1. BACKGROUND

Potatoes are swollen shoots (tubers) normally found underground. These tubers are very rich in starch that serves as energy for a new plant that will develop from the buds (eyes) on the tuber. Being a shoot, the potato tuber will become green when exposed to light and in the process develop a bitter taste.

Potato tubers are very easily infected with soil borne viruses, bacteria and fungi. The high starch content makes it an ideal growing medium for especially bacteria and fungi while the viruses are transmitted to new land when planted.

Not all potatoes can be stored for any length of time. Storage potential is influenced by numerous factors such as cultivar, growing conditions, handling and curing procedures and very important, post harvest temperature and humidity storage and transport.

Warm ambient temperature conditions will result in sprouting (root and shoot growth). Colder temperatures trigger the conversion of storage starch to sugars and the potato acquire a sweet unpleasant taste. (See par 2.1 for lowest storage temperatures).

A low humidity in the storage atmosphere (generally below 85% RH) will cause weight loss due to desiccation resulting in quality deterioration. Too high humidity (normally above 95% RH) make the tubers very susceptible to bacterial and fungal decay. High humidity in the storage and transport atmosphere very easily forms free moisture on the potatoes, should the temperature drop slightly to below dew point.

Humid and moist conditions are extremely hazardous for potato storage and it is therefore of utmost importance to store and transport potatoes under very constant temperature and humidity conditions. This requires high rates of active air circulation around each and every potato in the batch or consignment.

Potatoes, like all fresh produce, are still living organisms until processed or consumed. It therefore develops large amounts of respiration heat that, when not removed, will result in huge temperature increases in the load even under refrigeration. The only way to prevent these so called “hot spots” is to circulate large volumes of air at the correct temperature and humidity through the total load, i.e. around each and every potato tuber.

Large amounts of oxygen are also used by the potatoes during the respiration process and plenty of carbon dioxide is released into the storage and transport atmosphere. Increased carbon dioxide in the atmosphere very quickly result in a brown to black discolouration (generally known as blackheart) of the inner tissue rendering it unsaleable. The only way to supply adequate oxygen and remove excess carbon dioxide to prevent quality loss, is to introduce sufficient fresh air into the circulating air inside the storage transport facilities.

The key words therefore to obtain the best storage and transport quality is to ensure most optimum preharvest and post harvest quality potential, sound handling procedures and above all, optimum temperature, optimum humidity and optimum storage atmosphere conditions. This can best be done by applying refrigeration, positive air circulation through the total load to introduce sufficient fresh air into the storage and transport atmosphere.

2. OPTIMAL SHIPPING CONDITIONS

The conditions set out in this document were found to give most optimum market quality for South African produced potatoes and for voyages in the order of 5 to 21 days. It must also be kept in mind that landing cost must be kept to minimum and that expensive modern equipment cannot always be used for a variety of reasons.
It is therefore important that both the exporter and especially the importer are well informed of the optimum requirements for specific conditions. PPECB will gladly assist packers, exporters, importers and shipping lines in their export venture and will share all available information.

Please don’t regard a potato as a tuber coming from the ground, and therefore resistant to bad handling. This can cause severe losses – even within one week of non-optimum transport conditions. Do not allow pressure to keep costs down to apply less than optimum handling and transport conditions.

Some buyers or import authorities may however require precooling, cold storage and refrigerated transport irrespective of the length of the voyage. Exporters must obtain detailed buyer’s specifications prior to entering into contracts to avoid disputes and refusal of payment.

2.1 Optimum temperature requirements

Potatoes must be shipped refrigerated if the voyage exceeds 10 days. Optimum storage period is determined by factors such as purpose of end use, potential keeping quality, age of the product and storage, handling and transport conditions.

2.1.1 Seed potatoes

Can be stored between 0,5°C and 2,0°C for extended periods provided initial good storage potential. Beware of freezing when storing close to 0,5°C and ensure adequate air circulation and optimum RH.

2.1.2 Table potatoes

Most optimum product temperature for long(er) term storage is 5,5°C. Storage period should never exceed 7 days when stored between 4,5°C and 5,5°C. Warmer temperatures of up to 12°C can also be used for shorter voyages.

2.1.3 Processing potatoes

Potatoes to be used for deep frying (french fries or chips) or for other products must be stored between 12°C and 15°C.

Notes

1. Exporters must confirm required product temperature with the buyer prior to dispatch because some importing countries and even buyers will state “refrigerated transport” but will refuse payment if the consignment does arrive at a specific temperature (unknown to the exporter).

2. Exporters and buyers must realise that refrigerated storage and transport cannot guarantee a 100% outturn only because it was passed for export by the PPECB. Product quality is determined by many pre and post harvest conditions especially the “age” of the potato between lifting and marketing. Non optimal preshipment conditions will negatively affect market quality.

2.2 Optimum humidity requirements

Maximum RH : 95% with very stable temperature control.

Minimum RH : 80% for short periods only to prevent weight loss and desiccation.

Optimum RH : 90 ± 5% with adequate air circulation as applied in most refrigerated conventional shipping decks and marine containers.
Notes

1. Potatoes must always be kept dry and no condensation must be allowed. Even a microscopic film of moisture may result in decay.

2. **Humidity** below 80% may result in weight loss in excess of 200g per 25kg potatoes within one day resulting in the potatoes being rejected for not complying with minimum mass specification.

3. Adequate ventilation and fresh air must be supplied at all times (see par 3) to ensure even moisture distribution through the total load.

2.3 Packaging requirements

**Craft paper bags** absorb moisture from the atmosphere and lose strength in the process. It eventually disintegrates due to any cargo movement or when handled during off loading. It is therefore recommended to use two or three ply bags. **It is not recommended to use paper bag packaging** if the total time of the potatoes in a closed environment (deck or container) exceeds 10 days.

**Knitted jute or polypropylene bags** must be used for journeys exceeding 10 days. Potatoes are sometimes handled overseas in 1000kg bulk sling bags. This concept is not used in South Africa for potatoes and needs testing before commercial application, because high incidences of bruising were reported.

Palletisation of the bagged potatoes is highly recommended in all cases. The pallet allows for unitised handling and allows for bottom air circulation.

Exporters must confirm with the buyers on the size and mass of the bags required. This must also be checked with the RSA Directorate of Plant Quality Control to ensure that the proposed bag complies with South African nett mass specifications. Dispensations to deviate from the South African specifications must be requested well in advance to avoid last minute rejections.

3. SHIPPING METHODS

The following procedures and specifications were developed over the past 25 years or more. It is based on voyages between 5 days up to 3 weeks. It must be stated that these procedures are minimum requirements to ensure minimum risk and quality loss. It must also be kept in mind that **PPECB approval for export is based on the quality at time of inspection and does not imply that the product will arrive at the customer in the same condition.**

Potatoes can be shipped in a number of different ways depending the type and availability of shipping space, transshipment and final destination as well as requirements stipulated by the authorities of the importing country and the buyer. ([Please refer to PPECB HP19, Handling Procedure](#))

Very often exporters and buyers want to keep total costs to the absolute minimum by avoiding refrigerated transport. Although not always necessary, storage and transport under temperature controlled conditions can reduce quality losses substantially.

The following shipping methods are available:

3.1 Conventional decks – all destinations

- **Cleanliness:** Decks must be absolutely free from any odour, taint or traces of any other chemical product.
PROCEDURE OF POTATOES FOR SEA FREIGHT

- **Air circulations**: Optimum air circulation is a minimum of 60 and preferably 90 air changes per hour based on the empty volume of the deck.

- **Fresh air intake**: The standard specifications are at least two complete air replacements per 24 hours based on the empty volume of the deck. It is also extremely important to maintain the carbon dioxide (CO$_2$) concentration in the atmosphere below 0.5%.

- **Precooling**: The potatoes must be precooled to within 2°C from the carrying temperature. Utmost care must be exercised to minimise condensation because any free water will affect potato quality and may damage the packing material.

- **Loading**: The packed potatoes must be palletised and loaded to ensure maximum bottom to top air circulation through the total load. Pallets must be stacked tight and airbags used in all openings between pallets.

- **Temperature**: Refrigeration must be maintained within ± 0.5°C from the specified carrying temperature. Accurate temperature logs must be kept by the Master.

- **Deviations**: The following two deviations may be considered:
  1. **Direct loading**, i.e., loading unprecooled potatoes into conventional decks may be considered under certain – special conditions. Prior approval and proper planning is essential.
  2. **Ventilated shipments**, i.e., shipping without any cooling – see par 3.3.4

3.2 **Integral refrigerated containers – All destinations**

Integral refrigerated containers, or also known as reefer or integral containers, are fitted with a cooling unit that is powered by an external electric power supply. Integral containers are designed and built to carry product at a specified temperature and not to function as a mobile cold store to precool warm products.

The following requirements were developed over a number of years and must be applied to ensure minimum quality losses:

3.2.1 **Precooling of the product** to within 1°C from the container temperature set point (specified carrying temperature) is essential. Warm loading results in hot spots in the center of pallets and towards the door end of the container.

3.2.2 **Precooling** must be applied within two hours from removing the potatoes from the cold store. This means that an external electric power supply (Genset) must be provided if transport time to the port exceeds two (2) hours.

3.2.3 **Air circulation** rate should be a minimum of 60 complete air changes per hour based on the empty volume of the container. Air circulation rates of 90 or more per hour may be required when the potatoes are packed in densely knitted bags.

3.2.4 **Fresh air intake** rate should not be less than two complete fresh air changes per 24 hours based on the empty volume of the container. This normally requires a vent setting of approximately 15% and must be set at the container depot before the container is released for loading.

3.3 **Ventilated shipments – certain destinations only**

Ventilated shipments allowed for voyages less than 10 sailing days and mean that no refrigeration is applied and that ambient air is ventilated actively (or passively) over the product. This means that no temperature or humidity control is applied. At present there are four different methods to apply ventilation during the voyage. These are:
3.3.1 Conventional decks

Air is circulated, usually by very large extraction fans, at a rate of at least 90 and up to 120 times the empty deck volume of air per hour. This very high air circulation rate is essential to avoid heat build up in the load but it may also result in excessive moisture loss (desiccation) from the product.

It is important that sufficient fresh air is introduced to maintain the CO\textsubscript{2} concentration below 0.5% in the decks and other service areas. A minimum of two complete fresh air changes based on the empty volume of the total deck per 24 hours is required.

The following conditions must be followed and adhered to:

- Craft paper bags cannot be used if the voyage is longer than 10 days. It is recommended to use knitted jute or polypropylene bags, due to better ventilation.
- Palletisation of bagged potatoes is highly recommended.
- Pallets must be properly strapped and not higher than 2 meters.
- If decks allow for a two pallet high stow, then flat dunnage must be used between the pallets, in order to distribute weight. This is not recommended due to the possibility of injury to product or damage of packaging material.
- If pockets are stowed loose and higher than 9 high, then a dunnage break, supported with airbags and walking boards above 9 must be used. A maximum of 14 pockets high will be allowed, when stowed loose.

3.3.2 Ventainers or Fantainers

These containers are fitted with an air extraction fan continuously circulating fresh air over and through the product. There is a number of different designs available ranging from permanently fixed fans to loose non-returnable types. The correct cables and plugs must be fitted. Fans must also operate correctly, to ensure that fresh air is circulating through the load.

There are no detailed specifications available for potatoes but it can be stated that the fan must move sufficient air through the load to prevent hot spots and to maintain the RH inside the container at ambient RH.

Aspects to be considered when using actively ventilated containers:

- The product must be as fresh as possible to withstand the voyage without sprouting, excessive weight loss and minimum decay.
- Fan- or Ventainers should not be used for voyages more than 14 days. Total storage time in these containers must not exceed 18 days.
- Craft paper bags should not be used because the paper may absorb too much moisture and may disintegrate when handled afterwards.
- Sufficient air spaces must be allowed for air circulation. The potatoes must be loaded onto pallets (bottom air plenum) and at least 150mm space must be left between the top of the load and the ceiling.
- Container Terminal Order (CTO) must clearly indicate that ventainers/fantainers must be stacked at plug in facilities in Portnet terminals.
- No voyage conditions are available making it impossible to evaluate and explain quality losses or to substantiate insurance claims.

3.3.3 Open door containers (Voyage 10 days or less)
This concept is not recommended but sometimes used when no other equipment is available. Special loading conditions shall apply according to destination, customer requirement etc.

One of the major problems on vessels and in Portnet stacks is that the doors cannot always be kept open resulting in no fresh air circulation through the load. The other problem is that water (rain or sea) can enter the container rendering the contents unsaleable. Therefore these containers must be loaded as close as possible to vessel's departure time.

Please consult with the relevant PPECB Area office prior to making arrangements for open door shipments to avoid problems during loading and the voyage.

3.3.4 Open side containers (Voyage 10 days or less)

This container has one or both sides replaced with steel reinforcement and heavy diamond mesh wire. This concept is much better than open doors and allows for plenty of fresh air circulation.

Tarpaulins must however be fitted and rolled down during bad weather. If this is not done, rain or seawater may enter into the container. In this case the product must be rejected and presented to PPECB for a re-inspection.

Special loading procedures must be followed depending on factors such as time of the year, total time in the container and type of vessel. Please consult with your local PPECB Area office to ensure best procedures being followed.

3.3.5 Ventilated container (Voyage 10 - days or less)

This type of container is fitted with ventilation slots in the bottom and top of the "long sides". Ventilation is therefore only by convection and also only along the sides of the container and not through the load.

(These containers are used for dry cargo such as coffee beans and may be on offer for a return voyage hence the lower freight rate.)

Ventilated containers cannot be used for fresh produce.

4 COMPROMISE TEMPERATURES AND PRODUCT MIXES

The nature of the South African potato export industry many a time calls for mixed container loads. These mixed loads also vary widely making it impossible to make firm recommendations. The following general guidelines can be given:

4.1 Temperature compromise

In general it can be stated that table potatoes can be shipped between 4,5°C and 12°C. The most commercially used temperature however is between 8°C and 10°C for destinations such as West Africa and the Indian Ocean Islands.

Should it be absolutely necessary to mix other cargo with potatoes, the type of product(s) and relevant volumes must be considered when a temperature is stipulated.

4.2 Taints and cross tainting

Potatoes can severely taint other products such as eggs, dairy products and other fresh fruit and vegetables that are consumed fresh.

PPECB does not recommend mixed loads but the following products were mixed with potatoes in the past on special request by buyers:
Citrus fruit - all varieties
Onions - long and short day varieties
Eggs oiled - severe taint risk
Cheese - only certain types vacuum packed
Chocolate - for cooking purposes only
Avocados - carrying at 5.5°C
Mangoes - carrying at 8.0°C
Pineapples - carrying at 10°C

Exporters must consult with their nearest PPECB Area Office should they want to ship potatoes with any other product or cargo.