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A photograph of several cauliflower heads in a white foam tray, resting on a green surface. The cauliflower heads are white with green leaves. The text is overlaid on the image.

Post-harvest management of cauliflower for quality and safety assurance

***Guidance for horticultural
supply chain stakeholders***

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Guidance for horticultural supply chain stakeholders

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INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*) is a cash crop and the number one vegetable crop in terms of production and value in Nepal. The popularity and high consumer demand for cauliflower stem from its nutritional quality and health benefits. Cauliflower contains high levels of Vitamins C and B, calcium (Ca), Iron (Fe) and phosphorus (P) and is known to have health promoting benefits.

Cauliflower of good quality is sturdy and crisp; the curd void of brown spots and other discolorations. As specified in the Cauliflower Standard developed by the Federation of Fruit and Vegetable Entrepreneurs Nepal, good quality cauliflower must meet the following minimum quality specifications:

- ✓ Compact, with a white curd
- ✓ Fresh, clean
- ✓ Free from riciness and separation of clusters
- ✓ Well-trimmed with a maximum of four wrapper leaves
- ✓ With a 10 mm stem
- ✓ Free from cuts or bruises and rots of any sort
- ✓ No damage from insects or other pests
- ✓ There must be no foreign matter, absolutely no animal matter or compost, no stones, leaves, weeds, lumps of soil, wood, plastic, or metal
- ✓ No strange smells or tastes



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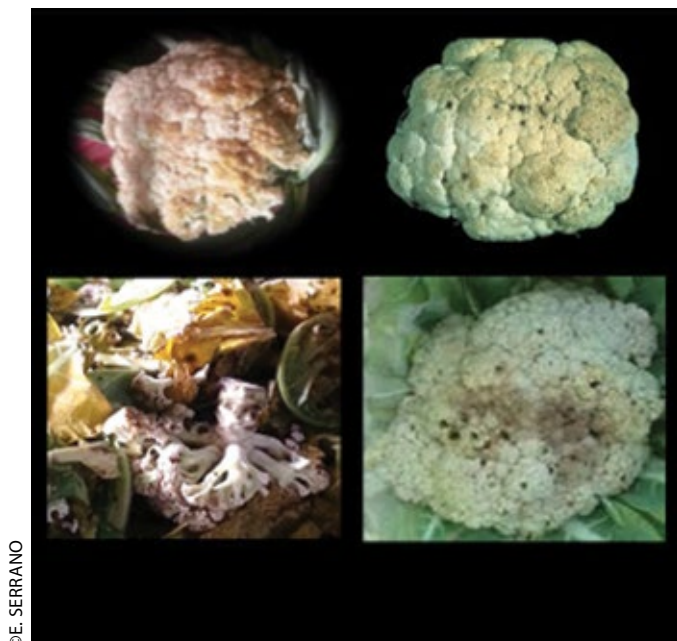
A good quality cauliflower curd

IMPORTANCE OF POST-HARVEST HANDLING

Post-harvest handling includes all the primary processes/steps – like raw material handling, storage, transport, distribution, marketing – that the harvested crop has to go through to get from the producer to the end consumer. Such processes add value to the harvested produce. Post-harvest handling is an element of post-harvest science and technology the goals of which are to reduce losses, maintain the fresh quality, as well as, assure the safety of crop commodities used as food and to meet buyers' specifications and trade requirements.

It has been shown that post-harvest handling is the weakest link in the production-marketing continuum for agricultural produce. Much is lost, both in terms of quantity and quality (including nutritional quality) during post-harvest handling, with fruits and vegetables incurring high losses due to their perishable nature. Post-harvest losses in cauliflower grown in Nepal have been reported most recently (2014) to range between 3–25 percent after transporting to the wholesale market and 5–25 percent during storage/retail marketing. Previous (2002) loss data was reported at 10–15 percent.

Post-harvest handling-related defects of cauliflower are cause of rejection by consumers



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Forms of rejects in cauliflower making the curds unmarketable (considered post-harvest loss)

The major causes of losses in the cauliflower supply chain have been attributed to the following:

- ◆ Pre-harvest factors neglected (non-compliance to Good Agricultural Practices or GAP).
- ◆ Harvesting at an improper stage of maturity.
- ◆ Direct packing, field heat is not removed by pre-cooling techniques.
- ◆ Inadequate cleaning, sorting.
- ◆ GHPH/GMP adopted by few export sectors.
- ◆ Insufficient grading and sorting.
- ◆ Improper packing.
- ◆ Poor transportation and handling.
- ◆ Poor storage facility (cool chambers, safe location).

Reducing these losses is best done through application of post-harvest technologies and through improvement of the post-harvest system.

Characteristics of cauliflower

The cauliflower curd or head is an immature flower bud consisting of many florets. As such, the curd when allowed to mature will exhibit 'riciness' with the appearance of tiny black specks typical of florets undergoing opening. 'Riciness' in cauliflower is a sign of over-maturity and poor quality.



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As an immature bud, the curd is very sensitive to even a slight applied physical force resulting in unsightly brown abrasion or compression damages.

The cauliflower curd is sensitive to ethylene. Ethylene is a naturally-emitted gaseous compound by all plant tissues; it causes senescence; it enhances deteriorative changes to commodities exposed to it.

The cauliflower curd contains almost 90 percent water, hence, it has the tendency to lose moisture (moisture loss) in the process of transpiration or evaporation. Moisture loss in cauliflower curd is high because it is not protected by a hard and waxy skin. High temperatures of the outside environment coupled with low relative humidity (RH) increase the rate of moisture loss from the curd resulting in loss of crispiness and consequently browning.

The cauliflower curd contains a large number of nutrients, which are also a source of food to some disease-causing microorganisms, that utilize it for their growth and multiplication. When attacked by these organisms, the curd develops disease making it unfit for human consumption.

HARVEST MANAGEMENT PRACTICES

Harvesting is the process of severing/removing the curd from the mother cauliflower plant. There are three important considerations to bear in mind during harvesting:

Harvesting index

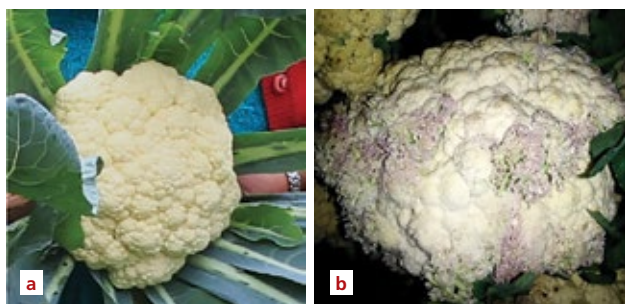
Signs or indications that the cauliflower curd has attained desirable characteristics intended for its use

The cauliflower must be harvested when it has reached the desired curd size (which is a characteristic of the variety) and the right stage for its intended use and so as to meet consumers' demand for quality, in this case, as a vegetable which should be tender and crisp. Cauliflower curd exhibiting 'riciness' indicates over-maturity which does not meet the standard of quality.

Time of harvesting

Time of day appropriate to harvest the curd of cauliflower

Many crops are harvested very early in the morning to take advantage of the cool temperature. However, for cauliflower, the appropriate time to harvest is late morning to early afternoon. There is a need to allow the excessive moisture inside the curd to evaporate quickly (which occurs at higher atmospheric temperature) for the curd to be a little bit wilted or flaccid in order to minimize physical injury/damage during harvesting.



Cauliflower harvested at the right maturity (a)
over-mature at harvest (b).

Method of harvesting, use of harvesting tools and harvest containers

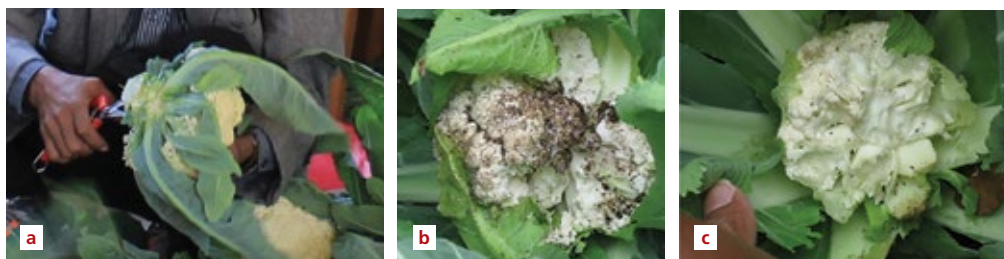
The manner of detachment of the curd and pooling of harvested curds

During manual harvesting, a cutting tool (such a scythe) is used to detach the cauliflower from curd. The curd should not be touched by the hand or by the cutting tool in order to minimize any physical damage to it. In many countries, the curd is harvested by cutting the stem with about 6 to 8 leaves still attached. The harvested curds are directly placed inside collection baskets with liners or in a plastic crate to be hauled to the collection center/area. The attached leaves protect the curd from physical damage during hauling.



POST-HARVEST HANDLING OPERATIONS

Post-harvest handling operations are activities that prepare the harvested produce like the cauliflower, for marketing that will meet the requirements of the target market. Handling operations can be done in the field, in collection centres or in a pack-house. The packing area should be well-protected from the sun and rain, kept clean at all times and must be enclosed to prevent entry of animals/pets that might contaminate the curds with pathogenic organisms from their faeces and urine. Similarly, workers who handle fresh produce should maintain a high degree of personal hygiene and where appropriate, should wear suitable protective clothing and head covering.



Forms of rejects culled during field sorting: diseased (a), insect damaged (b), rat damaged (c).

Green Meadows Community Garden. 2012. Retrieved from <http://greenmeadowscommunitygarden.blogspot.com/2012/11/cauliflower-and-who-is-eating-it.html>

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Field sorting

Culling out produce that are unmarketable in the field to lower the cost of hauling and to minimize disease contamination.

Field sorting of cauliflower curds should be done on farm to cull out unmarketable curds such as those that are diseased, insect-infested or rat-damaged. Performing this operation in the field will also minimize hauling cost.

Trimming

The removal of unwanted parts which may otherwise make the cauliflower curd unappealing to consumers or may cause the curd to deteriorate rapidly.

The field sorted cauliflower curds that reach the pack-house or collection center should be trimmed of excessively long stems as well as the leaves that are still attached to the stem. Based on the Cauliflower Standard set by the Federation of Fruit and Vegetable Entrepreneurs Nepal, "the cauliflower head or curd should be well trimmed with 10 mm stem and a maximum of four wrapper leaves". Based on studies, the attached leaves are the ones that deteriorate first during marketing and storage. This enhances deterioration of the curd as well, since the curd is very sensitive to the ethylene that is evolved by the senescing /deteriorating leaves.

Sorting/grading

Classifying the curds according to certain standard criteria.

Cauliflower curds should be sorted and classified based on certain standards of quality. The quality standard may be institutionalized nationally (e.g. Nepal National Standard for Cauliflower) or established by a private sector entity like the Federation of Fruit and Vegetable Entrepreneurs Nepal. According to the Nepal National Standard, cauliflower curds may be classified as: either Premium Grade, Grade 1 or Grade 2.



Sorting and grading must be done in a packing area equipped with sorting tables, weighing scales or a sorting device. Grading must be done in a location that is done well-lit. The work place must be compliant for the safety and welfare of the sorters/classifiers.

CAULIFLOWER			
Characteristic	Premium Grade	Grade 1	Grade 2
Weight (g)	500 g-1.5 kg	1.5 kg-2.5 kg	Less than 500 g or more than 2.5 kg
Color defects: Maximum % by weight	White or Creamy White only	5%	10%
Wrapper leaves: Maximum number: Length of Stem: Maximum	4 10 mm	4 10 mm	4 10 mm
Cleanliness required:	100%	100%	100%
Freshness required:	100% Fresh, no wilted leaves or curd	Very slightly wilted leaves permitted. Curd firm.	Slightly wilted leaves and curd permitted.
Bruise/cuts: Maximum % weight	5%	10%	15%
Insect damage: Maximum % weight	0%	2%	5%
Total defects: Maximum % by weight	5%	10%	15%
Pack Size:	10 kg crate with paper lining	15 kg crate	20 kg plastic bag

PACKAGING

Bulk packaging is probably one of the weakest links in the post-harvest chain. Losses and quality defects that result from inappropriate use of bulk packaging materials include: bruising, wounding (cut, puncture, crack, split, breakage), distortion, compression damage and abrasion. The extent of this damage increases when the packages are: either under-filled, over-filled or if the packaging material has rough surfaces, and when the packages are dropped during handling.

Packaging materials

The packaging materials commercially available in Nepal for use in handling and transporting fresh produce like cauliflower include: bamboo baskets or 'duko', wooden crate, returnable and stackable plastic crates, polyethylene or polypropylene plastic bags, sacks made from plastic twine, and cardboard box/cartons. With the exception of plastic crates, these packaging materials are commonly used because of their low cost and widespread availability, but in most cases, they are used inappropriately (overfilling, incompatibility with the nature of produce) especially in hauling and in transporting fresh produce from the farm. Although the plastic crate is the packaging material that is most cost-effective (due to the long time over which it can be used) and the high level of protection against mechanical damage, it is not popular and is not commonly used because of its high cost. Carton boxes are mainly for export but used carton



A sorting table used to sort produce.



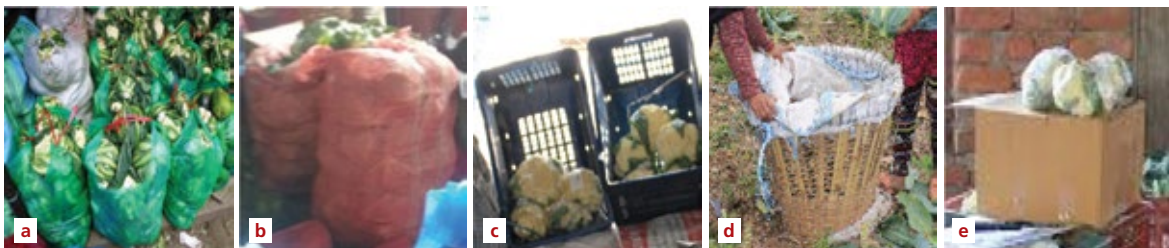
Bad practice during sorting and grading.

boxes find their way in the packaging fresh produce for local marketing. Used carton boxes have very low resistance to compressive load, thus, compression damage is high in this kind of packaging material.

Based on studies, the best container for cauliflower curds is the plastic crate because of its smooth inside finish, ease of cleaning and the fact that it can be used over a long period (10 yrs maximum). For best results, the layers of curds inside the plastic crate should be lined with plastic sheet liners so as to minimize abrasion damage to the curds during transit.

When using plastic crates as container, the following considerations should be borne in mind:

- ◆ Hygiene – plastic crates should be thoroughly cleaned with soap/detergent and then sanitized by dipping in a sanitizer such as sodium hypochlorite to reduce the microbial load on the crate.
- ◆ Handling – handle with care during loading, stacking and unloading; do not drop. Do not use as seats when sorting.
- ◆ Storage – store in a clean area that will prevent insects and rodents harbouring the crate or storage area. Store the crates separately from chemicals and farm machinery to prevent contamination. Crates should not be left exposed to the external environment since they will readily wear out. Do not use as a storage or transport container for chemicals (fertilizers and pesticides)



Packaging materials used to transport cauliflower curds: plastic bag (a), mesh bag (b), plastic crate (c), bamboo basket (d), carton box (e).



Cauliflower curds are best contained in clean and undamaged plastic crate (a). Damaged plastic crate (b) should not be used especially during transport.

TRANSPORT

Transport is key in the distribution of fruits and vegetables. Because of their inherent perishable nature, fruits and vegetables must reach the destination market in short period of time, necessitating rapid and reliable transport systems. Transport systems that are used to haul cauliflower from farm to collection center, from collection center to wholesale market and to retail markets. Losses incurred during transport are a complex problem not directly related to the transport vehicle, but affected by the length of the trip, number of loading and unloading points, road quality, temperature of the environment and availability of handling aids.

For the cauliflower curds to arrive at their destination in good condition, proper transport practices should be observed:

- ◆ Handle containers of produce gently during loading and unloading; they should not be dropped or thrown on to each other.
- ◆ Do not sit on top of packages of cauliflower during transport.
- ◆ Do not use containers at the bottom of the stack as steps to allow stacking to a greater height especially if semi-rigid containers like cartons are used.
- ◆ Do not expose packages of cauliflower curds to the sun during transport.
- ◆ Allow air to circulate in the stacks or piles of produce by providing space in between stacks. If canvass is used as cover, provide space for air to pass through at the bottom and top of stack; use light colored material as cover as this will reflect heat.
- ◆ Minimize delays or facilitate the transfer of packaged produce from one part of the market to another; four-wheeled hand trolleys will minimize damage during unloading and the transfer of produce packed in plastic crates.
- ◆ Ensure that the transport vehicle is clean at all times; produce safety is compromised when:
 - there are decaying remains of produce from the previous load;
 - insects and rodents nesting in the vehicles;
 - the vehicle is used as a storage area of farm implements and chemicals;
 - the transport vehicle was used to transport organic fertilizers.





Transport vehicle with light-colored cover absorbs less heat.



Plastic crate is the best container used in transporting commodities.



A two-wheeled hand trolley

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HANDLING AT WHOLESALE AND RETAIL MARKETS

Cauliflower is usually marketed by farmers or traders in wholesale and retail markets. Upon arrival at these distribution channels, certain basic rules should be followed to maintain the freshness and quality of the curds:

- ◆ Containers must be carefully unloaded from the transport vehicle to the marketing area or under a shaded area.
- ◆ Depending on the target market or buyer, re-sort or re-grade the curds and discard culls properly.
- ◆ Do not place the packages of cauliflower curds in dirty areas in the wholesale market to minimize microbial contamination.
- ◆ In the retail market, cauliflower curds are best sold in retail packs since this prevents damage due to frequent handling by customers when they select the curds. If the curds are not packaged in retail packs (exposed), they should be displayed in a place that is well protected from the sun and other hazardous contaminants.



a



b

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