Title:
POST HARVEST MANAGEMENT

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Summary:
The only post-harvest treatment required for the long storage of bulb onions is a thorough curing of the bulbs. Curing is a drying process intended to dry off the necks and outer scale leaves of the bulbs to prevent the loss of moisture and the attack by decay during storage.

Keywords:
Shorting ,grading, packing of fruits and vegetables, Reefer logistics, Reefer trucks , Temperature controlled

Article Body:
Curing

The only post-harvest treatment required for the long storage of bulb onions is a thorough curing of the bulbs. Curing is a drying process intended to dry off the necks and outer scale leaves of the bulbs to prevent the loss of moisture and the attack by decay during storage. The essentials for curing are heat and good ventilation, preferably with low humidity. This dries out the neck and the two or three outer layers of the bulb. The outermost layer, which may be contaminated with soil, usually falls away easily when the bulbs are cured, exposing the dry under-layer, which should have an attractive appearance. Onions are considered cured when neck is tight and the outerscales are dried until they rustle. This condition is reached when onions have lost 3 to 5% of their weight.

If onions cannot be dried in the field, they can be collected in trays, which are then stacked in a warm, covered area with good ventilation.

In cool, damp climates, onions in bulk ventilated stores are dried with artificial heat blown through the bulk at a duct temperature of 30 degrees Celsius.

Onions can also be cured by tying the tops of the bulbs in bunches and hanging them on a horizontal pole in a well-ventilated shades. Curing in shade improves bulb colour and reduces losses significantly during storage
Grading

Onions after curing are graded manually before they go in to storage or for marketing. The thick neck, bolted, doubles, injured and decayed bulbs are picked out so also misshapen small bulbs. Sorting and grading is done after storage also to fetch better price. The outer dry scales usually rub off during the grading process, giving the onions a better appearance for market. It has been experienced that if storage is arranged after proper sorting and grading losses in storage are reduced.

For local market the onions are graded based on their size.

Extra large onion (>6 cm dia.)

Medium (4-6 cm dia.)

Small (2-4 cm dia.)

The extra large onions have great demand and fetches very good price.
General Characteristics

The bulbs shall:

- be reasonably uniform in shape, size colour and pungency of the variety /type
- be mature, solid in feel, reasonably firm with tough clinging skins.
- be throughout cured and dried.

- be free from dust and other foreign material.

- be free from defective, diseased, decayed and damaged bulbs caused by seed stems, tops
- oots, moisture, dry sun scald burn, sprouting, mechanical or other injuries and staining.

- be free from moulds, soft rot and insect attack.
- % of seed stem or bolted bulbs shall not exceed 20% in Nasik kharif onions.

Bangalore and Krishnapuram onions will be free from bottle necks or doubles.

Grade designations and definitions of quality for export of onions:

Different size but not below 15

1. Tolerance for size in big onions: For accidental errors in sizing, not more than 5 % by weight of the bulbs in any lot may be of next lower grade than the minimum diameter prescribed in Nasik, Saurashtra, Bellary or Poona onions. In case of Podisu, this error in sizing not more than 10 % by weight. In this case, smallest onion in bunch would be taken for measuring the diameter.

2. Defective, diseased and damaged shall mean malformed bulbs and the bulbs internally or externally damaged, diseased or discoloured material affecting the quality. The decayed onions shall not exceed 2% in any lot.
General: The grade shall be allowed to be packed only against irrevocable letter of credit.

NS grade: This is not a grade in its strict sense but has been provided for the onions not covered under regular grade. Onions under this grade shall be exported only against a specific order from foreign buyer inducting the quality.

Packaging

Packing should be small for easy handling during transit and may vary according to market demand. Onions are packed in jute (hessian) bags for transporting to yard or brought as loose. For safe handling, 40 kg open mesh jute bags having 200-300 g weight should be used in domestic market. For export, common big onions are packed in 5-25 kg size open mesh jute bags.

Bangalore Rose and multiplier onions are packed for export in 14-15 kg wooden baskets. Nylon net bags, when used for packing have resulted in less storage loss because of good ventilation.

Handling

Bulbs intended for storage must be free from cuts and handled with extreme care. Onions should not be dropped on to non-resilient surface from more than 6 feet height. If onions are to be stacked after packing in store or trucks, the better height is 2-2.5 metres. Losses due to rot is reported to be more if onions are stored in gunny bags than in loose or wooden crates.

Storage

Proper storage of bulbs is necessary both for consumption and also for seed production. Onions should not be stored unless adequately dried either in the field or by artificial means. It is necessary to dry the neck tissue and outer scales until they rustle when handled otherwise the bulbs will rot in storage.

Sprouting in onion is controlled by temperature. The temperature between 10-25°C increases sprouting. Rooting is influenced by relative humidity (RH).

More the relative humidity, more is rooting. Weight loss is more when temperature is above 35°C. Under ambient conditions the onions are stored at a temperature of 30-35° C with RH of 65-70%. In cold storage, temperature is maintained at 0-2°C while the RH is kept at 60-75%.

Sprouting is checked effectively if Maleic Hydrazide at 2500 ppm is sprayed at 75-90 days after transplanting. Effect is, however, more pronounced in kharif season than in rabi season. The storage rots could be checked if proper cleanliness is maintained in store and crop is sprayed with 0.1% Carbendazim after 90 days of transplanting and just before harvest. In India, the farmers practice different storage methods. The onions are bulk stored in special houses with thatched roof and side walls are made up with bamboo sticks or wire mesh for good air circulation. In North India, the sides are also covered with gunny cloth. Onions are stored in these sheds by spreading them on dry and damp proof floor or racks. Periodical turning of bulbs or removal of rotten, damaged and sprouted bulbs should be done. Well-ventilated improved storage structures with racks or tiers having two or three layers of bulbs would be desirable for proper storage.

The salient features of improved storage structures are as below

- Construction of storage godown on raised platform helps in reduction of moisture and dampness

- Use of Mangalore tiles roof or other suitable material prevents built up of high temperature inside.

- Increased centre height and more slope is better for air circulation and preventing humid microclimate inside godown.

- Bottom ventilation provides free and faster air circulation to avoid formation of hot and humid pockets between the onion layers.

- Avoid direct sunlight on onion bulbs to reduce sunscald, fading of colour and quality deterioration.

- Restriction on width of each stack to 60-70 cm for cool humid weather, 75-90 cm for mild and humid weather and 90-120 cm for mild and dry weather conditions

- Restriction of stacking height to 100 cm for small and multiplier onion

and hot weather and 120 cm for mild weather and for big onion to avoid pressure bruising.

• Cubicles should be made instead of continuous stack leaving sufficient space for ventilation from all the sides.

One cubic metre area of store accommodates about 750 kg onions.

Transport

Onion stocks are transported in bullock carts, tractor trolleys and trucks as also railway wagons are used for longer distance movement within the country. Onions are transported in ventilated ships as well as sailing vessels / motorboats for export to Gulf and South-East Asian countries. It is also shipped in 3.5m containers or 7m containers by loading on ships.

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2.1 Pre-harvest Operations

The condition of onion leaves is a good indicator of the maturity and general state of the bulb. Bulb onions which are to be stored should be allowed to mature fully before harvest and this occurs when the leaves bend just above the top of the bulb and fall over. As a practical guide, farmers should conduct sample counts on the number of bulbs, which have fallen over in a field; and when the percentage of bulbs, which have fallen over, reaches about 70-80% then the entire crop should be harvested. Harvesting could commence earlier when 50-80% of the tops have gone over, before it is possible to see split skins exposing onion flesh Storage losses at optimum maturity are normally lower than those harvested before the tops collapse. Bulbs generally mature within 100-140 days from sowing, depending on the cultivar and the weather.

Spring onions mature for harvesting after 35-45 days from sowing. Harvested crop should be allowed to dry or cure and ripen in the sun for several days after lifting. Onions can yield up to 5 t.ha-1 under good growing and management conditions.

2.2 Harvesting & Transport

Manual harvesting is the most common practice in most developing countries. This is normally carried out by levering the bulbs with a fork to loosen them and pulling the tops by hand. In developed countries, especially in large scale farms, mechanical harvesting is commonly used. The harvesting techniques adopted are influenced by weather condition at harvest time. In areas where warm, dry weather occurs reliably, the curing and bagging of the crop can be done in the

field (two phase harvesting). In wetter, temperate regions, mechanical harvesting and artificial heating and ventilation for drying are essential for reliable production of high quality bulbs on a large scale.

The following steps are followed during two-phase harvesting of onions: (a) mowing the leaves (if necessary); (b) stubbing, undercutting and sieving the onions to remove stones and clods; (c) roll the soil in the row to get a plane surface; (d) drying the bulbs (windrowing) 8 to 10 days in the field; (e) turning the bulbs 1 to 2 times; (f) harvesting, sieving and hand-grading, overloading into a trailer or in crates; and (g) transport. For one phase harvesting usually commercial potato harvesters have been adapted. After mowing the leaves the crop is immediately harvested, sieved, hand graded and loaded onto the trailer. Because of the additional operations involved, labour costs for two-phase harvesting are about 30 to 100 % higher than for one phase harvesting. The main disadvantage of one-phase harvesting is the high energy consumption required for mechanical drying. Using combine harvesting, the standardised working hours has been calculated to be 2.7 to 2.9 hr.ha-1 for stubbing, 2.4 to 2.6 hr.ha-1 for turning and 8.9 to 11 hr.ha-1 (KTBL, 1993).

Harvested bulbs are placed in containers (basket, bins) or tied into bunches and placed directly on the floor of a trailer for transport. These trailers can be pulled by an animals (such as donkey) or mechanical transport such as a tractor. Both packaging and transport systems must be selected to ensure minimum handling damage to produce. Hard surfaces should be cushioned with leaves, foam or other appropriate force decelerators.

2.3 Curing & Drying

Both curing and drying remove excess moisture from the outer layers of the bulb prior to storage. The dried skin provides a surface barrier to water loss and microbial infection, thereby preserving the main edible tissue in a fresh state. Drying also reduces shrinkage during subsequent handling, reduces the occurrence of sprouting, and allows the crop to ripen before fresh consumption or long-term storage (Opara and Geyer, 1999). This process of dehydration is sometimes called ‘curing’, but the use of the word ‘curing’ for onion drying is rather inaccurate since no cell regeneration or wound healing occurs as in other root crops such as yam and cassava. Drying reduces bulb weight and since they are sold mostly on a weight basis, achieving the desired level of dehydration is critical. Weight losses of 3-5% are normal under ambient drying conditions and up to 10 % with artificial drying.

In traditional small-scale operations, onion drying is carried out in the field in a process commonly called ‘windrowing’. It involves harvesting the mature

bulbs and laying them on their sides (in windrows) on the surface of the soil to dry for 1 or 2 weeks. In hot tropical climates, the bulbs should be windrowed in such a way to reduce the exposed surface to minimise damage due to direct exposure to the sun. In wet weather, the bulbs can take longer time to dry and may develop higher levels of rots during storage. The side of the bulb in contact with wet soil or moisture may also develop brown strains or pixels, which reduce the appearance quality and value. Obviously, successful windrowing is weather dependent and therefore cannot be relied upon for large scale commercial onion production business. Bulbs harvested for storage require in total 14-20 days of ripening or drying before being stored. Harvested onions may also be placed in trays, which are then stacked at the side of the field to dry. In some tropical regions, the bulbs are tied together in groups by plaiting the tops, which are then hung over poles in sheds to dry naturally.

Harvested bulbs can also be taken straight from the field and dried artificially either in a store, shed, barns, or in a purpose-built drier. This method is commonly used when crops are stored in bulk but it can also be applied to bags, boxed or bins. Under this method, bulbs are laid on racks and heated air is rapidly passed across the surface of the bulbs night and day [O'Connor, 1979; Brice et al., 1997]. Drying may take 7-10 days and is considered complete when the necks of the bulbs have dried out and are tight and the skins shriek when held in the hand. The control of humidity level in the store is critical. Under very high humidity, drying is delayed and fungal infection can increase. However, if relative humidity is too low (below 60%), excessive water loss and splitting of the bulb outer skins can occur, resulting in storage losses and reduction of bulb value. Placing onions on wire mesh in well ventilated conditions and using air at about 30°C, 60-75% rh and 150 m^3.h-1.m-3 is generally recommended for mechanical drying of onions.

2.4 Cleaning

Freedom from any impurity, which may materially alter the appearance or eating quality, is essential. Soil and other foreign materials must be removed and badly affected produce must be discarded. Cleaning may be carried out using air or by manually removing unwanted materials on the bulb surface.
Care should be taken to avoid physical injury on the bulb during these operations.

2.5 Packaging

General Information

Good packaging for onions must meet the following criteria: (a) strong enough to

retain the required weight of onions under the conditions of transport and storage, (b) allow sufficient ventilation for the air around the bulbs to maintain relative humidity in the required range, and (c) in many circumstances, provide a means of displaying legally required and commercially necessary information (Brice et al., 1999).

There are many traditional methods of holding onions for transportation and/or storage that do not fit into conventional packaging classifications. These include 'string of onions', shelves and loose bulk In 'string of onions' packing, the bulbs are tied together by means of their tops to produce a bunch of bulbs is also a form of packaging. This is suitable for transporting small quantity of crop, and during storage, the bunches are hung from the roof or from special racks. Shelves for onion handling and storage are made from either wooden slats or metal mesh on a wooden or metal frame, and are usually fixed in position with the bulbs loaded and unloaded in the store.

Ventilation (natural or forced) is usually achieved by passing air over the shelves. To achieve adequate aeration of the bulbs, the depth of bulbs on the shelves should be limited to 10 cm.

Onions are also stored loose bulk (instead of containers) by heaping the bulbs directly on the floor or elevated platform. Because they are not restrained, the bulbs roll during store loading to completely fill the storage space. Bulk storage permits maximum utilisation of store space, and uniform aeration is easier to achieve than in stacks of bags or other rigid packaging.

However, where bulk storage is to implemented, the retaining walls must be strengthened when storing larger quantities of bulbs, and arrangements need to be made for rebagging before subsequent marketing. It is also difficult to inspect bulbs regularly under these storage conditions. Loose bulk handling of onion is most suitable for large-scale operations where forced ventilation can be provided during long-term storage. Soft cultivars (which are also generally sweet) 'Vidalia Sweets' should not be stored in loose bulk because of their high susceptibility to compression and impact damage.

Onions can be packaged and stored in a variety of containers such as boxes, cartons, bags, bulk bins, pre-packs, plastic film bags, and stretch-wrapped trays. Packages typically contain 25 kg and above, especially for transporting crop from field to store and/or during storage. The same 25 kg bags or smaller bags may be used from store to market place. Decision on which type of packaging to use depends on crop size, length of storage and marketing requirements. A problem with packaging onions in boxes, net bags and bulk bins is that if they are too large, and airflow pattern tends to be around rather than through them.

Under this condition, the respiration heat of the bulb results in a warm, humid environment in the centre of the package, which can result in decay or sprouting. To avoid these problems in large stores, the capital investment in packaging may be quite substantial.

Onion Bags

Sacks and nets used for onion packaging fall into three groups: (i) general-purpose jute sacks, as used for many agricultural commodities, (ii) open-weave sacks of sisal-like fibre, (iii) open-mesh nets, normally of plastic materials and (iv) big bags, used alternatively to crates, containing up to 1000 kg . Jute sacks are readily available in most developing countries, but their disadvantages include: (i) generally too large - may contain 100 kg onions, hence difficult to handle and an increased risk of mechanical damage; (ii) bulbs are not visible through the fabric, and it is difficult to monitor condition during storage; (iii) there is some resistance to airflow if they are used in an aerated store; (iv) difficult to label effectively; and (v) recycled sacks may encourage spread of post harvest diseases.

Sisal sacks are made from sisal-like hard fibres and have an open weave, with thick threads spaced between about 10 and 15 cm apart. The rough nature of the fibre provides a sufficiently stable weave. These sacks are similar to jute sacks, but will allow limited visibility of the onions and impedance to airflow is less.

Open-mesh nets are the most widely used package for onions, and they are normally red or orange in colour. The slippery nature of plastics can result in the movement of the threads allowing large holes to open up. To overcome this problem, alternative nets are industrially produced to give fully stable mesh and stronger bag. The principal techniques include: (i) using extruded net from high-density PVC, (ii) knitted (warp-knitted) and asymmetric construction, and (iii) special weave in which weft threads are double, and twisted. They are also slowly degraded by sunlight, and should not be left outdoors for long period before use. In comparison with the other types of bags, they offer several advantages, including: (i) light weight, small bulk when empty, (ii) usually available in 12.5 and 25 kg sizes, (iii) fairly good visibility of bulbs, (iv) excellent ventilation, (v) hygienic, (vi) easy closing (draw-string types only), (vii) and crop brand and marketing information may be printed around the middle of the bag for easy identification.

Rigid Packages

A range of rigid containers is used to package onions for transportation,

marketing, and/or storage (Opara and Geyer, 1999). The principal rigid containers are trays (10-15 kg of onions each), boxes (up to 25 kg), and bulk bins (up to 1000 kg). These types of packaging enable segregation of onions into different cultivars or sources. Choice of packaging material is important as wooden bins, for example, are liable to termite attack, and weathering during off-season. Rigid containers are also expensive, need regular maintenance and a forklift is required for handling larger containers. Where rigid containers are used for onion storage, building design is simpler than that for large-scale loose bulk storage as reinforcement of retaining walls are not required to support the bulbs. Handling damage of bulbs during filling and emptying can be high, but damage is reduced during store loading and unloading operations in comparison with loose bulk handling and storage.

Stacking of containers must be carried out with care and to ensure that the ventilation air is forced through the containers of bulbs and not around them. One of the main advantages of rigid containers is that they facilitate regular inspection of produce, and when problems occur with the stack, the area affected is often limited to a few trays, boxes or bins which may be more easily isolated and removed than in loose bulk handling system.

Onion Pre-packs

Onions are commonly sold in retail outlets in pre-packs with a capacity of 0.5-1.5 kg. Pre-packing offers the following advantages over single bulbs in heaps or bags: (i) price can be attached to produce, (ii) the collation of a number of pieces into one unit of sale may promote sale of a larger quantity than would be purchased otherwise, (iii) provides a clean odourless unit for the customer to handle, and (iv) reduces time spent at the check-out. The use of weight/price labelling machines and bar-coding has reduced the need to pack to fixed nominal weights. During preparation for retail, the quantity of produce is measured by hand or machine and filled into the pack. Then the actual weight and price and/or bar-code are automatically calculated and printed on a label, which is attached to the package. This mechanised weighing and labelling system assists the packer in accurate record keeping and avoids losses due to inaccurate pack weights. The three main types of onion pre-packs are nets, plastic film bags, and stretch-wrapped trays

2.6 Bulk Storage

General Requirements

The objectives of onion storage are to extend the period of availability of crop, maintain optimum bulb quality and minimise losses from physical, physiological, and pathological agents. Bulbs selected for storage should be

firm and the neck dry and thin. Discard thick-necked bulbs because they are most likely to have high moisture content than optimum for storage, and therefore would have short storage life. Skin colour should be typical of the cultivar. Microbial infections such as Aspergillus niger occur during production of onions but these will only develop on the bulbs during storage where the storage environment is conducive for their growth. Prior to storage, crop must be cleaned and graded, and all damaged or diseased bulbs removed.

Careful harvest and pre-storage treatments with minimal mechanical loads are important to achieve a long storage period. Both store room temperature, relative humidity, and atmospheric composition affect the length of storage that can be achieved. Several technology options are available for bulk storage of onions, including low-temperate storage, high-temperature storage, 'direct harvest' storage and the use of controlled atmosphere (CA) stores. The recommended storage conditions under these systems are summarised below.

Storage at Low Temperature

For successful low temperature storage, good ventilation and a low level humidity in the range of 70-75% is essential. To maintain good quality crop, the period of storage varies but may be up to 200 days. For maximum storage period and minimum losses bulbs should be fully mature at harvest, and dried until the 'neck' of the bulb is tight. For large-scale commercial storage, onions are usually stored under refrigeration and the most commonly recommended conditions are 0°C with 70-75% rh. Regular ventilation and monitoring of both temperature and relative humidity in the store are necessary to avoid significant fluctuations in environmental conditions. During the first few days of storage the fans should provide an adequate airflow, to remove water in the outer skins and to dry bruises. High air speed is needed for a period of up to 1 week, until the skin of the upper onion layers in the bulk rustles. Excessive humidity in-store will lead to the development of roots and promote rotting while higher temperatures will result in sprouting and promote development of pathological disorders such as Botrytis rots (Thompson, 1982) Bulbs freeze below -3°C and a range of storage temperatures and relative humidities have been recommended for safe storage of onions (Table 5). Spring (green) onions store best at about 0°C and very high humidity (95%) (Table 6). The maximum length of storage under these conditions varies from just a few days to about 3 weeks.

Ventilation must be carefully applied inside the store to achieve the required temperature and humidity levels without inducing condensation of water on the surface.

Onion Storage at High-temperature

Onions can be stored at high temperatures of over 25°C at a range of relative humidities (75-85%) which is necessary for minimising water loss.
Storage at temperatures of 25-30°C has been shown to reduce sprouting and root growth compared to low-temperature storage (10-20°C). However, weight loss, desiccation of bulbs, and rots occurred at high temperatures, making the system uneconomic for long periods of storage that is required for successful onion marketing (Thompson et al., 1972; Stow, 1975). In tropical climates, high-temperature storage of onions can be achieved under both ambient and heated storage conditions. Under these conditions, ventilation must be carefully applied inside the store to achieve the required temperature and humidity levels.

'Direct Harvest' Storage

The need to cure onions can pose considerable challenges in situations where the climatic condition is unpredictable during the harvest period. To overcome these problems, the 'direct harvest system' has been developed and used extensively, particularly by growers in the UK, since the early 1980s. The bulbs are harvested while green, topped, loaded into store, dried and cured using well controlled ventilation system, and thereafter held in long-term low-temperature storage as required (Table 7). During stage I, removal of excessive surface moisture is achieved at high airflow rates, ignoring the rh of the air. Stage II is completed when the skins have been cured on the bulb. Adequate control of the storage condition at the various stages is critical to the success of this storage system in maintaining required bulb quality.

A is used in combination with coldstorage to extend the storage life of onions. Recommended air composition and temperature regimes are summarised in Table 8. Spring onions generally tolerate higher CO2 and O2 levels than bulb onions, and the levels of CO2 and O2 combination required varies depending on the storage temperature (Table 9). Commercial CA storage of onion bulbs is limited partly because of variable success and inconsistent effects on bulb quality. However, high carbon dioxide (0-5%) and low oxygen (1-3%) levels in combination with low temperature storage has been shown to reduce sprouting and root growth (SeaLand, 1991; Hardenburg et al., 1990). The combination of CA storage (5% CO2, 3% O2) and refrigerated storage (1°C) also resulted in 99% of the onion bulbs considered marketable after 7 months storage; however, 9% weight loss occurred (Smittle, 1989).

Onion response to CA storage varies among cultivars. Therefore, experiments should therefore be conducted under local conditions to determine the appropriate level of gas composition suitable for safe storage of local

cultivars. CA storage generally increases the pungency of characteristic cultivars. For the 'Viladia Sweets' which are known for their sweetness and low pungency, the recommended storage conditions are (Smittle, 1989): 1 °C, 70-80% rh, 3% O2, 5% CO2, 92% N2, and ventilation rate of 5.m3.h-1.m3 of onions.

2.7 Processing

Onion bulbs are generally chopped into desired sizes and shapes using a knife. Many commercial devices are also available for chopping onions. In some food preparations, the onions are blended with other ingredients to produce the desired flavour.