market, has not made life any easier for growers. It is doubtful whether a return to unwashed product, as often seen in Dutch greengrocers would benefit sales in the UK.

**Silvering** of the skin of washed carrots also detracts from the appearance, especially on loose display. Abrasion of the root surface caused by lifting on coarse sandy soils or washing in water with suspended sand particles too long a washing period, have been suggested as causes. Washing shows up any imperfections on the skin. Corrugated roots with prominent secondary root initials are unattractive and have been linked with irregular water supply and heavy soils.

**Cavity spot, carrot fly** and **cut worm** damage are normally easily recognised after washing and removed from the packing line. The increased incidence of **violet root rot**, a soil borne fungus, is raising concern in many quarters. A policy of wider rotation and moving production to uninfected soil in new areas has been suggested as a better alternative to the use of fungicidal treatments. Some defects have almost been eliminated with the new hybrid varieties.

**Greening** of the crown and internal greening down the core are not now serious problems. Yellow, woody cores are also a thing of the past, and a return to the old varieties such as St Valery and James Intermediate, as encouraged by several supermarkets a year or so ago, showed how poor they were compared with today's product. Even Chantenay, once the best flavoured

carrot on the market, has fallen out of use though new breeding work might well give it a new future for the fresh market.

## Flavour

CFDRA has carried out extensive flavour assessments on varieties from different soil types. November harvested carrots from organic Fen soils were deeper orange coloured and stronger flavoured than those from mineral soils. Could this be due to lower sugars normally found in root crops grown on the high nitrogen and moisture holding Fen peat? The range of flavours is described as sweet, harsh, bitter, soapy, buttery and tangy. Some varieties were fairly consistent but others were **variable** in their flavour characteristics. Some seed houses have claimed particular characteristics such as sweetness and high carotene for their varieties. The principal flavour constituents are sugars, with a range of 3-8% terpenoids, in some cases this may give a turpentine taste. Phenolic compounds which give bitterness are not found in fresh roots. The effect of long term storage on the levels of these flavour constituents is to reduce the sugar levels and increase the unfavourable terpenoids and phenolics. There comes a stage in the storage life when overall flavour of carrots becomes unacceptable and this in turn will place a limit on the length of storage period. Supermarkets are becoming more aware of the **deterioration** in flavour and from mid-March onwards the flavour of the home grown crop can deteriorate quickly. The only alternative is to move into more expensive new season crop from Spain. Whether consumers are aware of the flavour differences between end of season home grown carrots, which can be harsh tasting or even flavourless, and sweet, well flavoured new season imports, is difficult to determine. The fact that the major buyers are now taking this into consideration should not be lost on the industry and the efforts to extend the storage of carrots beyond the end of March should be viewed with caution. Most UK crops are over-wintered in the soil under straw so the relevance of this information is difficult to evaluate. Some improvements in storage techniques are needed but so far the fully

successful storage of lifted carrots has not been achieved. The Dutch get over the problem by storing their crop as lifted and consumers do not appear to be too worried about poor skin finish.

## Texture

Texture differences between varietal groups have been commented on with the generally held view that the Amsterdam/Nantes group have a softer texture than late, winter hardy Autumn King types and require less cooking. The relationship between dry matter, flavour and texture could be worthy of more attention. High dry matter of 12-14% is important for the processing industry but not so for the fresh market where Amsterdam types have 8-9% dry matter and Nantes 10-11% dry matter.

## Nutrition

From the nutritional viewpoint carrots have achieved fame for their rich supply of **vitamin A** derived largely from the carotene which accounts for the interest in high carotene carrots. A good deep orange colour in the root is not necessarily an indication of high carotene content.

**Pesticide** use is always an area of consumer concern. The development of varieties with carrot root fly resistance is good news, but cavity spot, mildew and violet root rot still remain problems.

**Cavity spot** in particular has had considerable attention and a comprehensive investigation has been funded by HDC in Project FV5a. This has resulted in the introduction of the Cavity Spot Diagnostic Prediction Service launched by HDC in January 1994. Soil samples taken prior to sowing can give an assessment of the level of the causative agent, *Pythium violae*, and a decision can be made as to what cultural controls, if any, need to be applied. This work will form an important part of an Integrated Crop Management System as laid out in the NFU/Retailers Joint Protocol for carrots. Some minor

disorders are becoming of economic importance such as nematodes, powdery mildew and *Alternaria*. Die back and crown rotting may be linked to these and HDC Project FV136 has been initiated to investigate these problems. Storage of lifted carrots for the fresh market has not been completely successful from the retailer's viewpoint due to poor skin finish of the stored product. Even with very high humidity of 99-100% and low temperatures of 0-2°C problems have arisen. Field storage under straw despite its cost and difficulties is still the main method of overwintering the crop.

## Shelf life

Apart from the problems of drying out and silvering on loose carrot displays there are few problems with shelf life. Any progressive rots resulting from soft rot bacterial infection of damaged tissue can show up after several days in pre-packs. Work was carried out on carrot **Hydro-cooling** and the effect of **chlorination** of the water in HDC project FV133. A combination of hydro-cooling and chlorination gave best shelf life results. For pre-packs a shelf life of 3+3 days would normally be expected, and longer if the customer holds the product in refrigeration. Loose carrots can also be expected to have a similar life. Unwashed carrots can have double the shelf life of the washed product.

## Further Developments

**Pesticide residues** and the need to reduce pesticide usage are important consumer concerns and the Joint NFU Retailer Integrated Crop Management Protocol for the crop is an important step in the right direction. Criticism has been levelled at some producers in the past for inadequate crop rotation with resultant "soil sickness". A rotation of one umbelliferous crop in five years as suggested in the Protocol is to be encouraged. The feasibility of this must be determined by the industry. However since soil types are so important in determining the final quality of the crop a survey of suitable areas would be useful in the long-term planning for the industry.

Widening the customer choice has been accomplished by the introduction of baby and bunched carrots and new varieties such as the round Parisienne types. UK growers must be ready and able to meet these needs. **Ready prepared** carrots, either as batons, diced or shredded are in demand not only from the vegetarian and health conscious sector but also for catering and home use. Flavour and texture are increasingly important for these products and this is one crop in which organic growers have established a toe-hold.

## Key Issues

Need to look at further **areas of production**, partly to extend the season but also to avoid the build up of pests and diseases in existing areas. Successful **long term storage** of lifted product has not been accomplished.

## PARSNIPS

The flavour of parsnips is unique and some may say that it is an acquired taste. Production and breeding are limited to England, New England (USA) and Australia. Improvements have been seen in recent years and the parsnip is regaining popularity.

## Specifications

Because of the limited geographical market the EC has not included it in their Quality Standard. It has been left to the supermarkets and multiples to determine the specification. The first requirement was for **smaller sized roots** to facilitate prepacking. The traditional market roots weighing up to 0.45kg (1lb) were replaced by individual roots of 70-225g (2.5-8oz) to give packs of 2-6 trimmed pieces per 0.45kg (1lb) pack. With baby parsnips the size is even smaller with 10-12 per 1lb pack.

Length was determined at 10-16.5cm (4-6.5") of edible root with the long whip-like tail removed at 0.5cm (0.25") diameter or more. These size constraints encouraged the

development of broad wedge shaped roots rather than the wide shouldered bulbous or long narrow tapering (“bayonet”) roots. In effect the shape of roots can be affected by soil type, plant population and stress factors such as water shortage. The NIAB 1993 Descriptive list uses the term “wedge” in the description of all 14 varieties listed but other shapes also occur within individual varieties, even F1 hybrids. The NIAB trials define marketable roots as being between 10 and 30cm (10-12”) long and 3-13cm (1.2-5”) wide, but supermarket requirements tend to favour small to medium size roots from this size range. The NIAB Descriptive list recognises this requirement in its recommendations of varieties for either market or pre-pack use.

## Appearance

**Colour** and **skin finish** are particularly important. Brilliant white roots look attractive, are not always easily obtainable nor do they always retain their whiteness after washing. Whilst colour is largely attributable to variety, other factors such as soil type and post harvest handling are important. Some varieties will go dull and brown and one theory is that exudate from damaged root cells oxidises on exposure to air after washing and drying. Prepacking of wet roots is considered by some to reduce the browning process. A new HDC funded project (FV146) at HRI Wellesbourne is addressing this issue. Skin finish should be smooth. Again this is both varietal and cultural. Good, light, stone free soils are essential for obtaining uniform well-shaped roots but moisture shortage and soil pans, especially in dry seasons, can adversely affect the appearance and shape of roots. The depth of the crown or shoulder of the parsnip is important as far as washing and bruising is concerned and shallow crowned varieties are preferred.

## Defects

Shoulder **bruising** and **mechanical damage** are two main non-progressive defects. Varietal and cultural aspects are mentioned as major factors

although little seems to be known as to what controls the susceptibility of roots to damage.

**Canker** is listed as the major progressive defect. Differences in varietal susceptibility and good crop rotation are the major methods of countering this defect. Breeding for canker resistance has been continuing for some considerable time with reasonable but not total success. Early work showed that canker was more prevalent on older roots especially if held in wet soil over the autumn and winter period. The old practice of early sowing in Spring was found to increase the incidence of canker. **Carrot fly** can also be troublesome although present control methods would appear to be adequate.

## Flavour

Preserving the unique flavour of parsnips in new varieties does not seem to be a problem. The old adage that parsnips should not be eaten until they have had a good frost has also been laid to rest. It is not unreasonable to assume that an all year round market exists for the product, frost or no frost.

The relationship between size of core to that of cortex or fleshy outer part may also play a part in flavour and **texture**. Certainly the moves towards marketing smaller younger roots means that the old woody cored parsnip is almost a thing of the past. Flesh firmness, especially with regard to bruising, is not fully understood.

## Shelf life

Most parsnip varieties are **frost hardy** so lifting and storing is not normally practised and would be unwise where good skin colour is required. Shelf life for pre-packs is normally 3+3 days but loose parsnips can **discolour** and **shrive** after 2-3 days. Good control of product rotation is needed on retail displays. NIAB shelf life trials of PVC wrapped roots lists weight loss, tip discoloration, flecking of the skin, greening of the roots and disease as the main aspects determining acceptability. Of nine varieties on

test only one was significantly better overall, the others fell down on one or more of the characteristics mentioned.

## Future developments

As with carrots the control of soil borne diseases and subsequent **pesticide use** must be continuously addressed. Extension of the growing season by using polythene crop covers is already practised. Moves to grow early crops further south or on the Continent are a further logical development.

**Baby parsnips** have found a niche but one wonders whether using the small out grades from the commercial crop is really the correct way to consolidate and expand this niche market. The development of suitable varieties sown to give higher plant densities is now being undertaken.

Prepared parsnips are not so easy to handle because of browning but one cookery writer extols the virtues of parsnip chips as being an improvement on French Fries. Perhaps they could be called English Fries!

## Key Issues

More opportunities may be possible for the use of parsnips in **processing**.

The problem of **browning** and susceptibility to **bruising** needs to be understood.

## ONIONS Specifications

There seems to be little problem in achieving the Class I requirements for size. However interpretation of the standard as far as **skin finish** is concerned has led most supermarkets to label their product as Class II. This in turn does not appear to have influenced the customers perception of quality. Class I product is available as a special selection at a premium price in certain outlets but as far as differences are concerned they are mostly cosmetic and eating quality is no better. The British Onion Producers

Association (BOPA) have issued their own Quality Manual which is available to their members.

The problem of skin quality arises from the variability of the English climate. Onion production is more suited to the hot dry conditions of Southern Europe. Soil type can also affect skin finish and it is generally conceded that the organic peaty soils of the Fens give a less attractive product than the lighter sandy soils.

**Size** is generally not a major problem and with more accurate control of plant population in the field a fairly good control of size can be obtained. The size ranges used by NIAB are:

Picklers	: 15-40mm
Medium	: 40-60mm
Large	: 60mm and over

Most supermarkets work within these size ranges for pre-packs and loose produce. However there is evidence of a tendency towards larger bulbs, especially for **loose sales**, with a top diameter of 80mm. Growers are conscious of the need for flexibility in supermarket specifications from season to season to accommodate the variation in bulb size which can occur due to climatic factors (e.g. hot dry and cool moist seasons). The pickler size is generally available during the August to November period.

## Appearance

**Colour** of the outer skin and its ability to stay in place around the bulb are considered important from the consumer point of view. Whilst a deep copper colour is considered to be the ideal any variations of this through to a pale straw colour is accepted (**see Plate 1**). Paler skin, except in the case of white skin varieties grown for the purpose, is not liked. Greening, suggests immaturity and is not acceptable. Exposure of the white flesh due to the removal of the outer skin gives a poor visual impression of the product.

Globe shaped bulbs with moderate variation

towards a flattened or oval **shape** are acceptable but completely oval or very flat bulbs are not (see **Plate 2**). This raises some problems with the crops produced from onion sets which tend to give a flattish bulb compared with varieties grown from seed. It is reported that at least one supermarket has refused to accept product grown from sets. Plant spacing can affect bulb shape, close spacing tends to produce a more elongated bulb than wider spacings. Uniformity of shape is important within a variety.

## Defects

Thick bulb necks and badly trimmed necks give a poor appearance. The 4cm neck length allowed under EC Quality Standards might be considered too long for most supermarkets. **Thickness of neck**, although a varietal characteristic, can also be influenced by high nitrogen and seasonal factors.

Bolters are not accepted. This problem seldom occurs with drilled crops except for some over-wintered varieties but has been a problem in crops grown from sets or plants.

**Neck rot** was at one time a serious defect but seed treatment and good production techniques have largely overcome the problem. **Sprouting** or shoot growth is not allowed in Class I but early signs of this are allowed in Class II. Some supermarkets are more specific on this point because they realise that onions cold stored from September/October through to March/April will almost certainly start regrowth on coming into ambient temperatures, especially if no sprout suppressant treatment has been applied. No outwardly visible shoot regrowth is acceptable and subsequent sprouting should be sufficiently retarded to allow at least 10 days for marketing and consumer use. Varietal susceptibility to sprouting is an important part of NIAB assessment and is also under investigation in the HDC Project FV81 where the long term storage of naturally good storing varieties is under investigation.

**Mechanical damage** occurring during

harvesting and handling in storage can be a reason for rejection and down grading. Pressure bruising in store may not show up until the bulb has regained ambient temperature. More recent problems have been **bacterial watery scale** and the development of **storage rots**. These are being investigated currently in HDC project FV111.

## Texture

Bulbs must be **firm** and a pilot study of bulb softness was carried out in 1992 in HDC project FV112. Contrary to previous studies it was found that high nitrate levels were linked to harder bulbs. High dry matter is linked with improved firmness. Late irrigation or heavy rain close to harvest gives softer bulbs. Varietal differences, which are noted in NIAB trials, the maturity of the bulb at harvest and the timing of field applications of maleic hydrazide as a sprout suppressant, also affect the bulb softness.

## Flavour

Flavour is generally linked with **pungency** and sweetness. **Pungency** has been the subject of considerable research but so far it does not seem possible to produce sweet British onions of low pungency to compare with the Spanish product. Work at CFDR over the 1984-1988 period showed that there was some difference between varieties in pungency although seasonal variations due to weather conditions can occur. An interesting comment is made that Spanish onions are not always mild! New imports of American sweet onions may have an impact on the market.

The internal problems of sprouting and the use of maleic hydrazide as a sprout suppressant has caused concern even though the **chemical** is applied to the crop pre-harvest. A move towards the physical control of sprouting by controlled atmosphere storage would be welcomed by the consumer lobby. One effect of storage is a **sweetening** of the onion but whether this is significant was not confirmed.

## Shelf life

Shelf life is seldom a problem except when bulbs after long storage sprout within a few days at ambient. A normal shelf life of 7+7 days or longer can be expected. The prepacking of onions into nets has been criticised as causing much of the problem in de-skinning. Loose displays also suffer from this problem and the hot dry atmospheres of supermarkets are often blamed. Little can be done to overcome the problem though it can be alleviated by allowing bulbs from cold store to reach ambient temperatures over several days before packing. This should prevent sweating of the bulbs due to moist warm air condensing on cold bulbs.

## Future Developments

Despite two hot dry summers in 1990 and 1991 when it looked as if the whole of East Anglia would become a drought area, it has to be admitted that the areas most suited for quality bulb production are in the South Eastern quarter of the country. Production in Lincolnshire is moving more towards the production from sets in order to shorten the growing season. The threat of increased imports from Eastern Europe at the same period of production and availability as the UK, poses another problem for the industry. The considerable amount of research and investment which has gone into the storage of the crop will give the industry considerable advantages. There appears to be little prospect of increased demand for ready peeled or sliced onions although a small market niche has been established in some outlets for these.

Red skinned onions are gaining in popularity.

## Key Issues

Select optimum **areas of production** to improve quality and yield.

Storage without **chemicals** requires continuing effort.

## LEEKS

A well known TV cook writes that she takes leeks for granted as they are cheap and plentiful. She then goes on to complain about the earth and grit nestling between the leaves. Obviously she has never grown leeks or talked to a commercial grower of leeks. She would have found that the high labour costs in harvesting, cleaning and trimming do not justify the cheap price paid. Despite the problems leeks are an important crop in Northern Europe with production spreading into Southern Europe for summer supplies.

## Specifications

The EC Quality Standard for leeks encompasses a fairly wide and not always clearly defined range of product. The Dutch, for instance, sell their product with full leaf, although the Dutch housewife, like the majority of her UK counterparts only uses the shank or stem portion, but still has to pay for the leaf that is trimmed off. The **short leaf** left on most English leeks is probably a result once again of prepacking and the difficulty of putting a long spreading bunch of leaves into a bag. The shelf space that would be taken up by two feet or more of a leafy product is unpopular with supermarkets. The Welsh and Scottish appear to prefer more of the foliage left on and at least one supermarket has a dual specification to met the requirement.

An advantage of leaving more leaf, apart from the greater weight of product, is that bolting and re-growth is less noticeable. The disadvantages, apart from the space and packing difficulties, are that thrip damage and rust disease can be unsightly.

Settling on a uniform specification for the proportion of leaf to shank is not easy although as a rule of thumb a maximum of one third total length as leaf is acceptable. Thus a leek of 30 cm (12") may have 10cm (4") of leaf to 21cm (8") of shank. This is generally suitable for mid season product over the November to January period but early season leeks tend to be longer



in the stem and produce the “candlestick” type of product. Late season leeks can be much shorter. To cut these to 30cm (12”) would give more than 10cm (4”) of flag. Until plant breeders come up with varieties with the same length of shank, ideally 21-25cm (8-10”), to cover the whole season, it would be useful if some flexibility was provided in the specifications especially for prepacking.

EC Class I states that the white part must represent at least one third of the total length of the product, or half the sheathed part. For direct drilled leeks where there may be only 5-8cm (2-3”) of pure white this may be difficult to achieve. Depth of planting or earthing-up can increase the blanched portion but with the added risk of excessive amounts of soil getting between the leaves.

The minimum diameters for Class I are 8mm (0.3”) for early leeks and 10mm (0.4”) for late leeks, which are well below the normal supermarket requirement of 25 to 40mm (1-1.56”) but will accommodate baby leeks. **Bulbous** leeks are not liked and NIAB use a 1 to 9 scale for this characteristic in their variety assessments. Apart from varietal differences the factors affecting bulbing are suggested to be plant stress and over-firm soil, especially if there is a shallow soil pan. Varietal differences in the size of the root base can cause difficulties in the ease of trimming the roots. A small root base is preferred.

Other factors affecting the quality are the leaf characteristics. **Dark green** is preferred to pale foliage and an **erect flag** preferred to wide angle as this makes trimming and packing difficult (see **Plate 3**). Ease of stripping the outer leaves to give a clean shank needs to be given consideration by plant breeders as varietal differences are commented on by growers. The ability of the plant to stand in the field without rotting is especially important for post Christmas harvest. **Bolting** can also be a problem on over wintered crops especially.

The EC Quality Standard states in the minimum requirements for all leeks that “running to seed”

is not acceptable. Class II tolerates “a tender flowering stem, provided that it is enclosed within the sheath part”. Most supermarkets recognise the problem with over-wintered product and will modify their Class I requirement to accept leeks which are bolting provided the eating value of the product is not seriously impaired. NIAB assess susceptibility to bolting as an important varietal characteristic.

## Defects

Oddly enough the EC Quality Standards say nothing about the **straightness** of the leeks. Supermarket Quality Controllers have however been known to reject product with only slight curvature. This can be particularly serious when leeks are packed in a closed pre-pack and do not have enough room to expand as they grow and so curl up within the pack (see **Plate 4**).

Other defects commonly encountered are excessive soil between the leaves within the shank and bad trimming of the roots where either a tuft of stubble is left or the knife cut goes into the base of the leek.

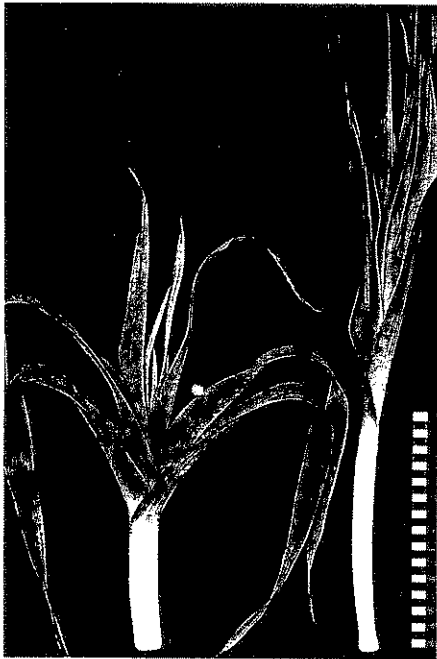
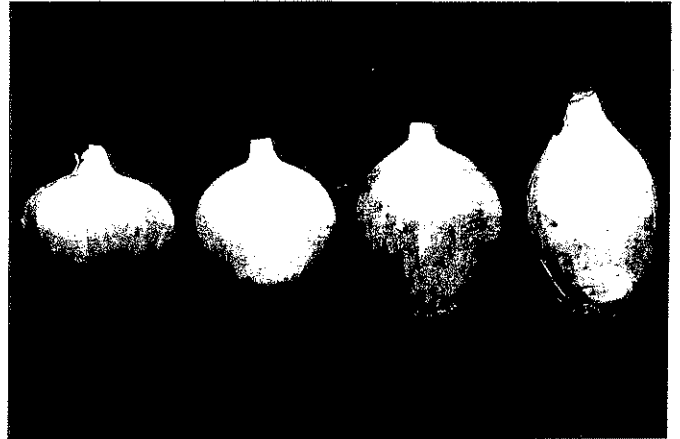
Regrowth of the central leaves is common after three or four days at ambient temperatures on trimmed leeks and can also occur with trimmed leeks held in cold store. Cutting the flag in an inverted V shape may help to disguise the problem but will not prevent it. **Delamination** is when the cut leaves split and bend over giving a very ragged appearance. No firm solution to this problem has been suggested and it may be associated with thickness of the leaf or its turgidity at trimming. The use of extra sharp knives does not appear to prevent the problem. Delamination is worse after periods of cold weather.

**Foliar diseases** such as Rust (*Puccinia porri*) and leaf blotch (*Cladosporium allii*) detract from the appearance of the product. These diseases or close relatives also affect cereals so the extension of approval for cereal fungicides to leeks is a logical path to pursue.



*PLATE 1:*  
*ONIONS: Skin colour.*

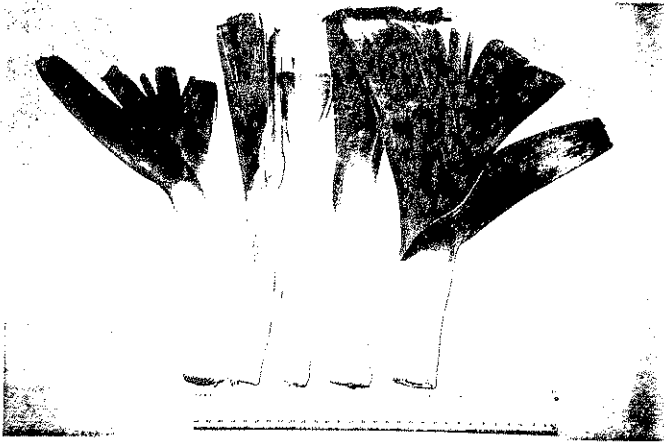
*PLATE 2:*  
*ONIONS: Bulb shape.*



*PLATE 3:*  
*LEEKS: Erect versus spreading flag.*

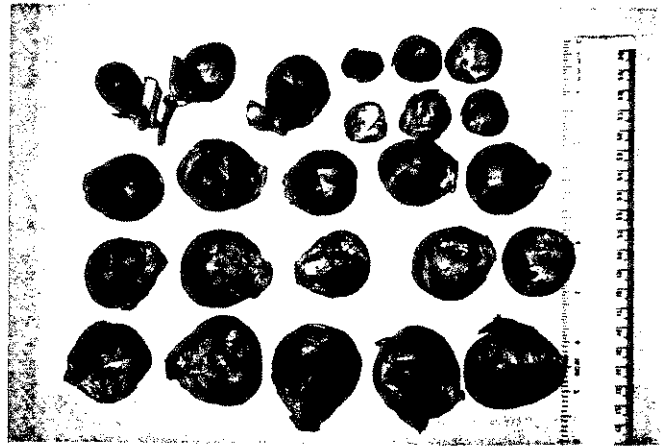
*PLATE 4:*  
*BABY LEEKS: Bending due to regrowth in pre-packs.*





**PLATE 5:**  
*LEEKs: Damage due to handling and prolonged display at retail level.*

**PLATE 6:**  
*BRUSSELS SPROUTS: Variable quality from a loose display due to topping up.*



**PLATE 7:**  
*CAULIFLOWER: Three examples of head trimming.*

**PLATE 8:**  
*CAULIFLOWER: Browning of wrapped produce.*



**Thrips** can be more of a problem and two HDC Projects have reported on this pest. Early work showed only slight differences in varietal susceptibility and this should be an important aspect of future breeding. HDC Project FV15 reports that the control of thrips is possible with insecticidal sprays and that the thrip problem is increasing. Dutch growers put straw down between their leeks, reputedly to deter thrips, but it may also give winter protection to the crop.

## Flavour

Flavour does not seem to come high in the quality assessment of varieties. One source commented that the strength of the leek smell on trimming gave an indication of the strength of flavour in the leek. CFDR carried out flavour testing in 1984/85 season and found that the pale green portion of the shank has a weaker natural flavour than the white portion. The pale green portion was also noted to be more stringy late in the season. Little difference was found between varieties but some were noted to be more bitter or having less sweetness in the green part. Little is known of the effect of low temperatures on flavour although work carried out at Luddington EHS, before it was closed, suggests that there is little difference in the eating quality of leeks stored in conventional cold store and those in controlled atmosphere stores. A comment was made that leeks lose flavour after a hard frost.

## Shelf life

The Luddington work, reported in HDC Project FV2 showed that leeks stored at 0-1°C and 95% relative humidity deteriorated significantly after 6 or 7 weeks. Those leeks held in controlled atmosphere stores (9% CO<sub>2</sub> 3% O<sub>2</sub>) had an additional 2 weeks storage life as well as better shelf life and higher marketable yield from store. The normal supermarket shelf life is 3+2 days but unless refrigerated displays are used pre-packed leeks can quickly deteriorate (e.g. yellowing of the leaves, regrowth, curving if laid flat, and rots). Normally all leeks are marketed

after some degree of washing. It remains to be seen whether increased levels of **chlorination** could reduce the development of rots and sliminess in pre-packed product. Leeks sold loose suffer from moisture loss and become limp and, if held on deep displays, can yellow (see **Plate 5**). NIAB shelf life trials indicated some varietal differences in shelf life.

## Future Developments

While there may be confusion as to what describes the perfect leek in the consumers eyes, it is more likely that commercial factors will control the specification as to the final product on offer. The concept of a leek based on the dibbed garden vegetable with 15-21cm (6-8") of pure white shank and dark green leaf, is not always feasible if low price and good availability are to be required.

Better **availability** over a longer season with more uniform product is desirable. This could be achieved at both ends of the UK season as shown by the now completed Luddington work already referred to. Uniformity of product can be improved, especially from the plant breeding aspect. Leek seed is very variable in its vigour, especially in direct sown crops. Assistance to overcome this problem might well come from the development of the F1 hybrid.

## Key Issues

**Storage**, bridging the gap between late March and the early crop.

**Shelf life**, controlled atmosphere packaging and growing on.

## BRUSSELS SPROUTS Specifications

The majority of supermarkets have written specifications which are on the whole practical and attainable from the growing and packing viewpoint. In general the quality standards aimed at is EC Class I with refinements for size, visual

appearance and flavour.

For the fresh market sprout size for prepacking lays between 25-35mm diameter although buttons of 15-20mm are acceptable at certain periods of the year. Larger sprouts, up to 40 mm, are acceptable as loose product, these are also favoured by Dutch and Scottish consumers. Split grading of the prepack size into 25-30mm and 30-35mm is required by at least one customer. There are indications of a trend towards larger sprouts in the 35-40mm range especially for loose sales.

Sprout size is reasonably well controlled by choice of **variety** and **plant spacing**, which in turn is influenced by soil type and availability of irrigation.

The standard NIAB spacing for fresh market trials is 27,000 plants/Ha (1100 plants/acre) at a spacing of 60x60cm for hand picking and 3600 plants/Ha (1400 plants/acre) at a spacing of 50x55cm for mechanical harvesting, especially for freezing.

The size grades used are:

Small	20-30mm
Medium	30-40mm
Large	over 40mm

Plant breeders are well aware of the size requirements and because of the greater importance of mechanical stripping in Holland the uniformity of maturity and size of sprouts over the whole length of the stem is aimed at.

## Appearance

Medium to dark green button **colour** is preferred as pale sprouts tend to indicate over-trimming or ageing. Red coloration, externally, due to anthocyanins is not generally liked and is often worse in crops grown under stress such as cold weather or water shortage. Red coloration internally, has been confused with internal browning and varieties showing this defect may be rejected.

The relationship between the presence of anthocyanins in a variety and its increased frost hardness is mentioned in discussions.

There is no colour chart for reference in general use. The effect of nitrogen on increasing the depth of colour of sprouts is only significant when applied at levels below those necessary for optimum growth and yield.

The effect of darker colour on shelf life is often remarked on and is an important consideration in the choice of variety for loose display. The use of dark green netting for pre-packs overcame some of the problems of acceptability of paler coloured varieties.

Round sprouts are preferred and there is a general dislike of elongated buttons partly because of the length of the stem usually present in these and the subsequent loss of product on trimming. Spacing of the button on the stem and to some extent plant spacing could affect sprout **shape** and breeders are generally conscious of this aspect.

## Defects

Close spacing of sprouts on the stem can result in the development of **rots** and **slime**, especially during moist warm weather.

**Looseness** of sprouts is not generally a problem and most varieties now on the market are considered to be sufficiently firm. Trials at CFDR in 1982/83 indicated that high nitrogen levels could lead to softer sprouts. There is a suggestion that very solid sprouts, especially with a tighter outer leaf, give consumers some problems in preparation. However the presence of a loosely held clasp leaf, while often giving the impression of better colour, also gives a poorer appearance, especially when the clasp leaf becomes detached or is pushed out to form a wing. There is also a problem in prepacking when loose clasp leaves are caught in the netting.

The size of **butt** with relation to the sprout size and the need for a clean removal of the button

from the stem are important factors in the visual assessment of picked product. No suggestions are made of an acceptable ratio of butt size to sprout diameter. Sprouts harvested from plants grown under stress or during frosty weather may detach with a tail of the parent stem attached. One of the major varieties used in Holland for post-Christmas mechanical harvesting is considered unsuitable for the UK market because of its large butt, difficulty of hand picking and loose clasp leaf. The variety has good standing ability in the field but does not meet the quality criteria for the UK supermarkets.

The **discoloration** of the butt to give a dull dirty grey colour has been an occasional problem, especially when it occurs within the normal shelf life of the variety. It is a particular problem in prepacked prepared sprouts. No reliable record of varietal susceptibility to this defect is available and one major grower indicated that the problem is worst during a period of warm moist conditions at harvest.

Internal browning which was particularly troublesome in the late 1970's is now rarely encountered. This may be due to the firmer F1 hybrids now used, the lower nitrogen applications, or more probably, the combination of these factors with a series of relatively mild winters. Few of the existing new hybrid varieties have been tested under extreme winter conditions. **Leaf diseases** spreading onto sprouts especially from oil seed rape are now a major factor in the rejection of the product especially since effective control can be difficult and could mean the late application of fungicides. The main diseases are *Alternaria* leaf spot, sprout powdery mildew (*Erysiphe cruciferanum*), light leaf spot (*Pyrenopeziza brassicae*) and white blister (*Albugo candida*). Breeders are well aware of these problems and are attempting to introduce some tolerance or resistance. Ring spot (*Mycosphaerella brassicicola*), once only a problem in the wetter South Western area, can be troublesome in wet seasons in the main production areas. Varietal susceptibility to these diseases is recorded in NIAB Trials.

HDC funded work (Project No FV53a/b/c) is underway to develop a forecasting system for a range of leaf diseases so that minimal use is made of **fungicides** on the crop.

## Flavour

Probably more work on flavour assessment has been carried out on sprouts over the past twelve years than on any other field vegetable. The problem of **bitterness** in sprouts was not always recognised as such, bitterness and strong flavour being considered by some as the same thing. Work to establish the cause of bitterness was carried out in the early 1980's by the FRI (Norwich), FDRA (Chipping Camden), and NIAB. The situation became so serious that in the late 1980's certain supermarkets issued a list of varieties which would be unacceptable to them because of bitterness. Most, but not all, of these varieties originated from one Dutch seed house and, to its credit, it commenced a thorough research programme into the problem. They are now confident by using bio-technology tests on their breeding material that no bitter tasting variety will be bred or released by them.

The genetic make up of varieties to a large extent determines the degree of bitterness. This in turn is associated with the level of naturally occurring glucosinolates in the sprout. Glucosinolates are present in all Brassicas and therefore could become a problem in any variety of cabbage, cauliflower, or broccoli, where the leaf is consumed. Factors affecting the levels of glucosinolates have been investigated and the major cultural factors appear to be plant stress (e.g. lack of water), poor growing or adverse climatic conditions. Soil type has been shown to have some influence, plants grown in light sandy soils are more likely to increase glucosinolate levels although this may be linked to the stress factor.

The traditional belief that a period of **frost** improves the flavour of sprouts was shaken by the experience of a taste panel at CFDR in December 1991. Sprouts picked after severe frost

of up to four days were found to have a totally unacceptable flavour. However after several days of thawing most of the obnoxious flavour was not apparent but indications are that frozen sprouts, i.e. those frozen on the plant, should not be harvested and that sprouts must be allowed to thaw out after a period of hard freezing. However to allow continuity of supply it is possible to cut sprouts on the stalk and thaw them out slowly at 6-8°C.

## Shelf Life

The normal shelf life of freshly picked sprouts is estimated at 3+2 days but extending to 5+2 days if held under cool chain and refrigerated display.

The main factors affecting shelf life are superficial leaf diseases, harvesting of frozen product and non removal of field heat, especially during mild and humid periods. By removing the field heat as quickly as possible and to as low a temperature as 2°C, the product life is extended. Very few supermarkets continue their cool chain through to retail display level except for prepared product. The major problem with displays of loose sprouts at ambient supermarket conditions is **inadequate rotation** of the display especially when fresh product is placed over product which may have been on display overnight (see **Plate 6**). Dehydration, yellowing and even breakdown has been observed in such displays at retail level.

The damaging effect of plastic netting and the moisture loss incurred in netted packs has also been a cause of reduced shelf life at retail level. The use of polypropylene plus (P+) films, together with complete cool chain to retail level, is necessary for prepared product.

## Future Developments

The UK consumption of sprouts has not increased over recent years and several reasons have been suggested. The most likely reason is the vastly increased range of competitive product now available to the consumer over the winter

period. Poor flavour and particularly the bitterness factor may also have contributed to the fall in demand. Plant breeders and enlightened growers are now very conscious of the eating quality and one breeder is now listing varieties bred for their sweetness and high **vitamin C** content. Sprouts also have a poor image, especially when overcooked and at least one grower group has issued customer leaflets with recipes to show the versatility of the vegetable. Preparation time and the difficulty of handling small sprouts has been cited as causes for the unpopularity of the vegetable. One major retailer considers that only "**pot ready**" product packed in specially selected film and held at temperatures no higher than 8°C will maintain and increase sales. Finally a suggestion was made that the unpleasant smell during cooking caused by sulphurous compounds can be overcome by breeding varieties with **low sulphur** content.

Brussels sprouts are one of the few horticultural crops where the usage of **pesticides** has increased over the last ten years. Much of this pesticide is in the form of fungicides and the breeding of varieties with tolerance or, if possible, resistance to superficially detracting diseases is a priority. It is unlikely that consumers will lower their expectations regarding the visual acceptability of the product.

The increase in **mechanisation** of crop harvesting will lead to increased blemish and damage compared with hand harvesting. The evenness of maturity and size of sprouts along the length of the plant will be as important as the ability for sprouts to hold on the stem. Mechanical harvesting could result in production peaks, and methods of storage for up to 2 weeks (for example with controlled atmospheres) might be worth pursuing although this suggestion has met little enthusiasm from the supermarkets.

Marketing of the fully **prepared product** is not everyone's ideal solution, although it will increase, especially for baby sprouts. Alternative methods of marketing such as selling whole stalks with sprouts attached have only been partially successful and the main problem has

been the high proportion of waste material i.e. the stalk, which has to be handled. Is there a solution to that problem somewhere in the breeder's material?

## Key Points

Improving **flavour** could revitalise the declining market.

Quality deterioration in ambient displays at retail level is a major problem.

Reliance on pesticides particularly **fungicides** is being addressed (NFU/Retailers Protocol in preparation to reduce pesticide usage).

## CABBAGE: HEARTED

Hearted cabbage has a poor image based on the overcooked result of bulk institutional catering and school meals. However it still accounts for about 25% of the sales of Brassica vegetables in the UK. This might be explained by the wide range of varieties now available, its ready availability and the natural advantages of the British climate for its production. From a retailing point of view it has few problems and with some enlightened culinary advice its poor image can and is being slowly discarded.

## Specifications

Supermarkets learnt very early that the concept of "big is best" suited neither the majority of their customers nor their own profitability. With smaller family size, it became apparent that a cabbage of between 0.7-1.0kg (1.5 and 2lb) was more likely to sell than one of 2kg (4.5lb) and growers were encouraged to produce **heads to meet the consumer demand**. This has been achieved by an effort from both growers and plant breeders as demonstrated by the head weight of varieties listed in the NIAB 1993 Descriptive list below.

	Range of Mean Head Weights
Early Summer cabbage	0.4 -0.77kg (14oz-1lb 11oz)

Summer cabbage	0.63-0.93kg (1lb 6oz-2lb)
Autumn cabbage	0.87-1.05kg (1lb 14oz-2lb 5oz)
Winter White cabbage	1.0-1.3kg (2lb 3oz-2lb 14oz)
Jan King/Savoy hybrids	0.95-1.37kg (1lb 1oz-3lb)

Added to this is the high proportion of the crop which is marketable, (i.e. well over 90%) largely due to the uniformity of F1 hybrids. EC quality standards give little cause for complaint and there is seldom a need to use Class II. The minimum unit weight of 350g (12.3oz) allows the lighter weight early summer cabbage into Class I category. However there is criticism from some growers that supermarkets can be unrealistic in not reducing their minimum weight requirements at the start of the early summer cabbage crop. Cut cabbage e.g. as in white cabbage halves, does not come within the EC quality standards.

There has been a recent resurgence of interest in the pointed early summer hearted cabbage described as "chou pointu" in supermarkets. These are covered in the EC quality standards however spring greens, which do not come under the EC scheme, but which have developed into hearted spring cabbage, fall into a grey area.

## Appearance

The wide range of varietal types offers a choice of **colours** and **shapes**. For green hearted cabbage there is little problem with colour, except for paleness of over mature heads or varieties with dull blue green colour. Normally all hearted cabbage, with the exception of white cabbage, is sold trimmed back to one complete ring of outside leaves clasping the head. Very flat "pancake" headed cabbage and rugby ball oval shaped heads have not been popular although some elongation in head shape of white cabbage is accepted. The effect of plant spacing



on head shape can be quite strong, producing more elongated and longer stemmed heads at close spacing. Heads should be **compact** and **firm**, with short internal stem and no gaps between the leaves, especially at the base. The presence of flower initials and their development as “**bolters**” is not acceptable. Normally this is only a problem with glasshouse raised early summer cabbage, which have suffered cold or a check to growth after planting out. Crops which have over-wintered in the field may also be subject to bolting in the spring and varietal differences do occur.

Red or purple coloration in winter cabbage, such as **January King** types is an important selling point, particularly in the eyes of older customers who prefer this type to the winter hardy, all green **Savoy**. It is in the Savoy that we have seen the most advances in recent years. The loose rosette headed and very variable varieties of ten to fifteen years ago have been replaced by a range of hybrids and interspecific crosses of uniform size and shape with maturities ranging from late summer through to early spring. The improvement in this type is at the expense of the January King and is no doubt due to the greater popularity of the continental Savoy type in Holland where the bulk of cabbage breeding work takes place. The dull green of some **Christmas Drumhead** types is not very popular. Whiteness in white cabbage is obtained normally by stripping off outer leaves but colour differences from pale green to creamy white do occur between varieties. White cabbage will develop a natural green coloration on exposure to light. This gives a good colour indicator as to the length of time heads have been left on supermarket shelves, and varietal differences have been noted in the rate of greening.

## Defects

The major defects in hearted cabbage arise from **pest and diseases** affecting the appearance of the trimmed head, or frost damage. Most varieties are selected now for their ability to hold

in the field without **splitting** and for **low temperature tolerance**. Leaf diseases as described in the HDC project FV77 also affect cabbage. White cabbage in particular also suffers from two visually detracting disorders, pepper spot and *Oedema*. Work has been done to determine the cause of these disorders. *Oedema* has been the subject of HDC report FV128 and thrip damage is suggested as the possible cause of the unsightly calluses.

Pepper spot is now less common and this may be due to the selection of varieties less prone to the disorder. More recently Turnip Mosaic Virus and subsequent internal necrosis has caused problems in stored white cabbage. NIAB assess varietal susceptibility to this disease (HDC Project No FV160). One of the major problems with these disorders is that there may be little or no external evidence and it is not until the head is cut for preparation that the defects are seen. The move by supermarkets towards whole white cabbage rather than cut pieces has made it even more necessary to ensure the products are free from these defects.

## Flavour

Following on from the bitterness in sprouts, plant breeders are always aware of the possibility of any Brassica leaf vegetable turning up with the same problem. There is little evidence to suggest that bitterness is a problem in the cabbage varieties now being grown but there is an interest in breeding sweeter, **nuttier flavoured** varieties.

Most flavour assessment work has been done with white cabbage, probably because of its use in coleslaw and salad production. CFDR carried out taste trials in 1983 and varietal differences were recorded. The variety Polinius was picked out as having a “**hot peppery**” flavour. Dark green leaf and red coloration are also linked with stronger flavour and the January King group of cabbage is thought by some to be superior in taste to the Savoy or white cabbage hybrids of the same maturity period.

## Shelf life

Shelf life for hearted cabbage depends on type but is normally 3+3 days. The susceptibility of white cabbage to go green or yellow after storage and **exposure to light** can reduce shelf life to 2+2 days. Cut cabbage also has a reduced shelf life compared with whole heads where discoloration of the cut surface and regrowth from the growing point occurs. The NIAB shelf life trial of winter hybrid cabbage reports varietal differences in yellowing and turgidity which in turn is linked to weight loss. Only slight differences were seen in the twenty varieties of Savoy cabbage on test. In Summer Cabbage thickness of leaf is an important factor in determining varietal differences in weight loss and turgidity. Thin leaved varieties lost more weight, and are less turgid than thick leaved cabbages.

**Pesticide residues** are a cause for concern where post harvest chemicals are used on white stored cabbage in the UK. Work is in hand to improve the storage environment so as to avoid the use of post harvest treatments. Some growers are using modified or controlled atmosphere stores to attain this end.

## Future Developments

The improvement in the range, uniformity and quality of hearted cabbage over the last ten years would appear to give little scope for dramatic developments apart from pest and disease resistance and better storage potential without the use of chemicals. Red cabbage has benefited from the **breeding work** and has emerged as a more accepted product with its own flavour and culinary status. Producing sweeter, nuttier flavoured varieties which need a bare minimum of cooking time, or can be eaten raw as in prepared salads, is one possible avenue to follow.

**Mini cabbage** and prepared ready to cook packs have established a small niche for themselves. Nutritional value of cabbage is not used as a marketing tool and any moves to publicise the

value of this vegetable in a healthy diet should not be lost.

## Key Issues

In 1992 the UK imported 29,300 tonnes of cabbage, this reflects the annual imported tonnage for the past five years, **improved storage** methods could reduce imports.

## CABBAGE GREENS Specifications

There are no EC Quality Standards for cabbage greens so specifications for this product depend largely on the requirements of the individual market. At one time, spring greens were an excuse for growers, especially in the milder areas, to cut oversized leafy cabbage plants and stuff them into nets for sale during the short supply period of February to May. Varieties were chosen for their winter hardiness, quick growth and above all, yield.

The product offered, especially on the wholesale market, varied from the large tough leaved "elephants ears" to plants with very little edible portion due to an excessively large stem. The arrival of supermarket specifications in the early 1960's saw the demise of the large leaved product as it could not be packed in a small polybagged retail unit of around 0.68kg (1.5lb). Another development was the upgrading of the vegetable to achieve a much higher proportion of edible product with more compact plant habit and almost semi-hearted plant types. The term spring greens was dropped when supermarkets saw an opportunity to offer the improved product for twelve months of the year as cabbage greens. **F1 hybrids** offered more compact heads but had the disadvantages of a short harvest period and the tendency to heart quickly in summer. Hearted spring cabbage was normally over-wintered, hearting readily in April through to May. Suffice to say that there has been a trend away from the open leafy varieties of greens to the more compact, almost semi-hearted varieties.

Supermarkets vary in their requirements for cabbage greens and individual supermarkets can also alter their specification from season to season. A summary of the current requirements denotes a range of 2-6 pieces per 500g pack with the trend being towards a reduced number of pieces between 170-280g (6-10oz) rather than the 110-225g (4-8oz) previously stipulated. This favours the use of the smaller, more compact F1 hybrids such as Duncan although the higher seed cost especially for direct drilled crops makes the cheaper open pollinated varieties more economic.

Greens should have a high proportion of edible leaf and tough old outer leaves should not be packed. Purple coloration normally indicates nitrogen shortage or stress and is not acceptable. Individual pieces should be compact with a short main stem. One specification stipulates the proportion of stem should not exceed 40% of the total weight of a piece. Plant spacing, as well as variety, influences the conformation of the plant, with very close spacing tending to induce leggy plants with a large stem.

NIAB trials use a spacing of 38x13cm (15x5") for greens but a slightly wider spacing of 38x26cm (15x10") for hearted spring cabbage. The crop is very responsive to **nitrogenous fertilisers**, top dressing and nitrogen status of the soil will affect yield and to some extent the texture of the product.

## Defects

Apart from Brassica **leaf diseases** cabbage greens are susceptible to **frost damage** which normally shows as marginal leaf scorching. **Internal sliminess**, especially in semi-hearted plants can occur during mild warm conditions. These conditions will also reduce the shelf life of the product unless quick and efficient removal of field heat and continuous cool chain is achieved. Reduced shelf life is normally shown by yellowing and heating of the product in the polythene bag, while unwrapped product will tend to wilt rapidly in hot dry conditions. **Bolting** or flowering can occur especially on over

wintered or early spring crops and varietal susceptibility is well documented in NIAB trials.

## Flavour

Apart from a general acceptance that the older outer dark green leaves will be stronger flavoured, or possibly more bitter, than the inner younger leaves, little work on flavour assessment has been undertaken.

Several supermarkets were concerned about the **level of nitrates** in their product but acceptable levels have not been publicised. The levels of lead and other industrial pollutants have been investigated especially on some over-wintered crops grown near major roads and industrial areas.

## Shelf life

Shelf life of the product is very dependent on the efficiency of the **cool chain** and seasonal factors. Fast growing, soft summer and autumn product tends to have a shorter shelf life of 2 + 2 days compared with winter and spring product which can be given 3+2 days. While the perforated polythene bag may not be the ideal packaging they are cheap and prevent moisture loss. NIAB shelf life trials carried out on summer/autumn varieties packed in 0.9kg (2lb) polybag holding 2-3 heads showed varietal differences in weight loss (turgidity). Blue/green leaved types hold their colour while paler types tended to yellow.

Storage of greens is seldom practised although one source had stored product successfully for 10 days at 2°C and 98% relative humidity. **Rots** are the main problem. Greens have been one of the first vegetables to be recommended for **hydro-cooling** when it was first commercially developed in the UK in the 1950/60's.

## Future Developments

The image of the product as a "cheap" gap filler is changing to that of a tender tasty fresh green



available throughout the year. The introduction of smaller more compact and semi-hearted varieties is also improving the product. **Prepared sliced greens** have appeared but whether the more expensive "polypropylene plus" packaging and cool chain up to the point of refrigerated retail display will make it economic remains to be seen. Some form of packaging is considered to be necessary for supermarket handling as experience shows that loose product on display is rapidly stripped of its outer leaves by customers who then only purchase the tender inner portion leaving a compost heap of loose leaves for the produce manager to clear up.

### Key Issues

Improved quality and presentation needed to maintain this crop.

## CAULIFLOWER Specifications

Normally Class I cauliflowers are demanded, although at certain periods of the season when this is not feasible some supermarkets will accept Class II for minor colour or head defects thus ensuring continuity of supply.

**Curd diameter** is not an accurate estimation of the economic value of the head in that a shallow curd has less edible weight than a deep hemispherical curd of the same diameter. A few supermarkets have recognised this and combine a minimum head weight with curd diameter. The minimum curd diameter for Class I is 11cm (4.3") and normal supermarket requirements are for a curd size of 11-15cm (4.3-6") diameter. Extra large heads of up to 18cm (7") are taken at certain periods of the year.

Curd size may also be measured by "taking the arc of the largest dimension of the upper part of the inflorescence", to quote the EC Regulation, which gives an indication of **curd depth** but is too cumbersome to apply especially when grading by eye on a field rig. Baby or mini cauliflower are exempt from the minimum size

limit provided they are packed in a consumer pack.

Head size is controlled largely by **plant spacing, varietal and nutritional factors**. Very large heads i.e. more than 18cm (7") diameter, are difficult to handle and uneconomic to pack and transport. Normal counts for supermarkets using 40x60cm (15x25") trays vary between 6 and 9 as single layer face-packs, although orders will only cover one or two counts on any one consignment. This therefore puts pressure on growers to adjust their techniques to obtain a high proportion of their production in the acceptable size ranges.

The use of F1 hybrids should, in theory, improve the uniformity of head size although because of the higher cost of seed and poor economic returns many producers are resorting to using good open pollinated varieties for summer and autumn maturity. The swing towards F1 hybrids is said to be more pronounced in Holland than in the UK. The more concentrated harvest period of F1 hybrids is stated by some growers to be a disadvantage. A **maturity prediction service** is now available and could be of help in crop management. Deep curds with a compact stem are required for fresh market and prepacking but may not be totally suitable for floretting where more loosely structured heads are preferred. This is largely a varietal characteristic although spacing can be a factor. The depth of the shallow supermarket trays are about 18 cm (7"), this further limits the size of head for packing without damage.

### Appearance

**Colour** of the curd is generally considered the most important feature and this means the whiter the better. Unfortunately whiteness of curd is normally reduced by exposure to light, especially sunlight. In the past breeders have concentrated on protecting the curd from light with a layer of wrapper leaves. Consumers on the other hand wish to see the curd, and supermarkets therefore specify that these inner wrapper leaves be cut

away. This leads to curd blemish due to knife damage especially on field rigs. **Plate 7** illustrates three standard trimmings. Curd damage in consequence leads to down grading and reduction of shelf life. One solution would be to breed varieties which would not discolour on exposure to light and some plant breeders consider this to be feasible.

## Defects

Mechanical damage to the curd done by trimmers and the bruising incurred by handling, allows the entry of bacterial or fungal agents. This was highlighted on the shelf life trials carried out at Luddington under HDC project FV21 and more recent work at Kirton, HDC project FV108 which states "it was apparent during the shelf life work that physical damage to the produce incurred when handling and cutting had a greater effect on shelf life than any of the cooling treatments".

NIAB states that "the accent is on quality not yield" and puts considerable effort into recording defects in head quality. Plant breeders are well aware of the importance of the **visual quality aspects** such as bracts, loose curds, pinking, yellowing, riciness, and great strides forward have taken place in improving the visual quality. However there are still varieties being grown which do not perform well in a comparison of the best and worst varieties on a Class I head quality criterion, as taken from the NIAB 1993 Descriptive List.

	% of heads in Class I		
	Best	Worst	Mean
Early Summer	88	45	70.5
Late Summer	79	63	70
Early Autumn	84	69	75
Late Autumn	85	69	76.5
Winter/Spring Heading	73	25	50

There is room for improvement in the **spring heading group** although this is probably the most difficult crop to achieve consistent results due to the variable weather and soil conditions early in the year.

In addition to the problems of curd defects there can also be difficulties with leaf scorch, especially of the central wrapper leaves round the curd, hollow stems and Brassica leaf diseases. One particular problem is the yellowing of the wrapper leaves after two days at ambient. This is particularly troublesome in **winter cauliflower** and in heads which have been cold stored.

Pests such as caterpillars and aphids are seldom recorded as serious quality defects although in hot dry weather late infestations of **aphids** can be troublesome. With the increased acreage of oilseed rape, **pollen beetle** has become a serious problem in recent years. HDC funding has resulted in the development of a system of **forecasting attacks** which is available to growers from HRI Kirton (Project No FV127).

The **tight over-wrapping** of cauliflower heads with unperforated PVC film has been shown to be very conducive to curd breakdown especially at the points of contact and now most supermarkets prefer open bags or perforated polypropylene films for prepacking (see **Plate 8**). An interesting observation from Luddington shelf life trials was that curd breakdown was highest in curds harvested early in the day, immediately prepacked then cooled. Least breakdown occurred on those heads harvested late in the day, cooled to 3°C overnight and packed the next day. Surface drying of the curd possibly explains the reduction in bacterial and fungal breakdown. The retailing of unpacked heads from self service displays, especially during promotions, can cause problems. Heads are removed from the protection of the crate and piled on top of each other while customer handling and their tendency to strip even more leaves off the head makes management of such displays an arduous task. Plant breeders must take into consideration not only curd

characteristics but also the whole **leaf conformation** around the head to give a protective compact unit. Supermarkets on the other hand should reconsider whether over-trimming is consistent with maintenance of quality.

## Flavour

There is no general view as to what the taste of a cauliflower should be. A fairly **bland** product which could be enhanced by a cheese sauce is accepted. **Texture** is perhaps more important, although this was largely dependent on the cooking time. Very little work appears to have been carried out on the culinary and organoleptic aspects of cauliflower varieties and certainly no one seems to be very concerned, apart from the processors, who would definitely not want a variety which turned into a soft greyish white mush on cooking. Work carried out at CFDR in 1983 on 17 varieties indicated there was little difference in flavour between them although differences in texture did occur. Sour or stale flavours were noted in some varieties on some sites. The over-wrapping of heads with certain films, especially non perforated PVC films has been thought to cause off flavours. The maturity of the heads may also affect flavour and texture.

## Shelf life

Curd yellowing and the incidence of bruising and disease varies between varieties and affects shelf life. There is very little indication that plant breeders and seedsmen carry out any detailed shelf life work. This is perhaps indicated by the rapid demise from the market several years ago of a widely grown late summer variety which broke down within 24 hours of receipt at the supermarket. The months of July and August, especially when there is a combination of high temperature and high humidity, can give the greatest incidence of shelf life problems although the efficient application of **cool chain** helps. Any relaxation of the current cool chain procedures (product temperature at least 6°C, handling/transport temperature at least 8°C) would be

likely to result in a loss of product life. Currently most cauliflower heads are displayed at ambient in supermarkets level and this is so throughout the wholesale operation. An expected shelf life of 2+2 days is normally laid down by supermarkets but this could be extended to 3+3 in refrigerated displays.

## Future Developments

Cauliflower is now a basic vegetable in the supermarket portfolio for 52 weeks of the year. The quality of the product is based on visual assessment although the obsession with pure white and blemish free heads has to be modified at certain periods of the year when such an item is unobtainable or too expensive.

The alternative forms such as **florets and mini cauliflower** extend the range of availability, although there are indications that florets, which are sometimes refrigerated throughout the distribution and retail chain, are less popular (see **Plate 9**). The production of mini cauliflower is a specialist operation and the original concept of this being a fully mechanised field system, including harvesting, has still to be achieved.

Of recent years other coloured variants, purple, green and red, have appeared and established for themselves a *niche* position on the market. The attractive cone shaped florets of the Romanesco type (see **Plate 10**) have the disadvantage of being very susceptible to damage unless handled carefully.

Obtaining a 52 week availability from UK sources alone might not be economically viable. There is scope for investigating some of the milder winter microclimates as has been done in Cornwall, developing higher quality and more reliable varieties for these regions. The storage of the high quality late summer and autumn heads using **controlled atmosphere stores** needs more attention, although once again several supermarket buyers were reluctant to encourage such development because they feel shelf life and quality would deteriorate.

## Key Issues

Visual appearance, particularly retention of the **whiteness** of the curd.

Controlled atmosphere storage to **fill the gaps in production**.

Pollen beetle forecasting now in place.

## BROCCOLI (CALABRESE)

The term "broccoli" is used here to apply to the greenish blue heads and shoots of the multitude of varieties and F1 hybrids originating from the Italian vegetable, calabrese. Sprouting broccoli, on the other hand, is the winter hardy purple and white sprouting English vegetable. It is suggested that the traditional use of the term broccoli for the winter hardy Cornish and Roscoff type cauliflower be dropped to avoid confusion. Broccoli first gained popularity in the UK with the introduction of the frozen broccoli spears in the 1960's. Its development as a fresh product followed on largely due to the interest of major retailers who had quick and efficient distribution systems which were able to handle the tender and highly perishable new product. The introduction of cool chain extended the marketing opportunities and a complete 52 week availability was made possible by growing the crop in Spain over the October to June period.

## Specifications

Early specifications were based on varieties and culture for small to medium primary heads which were cut to give a first crop. This was followed by the growth of secondary shoots harvested over two or three cuts to give the broccoli spears. The small heads and spears were then put together in a posy pack and over-wrapped into nominally fixed weight packs. The development of larger headed more compact varieties opened up the possibility of selling **individual heads** either over-wrapped as for cauliflower or loose (see **Plate 11**). Over-wrapped heads are normally sold at a unit price calling for a head weight of around 400g. When produce is sold by weight as from

loose displays, the range of head size can be wider and normally ranges from 250-600g. The Dutch Central Bureau of Auctions carried out a consumer survey which indicated Dutch customer preference is for heads of 400-500g.

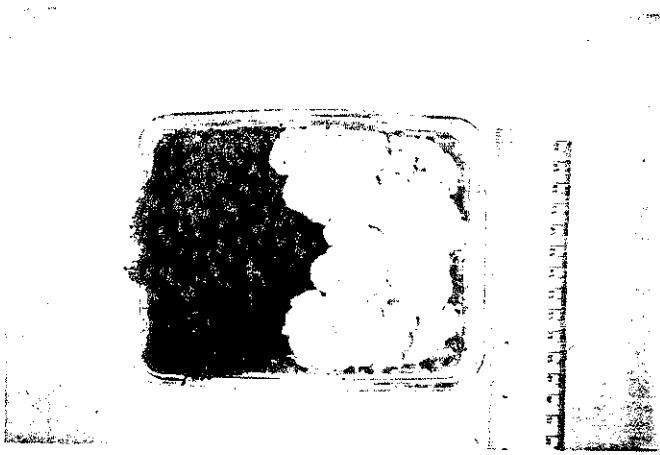
The specification for the **posy pack** is less clear and each major supermarket has individual requirements, which can cause problems in pack-houses serving more than one customer. In essence the pack is over-wrapped and sold at a unit price. The main pack sizes are 275g, 400g and 500g. Individual pieces of 275g are sometimes allowed as a single piece pack but normally the weights are made up to the nominal figure by putting together anything from 2-15 pieces with a minimum weight per piece of 35g. The development of varieties with long stemmed **multi-branched heads**, which when cut at the base would fall apart to give several individual shoots, has attracted the processors and might well form the basis of a new type posy pack (see **Plates 9 and 12**).

Stems are cut to give an overall length of about 15.5cm (6") because they are normally stood upright in the supermarket tray. There is already a 18cm (7") limit decreed by the depth of some trays, in itself is not a bad thing as excessive stem length, often cut off by the consumer, gives poor value especially when sold by weight. Some grading specifications lay down a relationship between head size and the amount of stem.

NIAB has in the past used the criteria of head diameter and butt diameter on spears cut to 15.2cm (6") length as follows:

Head Diameter	Butt Diameter
less than 75mm (3")	less than 30mm (1.2")
75-125mm (3" – 5")	30mm (1.2") and above

One retailer has gone even further with a specification for single heads stipulating that the ratio of the total length to head diameter should not exceed 1.25:1. For a spear length of 15.5cm (6") therefore the head would need to be at least 13cm (4.8") diameter. Others require that the overall length should not exceed the diameter of the head.



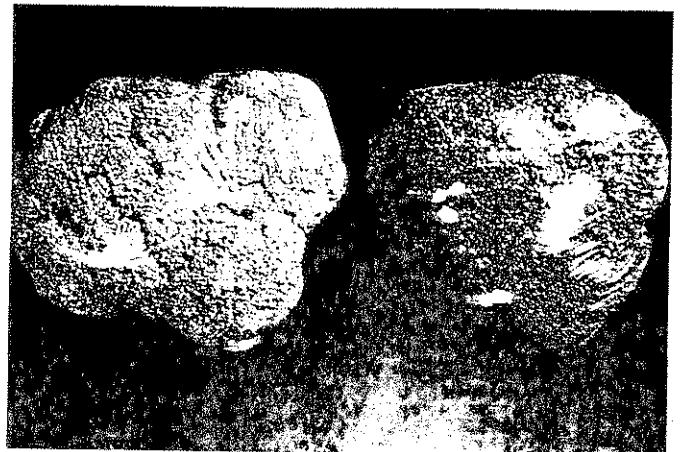
**PLATE 9:**  
*Prepared cauliflower and broccoli florets.*

**PLATE 10:**  
*Standard cauliflower, Romanesco  
and Cape varieties.*

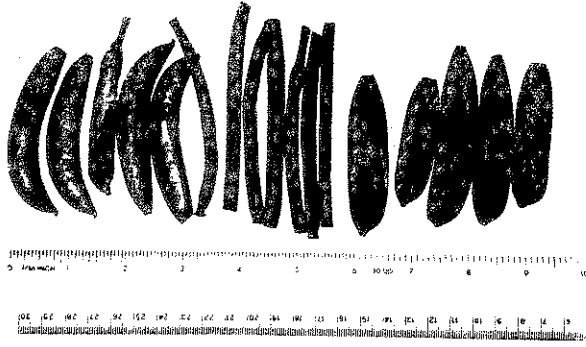


**PLATE 11:**  
*CALABRESE: Branching stems.*

**PLATE 12:**  
*CALABRESE: Yellowing of  
wrapped produce due to  
prolonged display.*

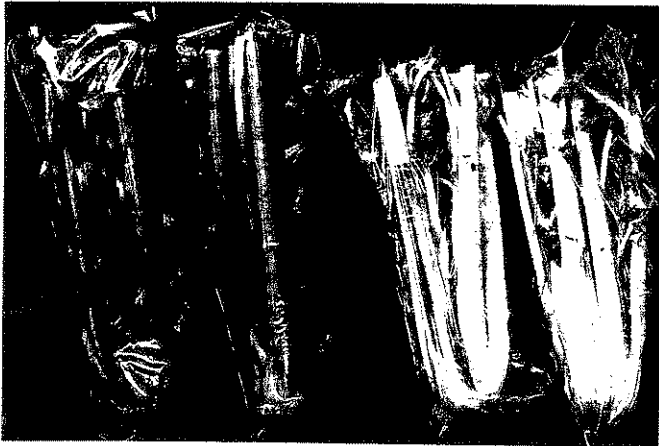






**PLATE 13:**  
*Topped and tailed imported sugar snap peas,  
 fine beans and mange-tout.*

**PLATE 14:**  
*ENGLISH RUNNER BEANS: Variable size  
 and shapes from a loose display.*



**PLATE 15:**  
*CELERY: Comparison of shelf life of a sleeved  
 green variety versus a self-blanching type.*

**PLATE 16:**  
*ICEBERG LETTUCE: Browning of the  
 butt and damage from handling.*



A review of six supermarket specifications for this one crop gave 17 different permutations of weights and counts. There are no EC grading standards and considering that most of the variations between the supermarket specifications are fairly minor it might be useful if the industry could draw up a uniform standard. This would also be useful to the plant breeders in their work.

Fortunately the range of varieties now becoming available should give little problem as far as meeting varied size and weight requirements, but the estimate that 90% of the UK acreage was in only **two varieties**, Marathon and Shogun, would suggest that the trialling and introduction of new varieties was essential.

**Plant spacing** as well as a choice of variety can influence the size of head and its structure. A plant population of 35,000 to 45,000/acre is standard for the production of small to medium size heads. For larger single heads the population is reduced to around 20,000 plants/acre and even lower.

## Appearance

An attractive blue green **colour** is asked for and any discoloration such as bronzing is unacceptable. Where whole heads are segmented there is often a paleness of the head at the edge of the segments where they are less developed and protected from the light. Although this does not affect the eating quality it is considered by some buyers to detract from the overall appearance, and more uniform coloration would be desirable.

The size of head or individual **flower bud** also affects the appearance. One breeder has laid down an ideal bud diameter at harvest of 1.5mm and in NIAB trials bud size is estimated on a scale of 1-9 with Marathon and Shogun coming into 3 or 4 categories where 1 is small and 9 is large.

The ability for the head to remain compact and in bud during warm weather is also required of varieties. The buds should also develop

uniformly over the head and not give an uneven appearance. There does not seem to be any strong views regarding the presence or absence of leaflets round the head although some comment was received on the poor appearance of stems stripped of their leaves.

## Defects

**Crown rot or bacterial spear rot and hollow stem** are the major quality defects and often whole crops have to be discarded because of these disorders. Weather conditions, particularly the incidence of warm moist conditions after a hot dry spell as the crop matures, is frequently quoted as being the most likely environmental factor. Crown rot has been investigated in HDC Project FV8 and the importance of water soaking of the buds in the development of bacterial rotting is indicated. Water soaking could be due to loss of wax from the tissue surface or some other method of infiltration of water into the tissue so that varietal differences can be expected. In this work Shogun was among the least susceptible variety to crown rot. High **nitrogen** fertiliser rates promoted both downy mildew and spear rot.

From both the retailer and consumer point of view the rapid development of crown rot at ambient, especially on over-wrapped heads, can be unpleasant and costly. The main problem with hollow stem, apart from it being unsightly, is the subsequent rotting and discoloration which can penetrate into the edible portion of the stem.

Pests such as **aphids and caterpillar** are occasionally mentioned as a rejectable occurrence, but the judicious use of pesticide has given the consumer a clean and safe product.

## Flavour

There is some difference of opinion as to where the flavour rests in broccoli. Some maintain it is in the fleshy stem, a fairly high proportion of which is cut away either in the pack-house or kitchen. Others feel that the immature buds in

the **head** have a distinct, but different flavour from the **stem**. Apart from one producer who considered Marathon to be poorly flavoured there were no great preferences expressed regarding flavour differences between varieties. Work at CFDR reported in 1986 indicated no great varietal differences in frozen broccoli spears although differences in texture were apparent and there was a suggestion of slight bitterness in one variety.

## Shelf Life

NIAB shelf life work reported in 1990 that there are distinct varietal differences in **yellowing** (see **plate 12**) and **weight loss**, with Shogun coming out particularly well. More work needs to be done in this area and all varieties should go through standardised shelf life tests before release. Again this is an area in which most plant breeders and seedsmen need to put in greater effort.

The expected shelf life of 2+2 days at ambient was likely to be extended to 3+2 with complete refrigeration up to point of sale. Work on the removal of field heat and a comparison of holding temperatures of 6° and 10°C is reported in HDC Project FV137 but, contrary to the conclusions of that report, most supermarkets and their suppliers would be unwilling to accept the higher temperature suggested for this crop.

## Future Developments

If, as was stated by a major grower, only five varieties are used to cover the whole season and of these, only two make up 90% of the UK acreage, there is a pressing need to obtain and test **new material**.

A new system of **predicting maturity** of crops using a simple to use computer model has been developed with HDC funding and is now available to growers from HDC in Petersfield. Varietal differences in shelf life, susceptibility to breakdown and possible flavour and texture needs further study. It would also be useful to have a clearer indication and rationalisation of

the consumer specification although present trends would suggest the whole head will largely replace the multi-spear posy pack. The emergence of the floretted ready prepared pack was not seen by most contributors as being a major factor in expanding the product sales.

Currently it would appear that the UK crop has now reached its production level to meet home market demands and extending the growing season into **unfavourable climatic periods** e.g. by over-wintering or late autumn cropping, especially in the traditional growing areas of Scotland and Lincolnshire, would not be beneficial to product quality. That is not to say that milder areas in the South and West of the country could not be utilised more.

The long term storage of the product is not favoured even though imported product may spend five or six days in transit and a storage life of 10 to 14 days at 0°C and 95% relative humidity has been obtained. The product is very susceptible to ethylene and should not be stored or transported with fruit unless for only short periods. The Californian practice of using crushed ice met little enthusiasm from those supermarket representatives who were consulted.

## Key Issues

Heavy dependence on too few **varieties**.

Direction of change in which specification of product needs to be ascertained.

Maturity prediction schedule is available.

## SPROUTING BROCCOLI

This vegetable fills in a useful gap between mid-February and late May. The main reason for its low production has been the lack of suitable varieties. Both **purple and white** selections are available and its description as "poor man's asparagus" gives an indication of its flavour potential. Purple heads tend to be stronger flavoured than the white but they are also earlier and hardier. The introduction of two new varieties, Red Arrow and Red Spear from the

Wellesbourne breeding programme, has improved not only the winter hardiness but also the productivity of the crop. It is now economically feasible to obtain 1-2.5cm ( $\frac{1}{2}$ -1") diameter crowns, 15cm (6") long tender shoots with small edible leaves. Improvements of the white varieties is however slow and the greatest need is to improve frost hardiness and head colour.

## CAPE BROCCOLI

Cape broccoli is another of the old home grown vegetables which fills the late winter and early spring gap. Although this product gap is now largely filled with imported calabrese and cauliflower there is potential for the distinctive flavoured purple heads of this vegetable.

**Improved varieties** are needed and production would be better suited to milder areas such as the South and South West of the country. This is supported by the crop failure at Kirton in Lincolnshire over the relatively mild winter of 1991/92 and reported in HDC project FV97. Several supermarket buyers are interested in the product and have been supplied by UK growers in mild areas.

## CURLY KALE (BORECOLE)

Until recently, curly kale has been a neglected form of Brassica greens but is now enjoying a new lease of life. Improved varieties are compact, more productive, suitable for prepacking and may be cropped from late summer through to spring.

The hardiness of curly kale has ensured almost continuous supply through the winter and a trial examining continuity of production over the 1992/93 season is described in HDC project FV96.

The popularity of the product on the continent probably accounts for the new range of F1 hybrids now available. It is a vegetable **well suited to the UK** winter production and has good

shelf life when handled in cool chain. Too often the good holding ability of this vegetable is abused when packed in polybags and displayed at ambient over several days, encouraging yellowing and rotting. While varietal differences in winter hardiness and shelf life do occur there is little documented work in the UK to provide clear guidance on these aspects.

## BROAD BEANS

Broad beans have declined in popularity over the last twenty years yet they are grown on nearly every allotment. The relatively large pod weight for such a small yield of beans does not help their image especially among younger housewives. Most fresh market varieties have a **shell out** of 25-28% which means that three quarters of a purchase is thrown away. The processed product has hardly enhanced its popularity. It can develop a tough leathery skin around the seed which some people loathe, even though it adds good roughage to the diet. How then can broad beans make a comeback? The removal of the drudgery in the kitchen by providing chilled shelled beans is an avenue followed by one leading retailer. The development of varieties with a higher yield of beans per pod and more uniform production is already taking place. A warning is given to breeders however not to develop the white flowered processing varieties for fresh use. The relationship between **flower colour** and flavour is often commented upon and purple flowered varieties are reputed by some to have the stronger flavour.

Taking a leaf out of the pea book there is the possibility of **mange-tout beans**: young pods picked 8-10cm (3-4") long, dependent on variety, and cooked whole. Cookery books often mention the culinary delights of this vegetable but seldom is it seen or available. There are now several small podded varieties which might fit the bill. Picking pods in a much younger state such as this would also overcome the problem of blemished pods due to **Chocolate Spot** and other disorders.

Climatic factors affecting flowering and pod set are said to account for the short season of availability which does not encourage supermarkets to allocate shelf space to the product. The **declining popularity** of the broad bean is also due to the lack of varieties giving a long season of high yielding beans of good eating quality.

## Key Issues

Further develop the market of **mange-tout and shelled beans**.

**Extend the season** by use of range of varieties and geographical areas.

## DWARF/FRENCH BEANS

Nomenclature of this group has always been confusing but it is generally accepted that, following the developments in processing varieties, dwarf beans are round podded (see **Plate 13**). They can range from the fine podded Kenyan imports referred to as "**fine or needle beans**", through to the more mature, large round pods, known as "**bobby beans**". Recent trends in the fresh market have been towards the finer type of bean. The old flat podded and stringy dwarf bean such as The Prince and Masterpiece are now hardly grown commercially.

## Specifications

Special criteria are laid down for fine beans (needle beans) in the EC Quality Standards. These specify three size ranges based on the maximum diameter of the pod:

Very fine: width of pod not exceeding 6mm

Fine: width of pod 6-9mm

Average: width of pod exceeding 9mm

Imported fine beans are hand picked in a fairly immature state over successive harvests. This would be uneconomic in the UK, even if it could be done mechanically. No length criteria is laid down.

The size requirement for UK produced dwarf beans is :-

Diameter: 8-10mm (0.3-0.4")

Length: 10-15mm (4-6")

## Appearance

Stringiness and parchment has been almost completely bred out of present day varieties especially if they are harvested at the correct stage of maturity. To obtain whole, undamaged pods free from soiling is not easy with **mechanical harvesting**, especially in a wet season. Breeders are well aware of the need to have erect plants with beans held clear of the soil. While better quality could be obtained by hand picking the pressures towards low prices cannot justify the higher costs. The maturity of fresh beans tends to be greater than for the processed product. CFDRA has reported on the **optimum maturity criteria** for both the fresh and processed market, this is based on seed length. Medium to dark green colour is preferred to pale or speckled pods. Yellow podded beans have not proved popular with the British consumer. A bright, almost **glossy green** is preferred by some to a dull grey green.

## Defects

Defects are of two kinds, the non progressive scarring of pods due to **wind rubbing** and the progressive breakdown caused by **fungi or bacterial agents**. *Botrytis* can be particularly bad in wet seasons, this and other rots can quickly develop through damaged tissue especially after mechanical harvesting. To reduce the problem in hand picking the beans should be picked with a small piece of stem and not broken off at the neck.

## Flavour

It is generally assumed that the downfall of the processed dwarf bean can be laid at the door of the American round podded varieties bred for mechanical harvesting, bulk processing and

cheapness rather than for flavour and texture. Fortunately European bred varieties have re-introduced these quality characteristics and it could be argued, that unlike peas, the fresh product, properly handled, has more to offer the consumer than the processed. CFDR has carried out work on flavour assessment of varieties both for the fresh market and processing.

### Shelf life

Picking too early can reduce shelf life due to the shrivelling and limpness of the bean as a result of moisture loss. Normal shelf life for pre-packs would be 3+3 days but for loose display this should be reduced to 2+2 days. Varietal differences in shelf life are reported in CFDR work.

### Future Developments

There is a wide range of **pod colours** and varieties which have not been exploited commercially. The arrival of topped and tailed **prepacked** product from Kenya and Zimbabwe does not seem to have aroused competition from UK suppliers. Although we are on the climatic margin for dwarf beans there are indications that even the processing crop is moving southwards and onto the Continent. There are areas, especially in the South of England where a reliable and fairly long season of production of good quality produce could be obtained. The demise of the mechanically harvested crop might in fact provide an opening for a higher quality **hand picked** product, provided this advantage is not thrown away in poor grading and selection. Unlike the other bean crops mentioned there is a good reservoir of varieties for the fresh bean grower to choose from. One major grower now achieves a four month production of good quality beans using a range of varieties, sowing dates and crop covers.

### Key Issues

Varieties to suit **climatic conditions** or move production into more favourable areas.  
**New markets** being taken over by imported fine beans and semi prepared beans.

### RUNNER BEANS

Runner beans are one of the most traditional of English crops. It is depressing however to see the amount of poor quality product which reaches the supermarket shelves and market stands (see **Plate 14**).

### Specifications

The ideal runner bean for prepacking would be 15-25mm (0.6-1") wide and 250-305mm (10-12") long. The introduction of loose produce has allowed a greater latitude in length although one supermarket spokesman said he likes to see loose beans laid in a line across the width of a 355mm (14") plastic tray. Runner beans are covered by the EC Quality Standards but no length restrictions are laid down. Choice of variety will strongly influence the length of bean. Streamline, Achievement and Prizewinner have given way to newer, shorter varieties.

The problem of producing **stringless** runner beans is compounded by the requirement for **straight** beans. Stringless varieties are listed and when prevented from becoming over mature they meet the stringless criterion. The problem of parchment within the pod wall has largely been overcome in new varieties but it remains important to pick the bean at the correct stage of maturity.

The rapid development of seed within the pod can be a problem especially late in the season when temperatures drop.

**Colour** and appearance of pods is covered in most specifications with a preference for smooth, medium green rather than dark, rough skinned pods. Reddening of the pods and russeting is

found in crops grown under adverse conditions and is disliked. There is a conflict of opinion concerning the advantages and disadvantages of **red flowered varieties**. Red varieties are reputed to be more tolerant to poor growing conditions, with a better flavour than white flowered varieties. Most retailers do not specify flower colour although one large multiple only sells White Emergo, mainly because it is stringless at the required stage of maturity.

Runner beans are very sensitive to poor **growing conditions**, requiring shelter and adequate moisture to produce well. Production and quality can be variable especially during hot dry periods in late July and August. More effective pollination is achieved by the introduction of hive bees into the crop. Very little if any research is being carried out on these aspects of production and quality.

### Shelf life

Shelf life of prepacked beans is normally 3+2 days but can be extended with refrigerated display at retail level in line with cool chain practice. Loose beans on display tend to go **limp**, especially if picked immature, 2+2 days shelf life is normally allowed for.

Efficient and quick removal of field heat after picking is necessary, especially during hot dry spells. Pod defects such as *Botrytis* rots can be troublesome in wet weather.

### Future Developments

Improvements in plant breeding have given a good range of medium length "**stringless**" varieties. The cultural and climatic factors governing quality and yield are not well understood. The introduction of self-fertile, flat podded, climbing beans of the **Helda/Kwintus group** erodes some of the market for traditional runner beans. They are stringless, fleshy, slow to form parchment and, with glasshouse production as well as outdoor, could give a longer availability from UK sources. The ground bean,

(e.g. Kelvedon Marvel) grown without support, appear to have lost out so far as quality and yield are concerned.

**Extending the season** of availability is possible using polythene covers for the early crop in areas free from late frosts.

## Key Points

Varieties more suited to our climate are needed to obtain **more uniform pod setting**.

Wind rubbing blemish and twisting of pods are major problems - stringless varieties are more liable to **twisting**.

## PEAS

One major retailer described peas in a pod as a disaster and would not stock them. Others struggle on half-heartedly with fluctuating quantities of variable quality for three to four weeks of the year, while high quality mange-tout and sugar snaps are on their shelves year round.

Fresh peas must be one of the most **difficult crops** to handle especially in the unpredictable British climate. Peas are one of the few vegetables where the frozen product, in general, is superior to the fresh. This is due to the speed and disciplines which the processors impose to maintain the quality of the product. Growers of fresh peas need to follow their example if they wish to succeed. **Discipline** and control over sowing date, picking, cooling and product selection are imposed for a reasonable chance of success. One large grower achieved an availability over 11 weeks in the summer of 1993 but even then lost 20% of his potential crop due to over-maturing in hot weather or pods being diseased in wet conditions.

## Specifications

There is an EC Quality Standard for shelling peas which describes Class I and Class II products. No pod size limits are laid down but for hand picking, which is still the only successful

method, large podded varieties would reduce the picking costs. They would also be more likely to contain the minimum of five seeds in a well filled pod required for Class I.

**Once over picking** will still require good field selection by pickers to remove flat immature pods or wrinkled silvery grey over-mature pods. A minimum of handling and the use of crates or boxes rather than bags or nets reduces mechanical damage. Very often this damage will not show up until 24 hours later when the product is on retail display. Rapid removal of the picked peas into a cooling area is essential. Efficient cooling facilities to bring down the product temperature to around 4°C within 2 hours of picking is the aim. Continuous cool chain thereafter, even on retail display, would extend shelf life from 2+2 days to 3+3 days if the product is also held in refrigeration by the consumer.

One could argue that the peas are enclosed in their own pack, the pod, **nets** are difficult to fill, cause damage and allow dehydration. Polythene bags tend to sweat and can accelerate the maturing of the peas which have a high respiration rate if not kept cool.

**Shelled peas** in "polypropylene plus" or similar films under continuous refrigeration have been on sale in at least two major outlets. Whether this is the only way forward for fresh peas remains to be seen.

Maturity criteria, apart from the obvious visual flat pods or wrinkled pods, are measured on the basis of sugars as a "**Brix reading**" or with a tenderometer as used by the processor. A Brix reading of 13% is the minimum stipulated by one customer. The shell-out percentage should be not less than 34% but claims for some new varieties achieving 50% have to be substantiated.

## Defects

Pod **disease** due to both fungal and bacterial agents are major problems during wet weather. Late crops are particularly susceptible and can be devastated by mildew attacks. PGRO has been

carrying out HDC funded trials on varietal susceptibility with some clear indications of significant varietal differences. This has shown some varieties with sufficient resistance to mildew to enable an extension to the season.

**Pea moth** is now well controlled by the use of forecasting in conjunction with sprays although in serious attacks it is possible that as much as 20% infestation of pods can occur. **Aphids and thrips** can also affect pea pod quality, the former because of the transmission of virus to young plants which produce malformed pods.

## Flavour

Taste evaluation for processing varieties is carried out at CFDRA and to a lesser extent PGRO, but little work has been reported on fresh peas. The ability of peas to hold their carbohydrates as sugars and only slowly convert them to starch as they mature would be an important attribute for fresh peas. It is for this reason that some supermarkets will not accept round seeded varieties such as the early maturing Feltham First because of its starchy, poor flavour.

## Future Developments

There is an urgent need to develop **better varieties** more suited for the fresh market. Short erect haulm, large pods (6-10 peas per pod), 40% plus shell out, **easily shelled** and good holding ability on the plant, could change the future of this crop. These factors together with more **pest and disease resistance** could extend the season of availability.

## Key Issues

Unless new **improved varieties** become available peas in pod will remain a minor crop. Only growers accustomed to **good disciplines** in handling and cooling will succeed. **Areas** more suited to production e.g. low rainfall but adequate moisture should be selected.



## MANGE-TOUT/SUGAR PEAS

Mange-tout peas, in the literal sense would cover both the flat podded varieties as well as those with small round and well filled pods, both of which are eaten whole. Present convention within the UK retail scene would tend to confine the term mange-tout to the flat podded “Oregon” types and use the term “Sugar pod” for the podded varieties. Seed catalogues do not necessarily agree with this definition so care must be taken to ensure that the variety description agrees with the retailers, definition of the type. To add to the confusion the terms “**Sugar snap**” and “**Snow pea**” are also used to describe both types (see **Plate 13**).

The appearance of these “**novelty**” legumes on the market has now been accepted as an established product with all year round availability. The fact that they come almost exclusively from areas of the world blessed with a warmer and more equable climate than the UK can partly explain why they are almost wholly **imported**. Cheap labour costs are counter balanced to a certain extent by high freight costs nevertheless they have established a place for themselves on retailers’ shelves and on many customers’ shopping lists.

Attempts have been made to grow them in the UK but so far not with conspicuous success. The variability of our climate, the vigorous growth of most of the varieties currently available and **high picking costs**, have made them unpopular from a grower’s point of view. Imported product is picked at an immature stage in order to reduce stringiness. This would reduce the yield for UK growers unless more mature product was accepted. In the event of **dwarfer varieties** more suited to UK growing conditions becoming available, this crop could enter the British grower’s portfolio especially in drier, warmer South Eastern areas.

### Future Developments

From the comments made on peas and beans the conclusion might be drawn that although

climatically the UK is **marginal** for many of these crops there are areas and varieties which could and are being used to produce good quality and economically successful crops.

Much of the research and knowledge of these crops has been translated from the work done on the processing crop and very little effort is being put into the fresh product. There is a vast reservoir of **information** from organisations such as PGRO, with whom HDC is already collaborating, and CFDRA. New work at CFDRA is being carried out under private funding and growers would need to subscribe separately to this.

The dramatic increase in consumer interest in the leguminous crops need not be passed over by UK growers because of the difficulties they pose. Looking at the opportunities they offer would be a more positive attitude.

### Key Issues

Almost all UK sales are imported.  
High **labour costs** limit UK possibilities.

## CELERY

The old system of earthing-up wide rows has become uneconomic in the face of Spanish and Israeli imports. This has also meant the virtual demise of blanched celery, newer varieties of **self-blanching** and green celery having taken over. Field production in the main UK production areas of the Fens and Lancashire becomes a gamble after mid-November because temperatures below  $-4^{\circ}\text{C}$  cause severe loss of quality.

The early season **cool glasshouse crop** developed on the former Land Settlement Estates still survives. This fills a useful slot during May and June when temperatures are too high in the Mediterranean and before the UK field crop is ready. **Floating mulches** have helped bring forward the field crop but late frosts in May, and even early June, can be a problem. A review of

glasshouse celery quality has been published by HDC under project PC84.

## Specifications

While the MAFF/EC Common Quality Standards classify celery as a vegetable on the premise that it should be cooked, many consumers would consider it a salad to be eaten raw. The use of the term "ribbed celery" in the EC Quality Standards is puzzling especially as many of the new varieties have quite smooth petioles. The standard does not apply to celery hearts or baby celery if prepacked and labelled accordingly.

The size ranges of trimmed heads laid down in the EC Quality Standards are:

Size	Large	Medium	Small
	over 800g	500-800g	150 – 500g
Range	200g	150g	100g

These size ranges are in conflict with most UK supermarket specifications which cover a head weight of 450-600g and so cross over into both medium and small size grades. Some supermarkets will attempt to offer two distinct sizes of head covering 350-450g for small size and a distinctly larger head of 550-650g where availability and price allows. The wholesale market tends to take larger average head sizes of 500g upwards but seldom above the 800g of the large EC Grade. These EC grading and uniformity requirements are only compulsory for Class I product though in effect even Class II product is graded into uniform sized heads and counts.

**Mini or baby celery** falls below the minimum EC small grade of 150g and must be labelled as such.

## Appearance

The consumer acceptability of the **greenness** of

celery has long been a moot point ever since dark green Israeli and USA imports came onto the scene. The claim that they only sold because there was no alternative paler, self-blanching product available has not been proven. A move towards a medium green, or apple green, colour is becoming the norm amongst supermarket buyers. This could also be a reaction to the poor quality, stringy, pithy sticks of over mature, self-blanching Lathom variety, the mainstay of the industry for so long, which is now being superseded. Many of the newer self-blanching varieties are greener, smoother and straighter than Lathom and as such, are easier to **pre-pack** in sleeves and do not show up damage quite as much as paler varieties. There is evidence of consumer resistance to very dark green varieties but assessment of colour, especially under supermarket display lighting can be misleading.

The **shape and smoothness** of the petiole are also taken into account on assessing the visual acceptability of a variety, although consumer reaction is less well investigated. Straight, narrow petioles and compact head formation make prepacking easier and as a high proportion of the crop is sold as pre-packs, even on the wholesale market, this is an important economic factor. The smooth rounded petioles of some of the greener American varieties are thought to be more attractive than the ribbed, broad petioles of the Lathom self-blanching types and the catering trade was reported to be more interested in the former types. There may also be evidence to suggest that the narrow round petiole varieties are less prone to damage in harvesting and handling.

**Length** of petiole from base to the first knuckle was generally required to 25-30cm (10-12"). This fits in well with the dimensions of the standard 40x60cm produce crate with the sticks laid horizontally across the crate. The mean petiole length of the 18 varieties in the 1992 NIAB trial at a mid-October harvest was 28cm came well within the specification. Normally the stick is trimmed to about 2.5cm (1") above the knuckle to leave some leaf.

Almost all celery is washed and most supermarkets require the final rinse to be in potable water. This is particularly important if the product is eaten as a salad item as consumers may ignore the supermarket instruction to wash the product before eating. A common defect, especially in imported product is the blue residues of copper based **fungicidal** sprays. Similarly excessive soil or peat lodged between the base of the petioles is unacceptable.

## Defects

**Mechanical damage** and breakdown are the two major quality defects. It has already been mentioned that the greener erect varieties appear to show less damage than pale spreading varieties. **Discoloration** of the butt has often been taken as an indication of the post harvest age of the stick. This is not always a reliable guide and other factors such as water stress are thought to influence the rate of discoloration.

The main disorders seen at retail level are *Septoria* leaf spot and blackheart. **Leaf spot** is normally controlled in the field by fungicidal applications however any infection of the harvested product, even if held in abeyance by normal cool chain temperatures, can quickly develop at ambient temperatures and cause yellowing of leaf tissue, and in severe cases discoloration of the petiole. Some varietal resistance is suggested but reliance on chemical control measures is normal practice.

**Blackheart** is a physiological disorder due to reduced calcium uptake in plants under water stress. The young tender growth at the centre of the plant develops dark necrotic areas which in turn can be infected by soft rot bacteria. Occasionally petioles can show symptoms of boron deficiency or imbalance in the form of brown cracks developing horizontally across the petiole.

**Pithiness and stringiness** are linked to cultural, varietal and maturity factors. Self-blanching varieties tend to become stringy because they mature more quickly than green types. NIAB lists varieties with low stringiness. On the other hand

green varieties tend to go **ditny** more quickly than self-blanching although again there are varietal differences. Bolting or the formation of flowering shoots can occur in field crops when young plants have been subject to cool temperatures while still in the juvenile phase of growth. The use of supplementary night lighting during this phase of growth, especially for early crops, has largely overcome the problem but it can appear, especially in early outdoor and glasshouse crops. Although Class I of the EC Quality Standards specifically states that the product should be free from **flower stalks**, a certain amount of tolerance is practised. Provided the flower stalk is not plainly visible without close examination of the head and does not detract from the eating quality of the individual stick then the product is acceptable. The degree of bolting should be agreed upon with the supermarket buyer before supplying an affected product.

## Flavour

Flavour of celery is a very contentious subject and the commonly held belief that green celery is better flavoured than self-blanching has not always been sustained in comparative testing both at CFDR and NIAB. Flavour can be affected by soil type, especially on mineral soils, crop nutrition, maturity and variety. The principal characteristics of flavour are described as paraffin taste, soapy taste and pleasantness. Stringiness was also assessed. The variability in the results from year to year and from site to site makes it difficult to reach firm conclusions. Some buyers have specified certain varieties as acceptable and others as non acceptable. Celery flavour is very influenced by soil and cultural conditions and is shown by the fact that imported product grown on a highly saline soil was so salty as to be inedible. This is despite the fact that trends in the USA showed that the application of salt increased the yield, reduced the excessively strong flavour and made the stalks crisper and less stringy. There would appear to be a gap in our knowledge of the flavour constituents in celery and the factors affecting flavour and stringiness.

## Shelf life

Shelf life of washed and sleeved sticks was normally given as 3-4 days plus 2-3 days for consumer use, dependent on the efficiency of the cool chain throughout marketing and customer handling. The **sleeving** of sticks helps to prevent moisture loss and gives a certain amount of protection against superficial damage. In NIAB shelf life trials conducted at 20°C and 50% relative humidity, sleeved celery had a shelf life of four days from harvest. The main defects that occurred during this period were yellowing, loss of moisture and **turgidity**. The conclusion is made that green varieties have a better shelf life than self-blanching (see **Plate 15**).

Celery benefits from holding at temperatures as low as 1-2°C but care must be taken not to fall below 0°C otherwise freezing damage can occur. Slight **freezing damage** shows up as a bubbling of the epidermis on the outside petioles.

Severe freezing damage will lead to complete cell breakdown and subsequent **bacterial infection**. Long-term storage up to four weeks at 1-2°C and 95% relative humidity has been achieved. Severe losses have occurred however on product stored longer than four weeks. British celery is susceptible to **Licorice rot** caused by soil borne fungus *Mycocentrospora* (or *Centrospora*) *acerina*. The use of dips or drenches has been examined but with a general hardening of opinion against the use of **post-harvest chemical** treatments this is not a likely solution to storage breakdown problems.

## Future Developments

A better understanding of the factors affecting flavour, stringiness and maturity are required. **New F1 hybrids** are now appearing which might provide some of the answers to these problems. Crosses between self-blanching and green types are also available while the appearance of Polish varieties in recent NIAB trials may introduce new blood.

Consumer acceptability, especially with regard to colour and appearance is still a matter of debate. At least one supermarket offers self-blanching and green celery to customers from the same counter, but it is doubtful whether conclusive results were obtained. Most buyers spoken to were in favour of the mid green or apple green petiole colour.

Most UK celery is grown on organic peaty soils but early frosts can bring production to an end well before Christmas, a peak period of demand. There could be an opening for **late crops** grown on similar organic soils in the milder south western areas. Alternatively controlled atmosphere storage of the late planted crop harvested in early November could help to fill this gap.

The general impression is that celery is losing its consumer following. Even the widening of **customer choice** by offering baby celery, celery hearts or chopped celery is not likely to expand demand greatly. Alternative colours such as the old pink varieties, have been tried but without great success. With terms such as paraffin like, turpentine and soapy being used to describe **flavour**, is this the area where greatest improvement is needed?

## Key Issues

Market is **static** if not declining for fresh whole head sticks.

Better quality and better flavoured **varieties needed**.

## ICEBERG LETTUCE

The meteoric rise of iceberg lettuce on the UK market over the last ten to fifteen years has meant almost a total eclipse of the round or butterhead lettuce. Several factors could account for its rise to such a predominant position in the salads area. It fits in better with the current trends in marketing. It has better shelf life than the butterhead lasting for up to ten days in the domestic refrigerator and with once a week

shopping, the iceberg offers better availability to the consumer. There is very little waste or dirt with the iceberg. The outer, older and dirtier leaves have already been removed. It was a major defect of outdoor grown round lettuce that after heavy rain it was virtually impossible to obtain a clean product to meet supermarket standards. The iceberg is better **value for money** on the basis of the edible weight. Round lettuce had diminished in size to between 150-250g in order to ensure a tender, almost non hearted, product, whereas iceberg is some four times this weight but not generally four times the price. Finally some would claim that the crisper and sweeter iceberg has more to offer the consumer than the fairly bland soft round lettuce. From a retailers' point of view the iceberg, especially where full cool chain is provided, is much easier to handle and has a longer shelf life than the round lettuce. Iceberg lettuce is normally available in Britain 52 weeks of the year.

## Specifications

The EC Common Quality Standard covers all types of lettuce except cutting lettuces which are the non hearted leafy variants now appearing on the market. Specific standards for Iceberg are a minimum weight of 300g for outdoor grown and 200g for Class I and II crops grown under protection. The difference between the lightest and heaviest heads in each package must not exceed:

- 100g for lettuces weighing between 154 and 300g per unit
- 150g for lettuces weighing between 300 and 450g
- 300g for lettuce weighing more than 450 per unit

This is a wider weight range than normally allowed by supermarkets for a product being sold at the same price rather than by individual head weight. Typical supermarket size grades are:

450-650g : count 12

550-750g : count 10

650-800g : count 8

(Count is dependent on size of tray and density of head)

Normally only two size grades or counts will be handled at any one time and more frequently only one. Size ranges will vary with time of season and growing conditions with largest head size normally available in the July/August period. Growers commented that supermarket buyers were often not fast enough to change their specification especially when large heads of (e.g. 700-800g) formed a high proportion of the crop and were too heavy to meet the maximum 650g head weight frequently laid down. There are indications that supermarkets would prefer the 450-650g range and the wholesale markets heavier heads of 600-800g. It was also suggested that in the early part of the season the minimum supermarket specification could be more readily met if it was reduced to 350 or 400g. From the NIAB 1993 Descriptive List of crisphead lettuce the mean head weight of nine varieties ranged from:

622-689g for June to mid July production

639-712g for Mid July to August production

602-680g for September to October production

Control of head size by variable spacing does not appear to be very applicable to the crop and too close a spacing can lead to **poor head shape**.

There has also been a suggestion that a **mini-iceberg** of 150-250g and about the size of a cricket ball would find a useful market and trials to develop suitable varieties were undertaken in 1993.

## Appearance

The conformation and shape of the head should be **firm** (but not solid) and round. Work carried out at Wellesbourne over the 1988/89 seasons showed that Saladin, the main cultivar used commercially in the UK, was very sensitive to environmental factors such as temperature and solar radiation at specific stages of growth. Denser heads were associated with **low temperatures** during the period up to and around hearting. Less dense heads were primarily associated with higher temperatures in the period up to hearting and high levels of solar radiation

in periods well after hearting. Other work in the USA suggests that high temperatures after hearting induced soft puffy heads. The initial dependence on **North American varieties** for UK growing conditions is being overcome with the introduction of Dutch bred varieties more suited to UK production and improvements continue to be made. This is shown by the fact that very few new varieties develop conical heads, a frequent problem in early variety trials. The shape of the head is also probably affected by environmental factors. Early flowering or bolting can cause **uneven growth** and distort the head shape and the presence of obvious flower initials can be a cause for rejection of the product.

## Defects

Tip burn, russet spotting and pink rib are disorders which can develop after harvest and cause serious loss. **Tip burn** probably originates from calcium deficiency due to moisture stress in the growing crop. **Pink rib** and **russet spotting** are considered to be post harvest storage disorders caused by low oxygen (or high CO<sub>2</sub>) levels and ethylene damage respectively. Other problems often seen at retail level are downy mildew (*Bremia lactucae*) bacterial soft rot and bottom rot (*Rhizoctonia*). Although **mildew** mainly affects the discarded outer leaves it can be a problem at certain periods of the year especially during the autumn when heavy dew and cool nights provide ideal conditions for the fungus to develop. Resistance to the various strains of mildew is bred into most new commercial varieties and is listed in the seed catalogues. **Bacterial soft rot** is due to various bacteria, these are normally soil borne and are favoured by wet conditions and affect the base of the lettuce. Trimming of the outer leaves can remove slight infections and cool chain can reduce the development of the rots. Attempts to grow the crop on soil covers such as black polythene which also restricts weed growth have been considered too expensive. **Rotting** due to bacteria and fungi such as *Botrytis* and *Sclerotinia* can also develop on damaged tissue especially if wet heads are over-wrapped or bagged and temperatures rise above 10°C.

**Bruising** and broken leaf ribs caused by poor handling are frequently noted as sites of breakdown.

**Bottom rot** normally attributed to *Rhizoctonia solani* can develop quickly around the base of the plant and may not always be trimmed off adequately. **Butt rot** can also cause serious loss when it proceeds up the stem into the centre of the plant. A more recent development of butt rot is a green slimy breakdown of the butt which has been associated with calcium deficiency.

**Browning of the butt** (see Plate 16) is normally taken as an indication of the age of the cut product but is not a reliable guide. The white sap or milk is produced more copiously when the plant is cut in the fully turgid state, for example, first thing in the morning. It not only browns readily, especially as temperatures rise, but can disfigure other cut heads and the packaging. For this reason some growers prefer to leave harvesting of crops until later in the day when the plants are less turgid but are obviously warmer and so require good fast removal of field heat if shelf life is to be preserved.

The most serious pests were **leaf aphids** or greenfly. Light infestations normally only affect the outer leaves and can be trimmed off. The fast reproductive rate of these insects can cause problems even after cutting and packing. Customers unfortunately are not likely to tolerate the odd greenfly, even if it can be washed off easily, and do not appreciate that to maintain a field crop free from this pest will also mean spraying with chemicals. **Root aphid** is more of a grower's problem and pesticides need to be used for control. However there is genetical resistance bred into several varieties for example the old Wellesbourne variety Avoncrisp.

## Flavour

Flavour is high on the list of major buyers, although no serious flavour defects have been recorded. Flavour was investigated at CFDR in 1988 when **bitterness** was stated to be due to a complex terpene alcohol named Lactucopicrin.

The detection and assessment of bitter and sweet taste in iceberg lettuce can be a difficult operation and for this investigation the panel of tasters were given standard solutions of sucrose at 4.0g and 8.0g per litre for sweetness and quinine hydrochloride at 0.025g and 0.05g per litre for bitterness. The findings of the investigation showed that older, greener leaves were more bitter and less sweet than younger inner leaves. Other comments obtained were that products from crops under stress, over mature, or grown with high nitrogenous fertiliser applications were more bitter than product from crops grown and harvested under **optimum conditions**. Varietal differences are less easy to confirm as soil, site, season and maturity at sampling are not easily controlled. Suffice to say that breeders should be very conscious that any new variety with a tendency to bitterness will be short lived, even if it is difficult to determine the level of bitterness which might be acceptable.

## Shelf life

Shelf life has been investigated at CFDR, NIAB and Luddington EHS (up to the time it was closed down). Choice of film was particularly important and PVC films for overwrapping were not recommended by Luddington. Most supermarkets now specify **perforated polypropylene bags** with differing degrees of perforation to suit the seasonal condition. Heat sealed film or taped polythene bags give good results and are preferred by certain retail customers who lay down their own specific requirements. The aim is to cut down moisture loss and at the same time allow sufficient ventilation to avoid a build up of CO<sub>2</sub> or ethylene within the bag.

Fast removal of field heat and constant **cool chain** are essential for optimum shelf life. Storage and distribution temperatures as low as 0-2°C can be used but care must be taken at temperatures around 0°C as **freezing damage** can occur if there are sub-zero spots in a store or vehicle. It is for this reason that ice bank or similar stores have become useful for iceberg

lettuce as temperatures do not fall below 0°C and relative humidity is in excess of 95% can be obtained. Storage under ideal conditions up to 2 weeks has been easily obtained without serious loss of quality or subsequent shelf life. The use of controlled atmosphere storage is reported to extend product life by a further two or three weeks depends on varieties but CO<sub>2</sub> and ethylene levels must be carefully controlled. No comments have been obtained on any changes in flavour as a result of storage although Luddington work suggested there was a decrease in bitterness after storage.

Shelf life is normally expected to be 3+3 days under ambient and 4+5 days if product is held under refrigeration at 8°C by both retailer and consumer. The use of flaked ice as practised in the USA was not welcomed by UK retailers because of the excess moisture which occurs as the ice melts.

## Residues

So far, **pesticide residues** in iceberg lettuce have not become a serious area of contention although the use of fungicides and insecticides are necessary to produce a satisfactory product. If the healthy salad image is to be maintained every possible step needs to be taken to reduce pesticide usage. A protocol for **integrated pest management** is under preparation similar to that for carrots and cauliflower.

Germany, and eventually the EC, may lay down maximum **levels of nitrate** in lettuce, however, this is not likely to affect field grown iceberg. One Dutch breeder claims to have developed varieties with naturally lower nitrate levels, without impairing the agronomic or consumer attributes of the variety.

## Future Developments

The wide variety of lettuce types now available offers the consumer a baffling choice. Many of the bitter, leafy types will only be used to add interest to a salad, the basic ingredient of which

is now the iceberg type. New varieties of non heading, sweet flavoured leafy lettuce are now on the market, are greener and smaller leaved so lacking the large fleshy mid rib of iceberg. Whether these will erode the position established by iceberg remains to be seen. The development of a **mini or baby iceberg** has been mentioned and it is interesting to note that early attempts to introduce some of these varieties are held up because of bitterness.

A move towards smaller, greener heads was indicated by two of the retailers interviewed and with the provision of **refrigerated displays** all buyers are offering prepared chopped or sliced iceberg. This could be an expanding market, not only for retail sale, but also for catering and institutional markets where costs of preparation are being cut. A major problem here, apart from the necessity of the preparation being carried out under food hygiene conditions, is the **cost of packing** in special "polypropylene plus" or similar films and the need to keep strict cool chain disciplines. A technical problem has been the **browning of the cut edges** of the product. This has been reduced by the use of gas flushed packs and other treatments. The development of varieties which do not brown so readily would be an advantage for the prepared salad industry.

## Key Issues

Integrated Crop Management - **reducing pesticide usage** and increasing biological control. Measures now being addressed through Link projects with HDC and MAFF funding.



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