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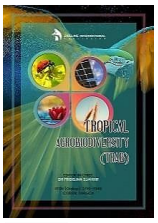

RESEARCH ARTICLE

POST-HARVEST COMMODITY PROFILE OF COLE CROPS: A REVIEW

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ABSTRACT

Cole crops are cool-season vegetables that are rich in minerals and vitamins. Post-harvest loss in the different commodities including cole crops is due to inappropriate handling, harvesting, lack of storage, transportation, and other preservation technology. The study for the topic "Post-Harvest Commodity Profile of Cole crops" is based on secondary data where relevant information is collected from different published articles, books, journals, documents, and other relevant publications. Under topic-wise discussion, maturity indices, harvesting methods, pre-cooling, transportation, storage technique, different packaging practices with value addition technologies, and marketing of cole crops are studied. The adoption of appropriate post-harvest management practices like harvesting at the right stage, and with the appropriate methods, proper field level cleaning, sorting, grading, proper packaging, and transportation contributes to the reduction of post-harvest loss under smart marketing.

KEYWORDS

Cole crops, Commodity, Post-harvest

1. INTRODUCTION

A legal instrument is a term of art that refers to any formally executed Cole crops are the group of vegetables belonging to the mustard family i.e. Cruciferae or Brassicaceae. From the word "caulis", the word cole crops were introduced, meaning the stem or stalk of the plant. It includes vegetables like cauliflower, cabbage, broccoli, brussels sprout, kale, kohlrabi, etc. Many of the vegetables come under it, which originated from a similar parent "Colewart" or wild cabbage. Cole crops are grown in the cool season and require 60-70°F for better growth and development. They can resist mild frost without bearing chilling injury (Sprouts, n.d.). They are rich in minerals and a good source of Vitamin C. Based on nutrient content they are a rich and good source of Vitamin A, Vitamin C, potassium, calcium, phosphorous, folate, etc. (Crops et al., n.d.). Cole crops are grown on the soil which fulfills the water requirement all around the season. Soils with well-drained, sandy loam and loamy clay are better suited for cole crop cultivation. They are the most grown and economically important vegetable crop grown with high consumption.

Different parts of different vegetables are used for consumption like a curd of cauliflower, head of cabbage, knobs or tubers of knolkhol, green leaves of kale, the enlarged axillary bud of brussels sprout, etc. Among the Cole crops, cauliflower is the most important crop grown throughout the country. In Nepal, cauliflower is cultivated in 35,764 hectares of land with an annual production of 574,795 Mt and yields 16.07 Mt/ha (MOALD, 2020). Similarly, cabbage is cultivated in 30,331 hectares with an annual production of 519,061 Mt and yields 17.11 Mt/ha (MOALD, 2020). Broccoli is cultivated in an area of 2,565 hectares with the production of 28,838 Mt and yields 11.24 Mt/ha (MOALD, 2020). The total area, production and productivity of vegetable crops are 2,44,102 ha; 32,03,563 mt and 10.84 mt/ha respectively (VDD, 2011).

Post-harvest technology is a set of procedures and applications for preserving the quality of agricultural goods from harvest to consumption. It refers to the use of science and technology in the management of food products, such as harvesting, grading, sorting, packing, transportation, storage, processing, product creation, preservation, and marketing. The problem of post-harvest is more in under developing and developing countries like Nepal. The losses are more in post-harvesting due to inappropriate handling, harvesting, lack of storage, lack of transport facility, and other preservation technology. A different study in Nepal shows that the post-harvest loss in Nepal is about 20-50%. The estimated loss of cabbage and cauliflower is 7.08-25% (Barche and Kirad, 2010a). Different factors are responsible for post-harvest loss however, improper harvesting, handling, packaging, lack of basic equipment, facilities, and low-level technology aids a great role in it.

Table 1: Post-harvest loss of some vegetables

Name of Vegetables	Post-Harvest Loss (%)
Tomato	10-20
Potato	15-20
Cauliflower	10-15
Cabbage	7-15
Brinjal	10-13
Onion	15-30
Garlic	1-3
Peas and Beans	7-12

(Glaustas, 2014)

The post-harvest loss of cauliflower and cabbage in Nepal according to a study is about 2.19% and 13.65% respectively (Singh, 2019). Different pre-harvest factors determine the extent of post-harvest quality of fruits and vegetables like production area, types of soil, irrigation, nutrition, etc. Monselise and Goren classified the pre-harvest factor into primary and secondary factors (Monselise and Goren, 1987). On the post-harvest

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quality of fruits and vegetables, different pre-harvest factors influence radiation, temperature, irrigation, relative humidity, nutrition, plant growth hormone (PGR), harvest maturity, etc. According to FAO analysis, worldwide quantities of lost and discarded food are larger in the downstream phase of the food chain in high-income countries, while the converse is true in low-income regions, where more food is lost and wasted (Jan et al., 2011).

2. Methodology

The study for the post-harvest commodity profile of cole crops is based on secondary information where relevant information is collected from different published articles, journals, documents, and other relevant publications. Different author books are also used as a reference which is available at the campus library. Similarly, different web pages are also used for exploring the necessary and valid information.

3. Topic-Wise Discussion

3.1 Maturity Indices

Maturity indices are an indicator which aids helps to know the commodity ready for harvest. It is used to know the date of harvest. Perishable commodity after harvest has a significant effect on the storage life and quality as well as handling, transporting, and finally, the marketing of the harvest produced. Cole crops should be harvested with caution after determining the correct maturity level and quality at the proper time. Premature harvest results in poor quality and deterioration at a faster rate than handling at the proper stage of maturity. Overripe commodities are more susceptible to mechanical damage, pest, and disease (Gautam et al., 2020).

Table 2: Maturity indices of Cole crops

S.N.	Commodity	Maturity Indices
1.	Cauliflower	Curd Compact surrounded by turgid green leaves, Clear white, Curds at least 15 cm in diameter (Mitcham et al., n.d.).
2.	Cabbage	Head Compact, firmness, Solidity, tender
3.	Broccoli	Bud Cluster Compact (Barche and Kirad, 2010b)
4.	Brussels Sprout	Buds are firm, over-mature results splitting of outer leaves ("Brussels Sprouts," 2008)
5.	Kohlrabi/ Knol Khol	The edible portion is tender and non-fibrous (Thompson and Kelly, n.d.)
6.	Chinese Cabbage	Heads are fully developed (Thompson and Kelly, n.d.)

Hence, harvesting should be done at the proper stage of maturity because it not only determines the quality but also prolongs the shelf-life of the commodity.

3.2 Harvesting Method

It is a straightforward process that involves removing the matured commodity from the parent plant and placing it in containers for transport from the cultivated field to the market. The entire or a portion of the growth of the vegetables can be harvested by hand or with the help of a sharp knife/scythe. The knives should be cleaned and disinfected to prevent the disease from spreading from plant to plant. The best time for harvesting is during the cooler period of the day i.e. either early in the morning or late evening when the field heat is lower. The harvested produce should be transported to a local market during the cooler night hours when harvesting is done in the late afternoon (Thompson, 2004). It is also advisable to prevent harvest when the field is wet or when it is raining. It is cheaper to keep the harvested commodity at the cooler hour of the day rather than to cool it when its temperature rises (López Camelo & Food and Agriculture Organization of the United Nations., 2004). Several post-harvest losses result due to improper picking and harvesting. During harvesting, consideration should be made on avoiding extreme temperature, minimizing mechanical injuries and contact with the soil, harvesting during dry weather, and avoiding keeping the harvested commodity in the clamp.

Table 3: Harvesting Method of Cole crops

S.N.	Commodity	Harvesting Method
1.	Cauliflower	Cutting off well below the curd leaving 6 to 8 leaves is recommended so that it protects the curd from physical damage during hauling (Serrano and Rolle, 2018).
2.	Cabbage	While harvesting, the head is tilted to one side, and stalk is cut above the ground with a sharp knife, and large leaves are trimmed away leaving sufficient jacket leaves to protect the head from bruising, and another mechanical in during transportation. After harvesting, it should be kept in the shade for cleaning, grading, and packaging.
3.	Broccoli	Cutting/removing central head along with 10-15 cm long fleshy stem when head attains proper size (Mitcham et al., n.d.).
4.	Brussels Sprout	Early sprouts are harvested several times, the lowest on the plant being taken each time, usually in 3 to 3.5 months (Thompson and Kelly, n.d.).
5.	Kohlrabi/ Knol Khol	Roots are cut off and plants are tied together in bunches Knobs are harvested with a sharp knife, foliage is kept with harvesting (Thompson and Kelly, n.d.; Jauron, n.d.)
5.	Chinese Cabbage	Heads are cut from the stalk in the same way as done in cabbage and cauliflower (Thompson and Kelly, n.d.)

3.3 Pre-Cooling

Harvested cole crops must be pre-cooled to remove excessive field heat. At the harvesting stage, the field is generally high and unwanted, and it should be cleared as soon as possible before any post-harvest handling activities. Pre-cooling slows ripening pace, water loss, and degradation maintaining quality and prolonging the shelf life of harvested horticultural items. It also reduces microbial activity, metabolic activity, respiration rate, and ethylene generation. Within 4 hours after harvest, cole crops are pre-cooled to eliminate field heat of less than 2°C. Several methods and techniques of pre-cooling are available, primarily to meet the requirement of large producers and markets (Kienholz and Edeogu, 2002). Room cooling forced air cooling, hydro cooling, vacuum cooling, and other pre-cooling procedures are some pre-cooling techniques. Room cooling is a low-cost, gradual cooling process that involves loading produce into an insulated cool room and allowing cold air to flow through the cartoons, bags, bins, or bulk loads.

It is mostly useful for small quantities of produce or product which do not deteriorate fast (Kienholz and Edeogu, 2002). Forced air cooling is the quickest method of pre-cooling since it draws hot air or pushes cold air through the vents/holes in storage containers. Hydro cooling, or the use of

cool water to swiftly cool a variety of fruits and vegetables before packaging, is an old and effective chilling technology. For cole crop vegetables, the most popular and successful pre-cooling method is forced air cooling, which takes 2-6 hours to cool the commodities (Kahn et al., 2017). The swiftly decreasing the temperature of the food by drawing cold air through it in vented containers, bins, crates, or packages-usually on pallets. The fundamental benefit of forced air cooling is that it is simple to utilize and integrate into grading, packaging, and storage processes.

Table 4: Pre-cooling of Cole crops

S.N.	Commodity	Pre-Cooling
1.	Cauliflower	• Hydro cooling (most desirable), forced air cooling, Hydro vacuum cooling • Cooled Below 5°C (Kahn et al., 2017)
2.	Cabbage	• Forced air, Room cooling can also be suitable • Cooled close to 0°C soon after harvest if harvested under warm conditions. (Kahn et al., 2017)
3.	Broccoli	• Hydro-vacuum cooling is fast and energy-efficient, forced air and hydro-cooling can also be used. • Cooled below 5°C as soon as possible if harvested under warm conditions. (Kahn et al., 2017)
4.	Brussels Sprout	• Hydro- cooling, Top icing, Vacuum cooling
5.	Kohlrabi/ Knol Khol	• Hydro-vacuum cooling
6.	Chinese Cabbage	• Hydro-cooling, Top icing, Vacuum cooling

3.4 Transportation Technique

Transportation is an important part of product marketing. This is especially true since, despite a local environment that may not allow year-round production, consumers today want year-round access to their favorite fruits and vegetables (Govindasamy, R., n.d.). Trucks and buses are commonly used to carry cole crops (cauliflower, cabbage, broccoli). The packages should not be disturbed during shipment and should remain firmly in place, transporting goods to distant marketplaces is easier at night. It is critical to handle the goods with care, and they should arrive in the main market in the morning to allow for early promotion. Master Plan for Horticulture Development (MPHD 1991) reported 35% losses on apples due to improper transport techniques from Marpha to Pokhara, Nepal. Physical loss of about 22.5% in tomatoes, 15.84% in cabbage, and 12.85% in cabbage is reported from the research of FAO, in terai (Werner and Subedi, 1991).

3.5 Storage Techniques

A fruit or vegetable's storage shelf life is determined by its original quality, storage stability, external circumstances, and handling techniques. A commodity's shelf life can be extended by keeping it at the right temperature, relative humidity (RH), and environmental conditions, as well as using chemical preservatives or even irrigating it (Shewfelt, n.d.). The principle of the storage technique in post-harvest is to reduce the metabolic activities of the stored produce. Poor storage condition control, excessive storage time, and improper storage conditions for a particular commodity will all result in a low-quality output (Wills et al., 1996). The storage temperature along with relative humidity and length of storage of different Cole crops (cabbage, cauliflower, Broccoli) are tabulated below:

Table 5: Temperature, Relative Humidity, and Length of Storage of Cole crops

S.N.	Commodity	Temperature (°F)	Relative Humidity (%)	Length of Storage
1.	Cauliflower	32	95-98	2-4 Weeks
2.	Cabbage Early	32	95	3-6 Weeks
3.	Cabbage Late	32	95	3-4 Months
4.	Broccoli	32	95-100	10-14 Days
5.	Brussels Sprouts	32	95-100	3-5 Weeks
6.	Kohlrabi/ Knol Khol	32	95-98	2-3 Months
7.	Chinese Cabbage	32	95	3-5 Weeks
8.	Kale	32	95-100	2-3 Weeks

(Centre, 2077)

4. Packaging Practices/Value Addition Technologies

4.1 Cleaning and Grading

Harvested commodities should be graded according to the requirement of market and consumer preference. Grading should be done by separating similar color, size, compactness, and variety (Tamil Nadu Agricultural University, 2015). After harvest, diseased, damaged, undersized, and wounded heads or burst is to be separated. According to the Nepal National Standard; cauliflower curds can be classified as Premium Grade, Grade 1, or grade 2. Curd size, color, wrapper leaves, stem length, and other factors are considered for grading. Firm, compact, creamy, or snow-white curd should be well-trimmed, free of discoloration, softening, bruising, fuzziness and richness. It should be wilt-free, disease-free, and pest free. The cabbage may be divided into small, medium, and big groups based on size, tightness, and color. Large heads weigh more than 2 Kg, medium heads weigh 1-2 Kg, and tiny heads weigh less than 1 Kg (Pandey et al., 2017). The head should be robust and compact. Before grading, the heads are uniformly cut to ensure that they all have the same quantity of wrapper leaves. Also, the water used for cleaning purposes should be potable (Macsuga, 2007). Thus, cleaning and grading create a foundation for the orderly selling of cole crops, allowing customers to determine quality based on price, and providing dealers with marketing incentives.

4.2 Packaging

Cole crops use a variety of packaging methods, including bamboo baskets, plastic crates, plastic bags, and cardboard boxes/cartoons. Cole crops are often preserved in Nepal in bamboo baskets or gunny bags with enough aeration after harvest. During packaging, the jacket leaves should be positioned so that the curd and heads do not rub against one other during travel. Curds and heads should be positioned consistently upright or facing down, and young jacket leaves should be used to protect them from sunlight and dust. Different types and grades of products should be packaged separately. For restoring freshness and extending the shelf life of fresh cauliflowers, modified environment packaging works effectively. It is designed to properly fit the user's handling conditions and respiration rate. It creates a low-oxygen, high carbon dioxide environment that slows metabolic activities and water loss (Pandey et al., 2017). In cauliflower, it lowers weight loss by 6% and enhances shelf life while improving return (Acedo, 2016). Farmers must pay for packaging, which determines whether the container may be recycled or reused (Liu and Wen, 1999).

4.3 Marketing

Producing areas have limited marketing facilities, which are primarily in the hands of middlemen and commission brokers. There is a lack of price

support and market knowledge, as well as prediction data and demand. Both producers and consumers suffer from the intermediate position of gluts and scarcities. To enable farmers to achieve reasonable returns, effective marketing methods are necessary. Due to their bulky size, seasonality, and high level of perishability, fresh vegetable marketing faces a variety of challenges. The majority of cole crop vegetables are sold by growers to middlemen or commission agents, who control the market and earn handsomely. More than half of the cost of vegetable production is spent on marketing, lowering producers' profits (Pandey, 1998).

4. Conclusion

Post-harvest losses are more due to inappropriate handling, harvesting, lack of storage, lack of transport facility, and other preservation technology in different commodities including cole crops. Right maturity indices, harvesting methods, pre-cooling techniques, transportation, and storage facility with different packaging practices or value addition technologies including marketing of the harvested produce should be managed properly. It is concluded that the adoption of appropriate post-harvest management practices like harvesting at the right stage, and with the appropriate methods, proper field level cleaning, sorting, grading, proper packaging, and transportation contributes to the reduction of post-harvest loss under smart marketing.

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