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Farheen Naqash
Division of Agricultural Economics & Marketing, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, Jammu and Kashmir, India

SA Wani
Division of Agricultural Economics & Marketing, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, Jammu and Kashmir, India

Naveed Hamid
DAC&FW, New Delhi, India

Correspondence
Farheen Naqash
Division of Agricultural Economics & Marketing, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, Jammu and Kashmir, India

Economics of controlled atmosphere storage of apple in Jammu and Kashmir State

Farheen Naqash, SA Wani and Naveed Hamid

Abstract
The study focuses on Economics aspect of Controlled Atmosphere Storage of Apple in Jammu and Kashmir State of India. The study depicted that there are problems of inadequate CA store facilities for fresh fruits. It has been observed from the field studies that no CA store was found in the Baramulla district an important producing hub for apple, although a small percentage of the fruit was kept in the CA stores located at other places in the valley. The quantity that finds accommodation in the CA stores does not suffice the need of the customers. On account of non-availability of required number of CA stores, many growers after harvesting apple, store them in orchards with huge spoilage because of dampness, high temperature and humidity problems. The study revealed that Overall 10 to 25 percent of fruits get destroyed in this way. Besides, the quality of the produce is also affected adversely due to lack of cold storage facilities and the chances for damages to the fruits. The grower's capacity to hold stock for better prices during off-season also gets considerably reduced when storage facilities is minimal. The paper revealed that these facts compel the growers to dispose off their produce in the shortest possible time. This situation naturally leads to a slump in the market prices and thereby the growers fail to harvest good prices. Extended storages facilities in the potential areas at the block/tehsil level may prolong the marketing season and may prove beneficial to the growers. An important concern CA stores and the processing plants face that they incur high power expenses.

Keywords: controlled atmosphere, non-availability, off-season, marketing

1. Introduction
Since most processors cannot use the whole harvest they receive, some fruit is stored, for short term. Other fruit is stored refrigerated in a temperature range of 1 to 4°C, depending on the cultivar. The next level of storage is controlled atmosphere (CA). CA storage usually consists of a modified atmosphere, 2 to 3 percent oxygen and 1 to 4 percent carbon dioxide, at a reduced temperature. The exact specifications are adjusted to the cultivar being stored. Apples can maintain quality under these conditions for 4 to 6 months. Only the highest quality apples destined for the fresh market are placed in CA storage. However, many times the fresh market price will drop to the point that CA apples will be dumped to a processing market. Apples from CA storage should be allowed to "normalize" for a few days before processing. These apples from refrigerated storage are capable of producing good quality processed product. Processors take into consideration that different qualities of juice or applesauce can be manufactured from the same cultivar, depending on the type of storage, time of storage and stage of maturity when processed.
Advances in controlled atmosphere technology have had a dramatic effect on apple storage logistics and opened up markets hitherto unavailable for fresh and processed apple products. This is an advantage not fully shared by other fruit crops whose shelf life extension by CA is much less.

(a) Storage facilities
There are essentially three types of storage buildings for apples: air cooled storage, mechanically refrigerated storage and refrigerated and controlled-atmosphere (CA) storage.

i) Air-cooled storage
These storage houses cool by admitting cold night air (applicable climates) at inlets near the floor of an insulated building and forcing upper accumulated warm air out at outlets near the ceiling. Both openings are closed during the day. These storages are economical and effective in areas where the night air becomes cooler than the accumulated air in the storage house.

ii) Mechanically refrigerated storage
For longer periods of storage than is afforded by the air-cooled storages, mechanical

refrigeration is needed. This would become necessary to extend the season on fresh-market apples or to extend the cooling of processing apples because the volume is so large they cannot be completed in the period of time afforded by the air-cooled storage situation. Specifications of room size, room construction, capacity, compressors, condensers, expansion coils, etc. for both mechanically refrigerated storage and CA storage can be found in Childers manual.

iii) Controlled atmosphere (CA) storage

It is a widely used technique for long-term storage of freshly picked fruits and vegetables. Historically, CA storage has been the primary method for the long-term storage of apples. Through a biological process called respiration, apples take in oxygen and generate carbon dioxide, water, and heat. Controlled Atmosphere storage is an entirely natural process that reduces the effects of respiration to a minimum by controlling the environmental conditions surrounding the stored fruit. CA storage makes it possible for consumers to buy crisp, juicy apples year round. Many cultivars of apples can be preserved for a remarkable 9–12 months in CA storage, as opposed to only 2–3 months if using refrigerated storage (GOI, 2001; 2001b) [2, 3].

(b) Harvesting apples at optimum maturity

For successful controlled atmosphere (CA) storage, harvest apples when they are physiologically mature but not ripe. Harvest each cultivar at the proper maturity to achieve maximum storage life and marketing season. Apples harvested too early are of poor colour and small size and have little flavour. They may fail to ripen or ripen abnormally, and the overall quality will be poor. Characteristics of immature apples that contribute to inadequate flavour development include high water loss, low sugar content, high acidity, low aroma volatile production and high starch content. Immature apples are also more likely to develop storage disorders such as superficial scald and bitter pit.

Harvesting apples too late can result in a short storage life. Such apples are too soft for long-term CA storage and are more susceptible to mechanical injury and disease infection. Over-mature apples may develop poor eating quality and off-flavours and are more susceptible to water core and internal breakdown. For these reasons, determining optimum apple maturity for harvest is essential for maximizing storage life and quality, while minimizing postharvest losses. Numerous methods have been suggested for determining harvest date, but no single test is completely satisfactory, and some are too unpredictable, complicated or expensive.

Days after full bloom for a given cultivar provide an approximate date of harvest maturity. Confirm the date using tests such as internal ethylene concentration (IEC), starch-iodine staining, flesh firmness and soluble solids content (sugars). In general, an IEC of 1 ppm is considered to be the ultimate threshold above which fruit ripening and flesh softening are initiated and progress rapidly.

Complete harvest for long-term storage before 20% of the apples has an IEC greater than 0.2 ppm. Using the starch-iodine test, apples destined for long-term storage should have 100% of the core tissue starch degraded (no stain) with greater than 60% of the flesh tissue still having starch present (stain). It is important to note that not all apples mature and ripen in the same manner each year. Often there will be a need to compromise between correct maturity and the required firmness and sugar levels for market (Khan *et al*, 2006) [7].

(c) Guidelines for placing apples into CA Storage

Segregate apples into lots at harvest by their storage potential. The following types of apples are not suitable for long-term storage because of their potential for internal breakdown (or developing bitter pit):

- Large fruit from lightly cropped tree
- Fruit from excessively vigorous trees
- Fruit from young trees just coming into bearing
- Fruit from heavily shaded interior parts of trees
- Early-harvested fruit high in starch
- Fruit with a low number of seeds

After harvest, cool the apples as rapidly as possible. Fruit off the tree mature much faster; with warmer temperatures, fruit begin to ripen sooner. Try to get the harvest from each day into the cooler by nightfall without straining the capacity of your cooling system to the detriment of apples already pre-cooled and in storage.

When using CA storage, the quicker the apples are cooled and the desired atmosphere is achieved, the longer the apples will store and be of good quality upon removal. The longer it takes to adjust the oxygen (O_2) and carbon dioxide (CO_2) levels, the less effective the length of storage will be. The objective should be to cool the apples and achieve the desired atmosphere within 5 days of initial harvest.CA storage will not improve fruit quality - place only the best fruit in CA storage. If over or under mature or poor quality apples are put into CA, the result will be poor-quality apples upon removal. Successful CA storage begins with harvesting apples at the proper maturity, followed by rapid cooling and establishment of the CA, then proper maintenance of the desired temperature and atmosphere. In general, the standard CA recommendations range between 2.5%-3% O2 and 2.5%-4.5% CO2 at 0°C-3°C. Due to recent research using new storage technologies and strategies, cultivar-specific CA recommendations have been reviewed.

2. Situation analysis of Ca storage

(a) Integrated cold chain in Jammu & Kashmir

The peak harvest season witnesses a glut in the market and depresses the price realisation. This is caused by the absence of viable infrastructure to pack, transport and store apple in a manner designed to preserve quality and release the same in the market when the prices are attractive. Most of the outflow of the apples takes place during September to December, being the period of peak harvesting arrivals. The farmers will benefit from arrangements that reduce the peak arrivals during September to December, and delay the marketing till March-June of the next year. This will be possible if adequate storage facility suitable for apples is created and more importantly the holding capacity of farmer is increased through credit for stored apple.

There are 18 operational Cold Storages (CS) with a total capacity of 49769 MT in the State of Jammu & Kashmir; all of which are located in Jammu. These cold storages are multipurpose with a part of their capacity (say 30 %, being about 15000 MT) used for storage of apples. There are 8 Controlled Atmosphere (CA) Storages in the Kashmir valley with a total capacity of 38000 MT (Table 1) (Plate1). The average capacity utilization is 60 % during peak season and the annual average capacity utilization is estimated to be around 40%. The capacity is not fully utilized due to lack of awareness about grading, packing and storage as well as prevailing trading systems in the valley that focus on immediate sale after harvest. Due to seasonal nature of apple

and no other commodity being stored in CA stores, capacity utilisation is low. Better scientific cultivation practices, training, pruning, pre harvest foliar sprays, proper harvesting and handling practices are likely to improve the availability of produce suitable for CA storages. Although the importance and benefits of proper sorting, grading and packing is known to some of the growers, the same is done manually by the growers before bringing the same to the market yards. The different grades are mixed up in manual sorting and grading which adversely affects the price realization to the growers and also reduces the bargaining power of the growers due to mixing of different grades. None of the market yards in the valley are equipped with any sorting, grading and packing facilities. Electronic sorting, grading and packing facilities are available with the CA storages in the valley.

The requirements of storage in 2017-18 for even 25% of incremental market arrivals is likely to be about 3 lakh tons. A study after examination of production and market clusters has proposed creation of cold store capacity of 1.6 lakh tons and CA store capacity of 3 lakh tons. This will form less than 10% of the grade A and B apples produced in 2017-18. However, the proposed storage investments should be seen as proof of the concept which will induce more private investments riding on increased demand for storage. Refrigerated transport using reefer vans will be a necessity when the fruits are stored in CA stores. Under such situation we have to introduce 20 such reefer vans with a capacity of 10 tons each. When their functionality is established, more private sector investments will flow in refrigerated transport. Twenty seven automated sorting, grading and packing facilities each with capacity to handle 2 tons of apple per hour are also needed. When linked to CA stores or cold stores these lines would offer a complete packing cum storage solution to farmers. (NABCONS, 2013) [9].

Table 1: Functional CA stores in Kashmir Valley

S. No.	Name of the CA store	Location	Capacity (MT)
1	Valley Fresh Cold Chain Pvt. Ltd.	Lassipora, Pulwama	5000
2	I-Fresh, Kehwa Square Pvt. Ltd.	Lassipora, Pulwama	5000
3	Golden Apple Agro Fresh Pvt. Ltd.	Lassipora, Pulwama	2000
4	Harshana Naturals Agri Serve Pvt. Ltd.	Lassipora, Pulwama	5000
5	Fruit Master Agro Fresh Pvt. Ltd.	Lassipora, Pulwama	5000
6	Shaheen Agro Fresh Pvt. Ltd.	Lassipora, Pulwama	5000
7	Kashmir Premium Apples Pvt. Ltd.	Lassipora, Pulwama	5000
8	FIL Industries Pvt. Ltd.	Rangreth, Budgam	5000

(b) Cold stores and CA stores around Delhi

There are approximately 100 cold stores and controlled atmosphere stores (CAS) which were set up recently in Industrial Growth Center at Kundli (60 units), Industrial Area Rai (30 units) and 10 units under construction, in Sonepat district of Haryana near Delhi–Haryana border, which is just 10 km from Tihri Khampur check post. Average capacity of each store is 1.50 lakh boxes (maximum up to 5 lakh boxes per store). Total storage capacity is 150 lakh boxes of apple or *3 lakh MT*. Currently 50% or 1.50 lakh MT capacity is used for apples and 50% (1.50 lakh MT) for other fruits and green vegetables, pulses, seeds and agri. commodities. Pattern of utilization among commodities may be changed within the maximum available capacity of 3 lakh MT depending upon demand and season. Of total capacity of 1.50 lakh MT currently earmarked/used for apple, 50% (0.75 lakh MT) is used for Kashmir apple and 50% (0.75 lakh MT) for apple arriving from Himachal Pradesh; this ratio may also be changed depending upon demand, requirement and profitability of storage. These cold stores/CAS units are owned by individual private entrepreneurs, companies, procurers, etc. and some of which are also set up by commission agents of Delhi market for storage of owned apple and renting out excess space to other wholesalers. During 2012, 10-12 new units are coming up in Sonepat with average capacity of 2 lakh boxes each.

Besides, there are 7 cold stores/ controlled atmosphere stores within principal market yard of Delhi Azadpur market. These cold stores and controlled atmosphere stores in Delhi, Kundli and Rai (Sonepat border) are instrumental in enhancing the buying power, control and hoarding (storage) of apple from Kashmir by commission agents and traders who store it for 2-3 months initially starting with July/August only to effect off-take of stored produce in October-November and December around Diwali festival in phases of staggered supplies to the local Delhi and outside markets at higher price. Some of them take out stored apple around May-June in off season to supply it to the metropolitan cities of Mumbai, Bangalore and other big cities like Ahmedabad and South India. In off season, stored apple sells at higher price up to Rs.2000/- per box whereas its seasonal price may be Rs.800/- per box at the most. Therefore, it is the commission agents, wholesale buyers, companies, organized retailers, procurers, traders, etc. who make profits out of stored apple in Kundli, Rai and Delhi. Grower rarely stores in these cold stores except under compulsion when so-called "excess" or unsold apple in auction is diverted to these cold stores at extra storage and transportation charges incurred by growers only to be sold at lower price later (or at the most same price) under distressed conditions.

Other concurrent major developments that took place during first decade of the new millennium were headways made by Indian corporate (industrial) sector by way of investment in apple business and marketing for organized retail trade. Major industrial companies entering in apple market around the year 2007 were Reliance, Bharti, Mahindra, Field Fresh, Adani, Uni Fruti, etc. They would buy directly from orchards as also in APMC markets (Parimpora in Srinagar, etc.). Bharti Group isnow reportedly doing market research to re-enter Kashmir market for wholesale buying of apple. Presently, there is no domestic industrial/corporate sector company operating in Kashmir. Adani has shifted to Himachal Pradesh because Shimla/Kinnaur apple is regarded as cheaper and of better quality (crunchy, colour) which suits the requirements of organized retail business, more than what is possible with Kashmir apple. (NABARD, 2013) [9].

3. Costs & returns from storage

(a) Estimation procedure

The gross return on storage may be defined as the increase in the price of the stored product at the time of storage till it is

"de-stored" and either sold or consumed. The cost of storage should include the following:

i. The cost of the maintenance of the storage structure i.e., depreciation, repairs, insurance and interest on sunk capital; or, alternatively, the rent paid for hiring the storage structure;
ii. Interest on the value of the stored goods;
iii. Value of the quantitative and qualitative loss during storage;
iv. Risk premium for a possible price fall and damage during storage;
v. The cost of protective materials, for example, insecticides, pesticides. The costs and returns from the storage were determined to know whether it pays a farmer to store his farm produce and it was worked out with the help of the following formula, given by Acharya and Aggarwal:

$NR = GR - C$

Where,

NR = Net returns to storage
GR = $P_1 - P_0$ (Gross Returns)
P_0 = Purchase price or market price at the time of storage
P_1 = Selling or market price at the time of de-storing
C = Cost involved in storage
NR = > 0, implies positive returns on storage
NR = <0, implies negative returns on storage.

(b) Economics of apple CA storage

CA storage was found to be an important link in the value chain which was considered and the economics of CA storage also worked out. The results depicted in Table 2 showed that more than 67 per cent of the total production cost was constituted by variable cost. The wages and salaries to staff and casual labourers turned to be the major cost component of the variable cost on which plant spends more than 98 lacs. The total variable cost on an average was computed as Rs. 626.70 lacs. The second important cost item includes utilities which account for 80.07 lacs. The costs on waxing of fruit (@ 50 paisa /kg) and advertising expense accounts for 28.34 lacs and 24.69 lacs respectively. The fruits are purchased @Rs. 23/ kg and costs about 388.13 lacs on an average. The other cost components are administrative expenses, rent and insurance, pre-operative expenses and repairs and maintenance which together accounted for about 7.01 lakhs. The fixed costs included interest on working capital and term loan and depreciation on the plant. This cost constitutes about 34.17 per cent of the total production cost. The major cost component of fixed cost is depreciation on plant (@11% per annum) which amounts on an average about 218.74 lacs followed by interest on term loan (90.21 lacs) and interest on working capital (16.47 lacs) both at the interest rate of 15% per annum. The capacity utilized by the plant had increased from 50 per cent to 70 per cent. The average capacity utilization of plant worked out 65 per cent. On an average, the revenue released was Rs. 1275.3 lacs. It can be observed that the revenue has increased continuously over the period of first three years and then remained constant. The gross profit on an average worked out to be 648.60 lacs with a net profit of about 323.17 lacs.

(c) Effect of cold storage capacity on prices

It was observed that both absolute and relative price variability decreased for apple crop after the promotion of cold storages in Pulwama market for the entire period. However, increased arrivals were witnessed particularly during the storage period. After setting up of cold storages, the tendencies of price fluctuations were minimal. This indicated that with the promotion of cold storages, fluctuations in prices were reduced and this has helped in achieving the price stabilization. These results were in close proximity with the findings of Jairath, 2000, 2002, 2004 [4-6].

(d) Costs and returns from storage

The costs and returns from storage were also worked out to study whether it is profitable for farmer to store his farm produce or not. The results from Table 2 revealed that the net returns from storage turned greater than zero in all the three cases, hence, reflecting positive returns on storage. It was observed that the cold storages were utilizing 50 per cent of their capacity. Majority of the promoters complained that lack of continuous availability of power supply accompanied by high tariff rate was a major constraint for the poor utilization of the installed capacity. Lack of technical guidance from the National Horticulture Board (NHB) was another problem encountered by the promoters of CA stores. Besides this there was complete absence of publicity as well as awareness programme on CA store. In the absence of such programmes, it becomes all the more difficult for the entrepreneurs to take full benefit of the CA Stores. Time taken for the appraisal of projects, sanctioning and disbursement of terms loans and release of subsidy by banks (both partial as well as full) were some other constraints faced by the promoters of CA stores. There is also a strong need to launch a campaign on CA stores with a focus to educate farmers which varieties of apple are to be grown and stored to meet the consumer demand, these suggestions were also provided by Jairath (2004) [6].

4. Conclusion

There are problems of inadequate CA store facilities for fresh fruits. It has been observed from the field studies that no CA store was found in the Baramulla district an important producing hub for apple, although a small percentage of the fruit was kept in the CA stores located at other places in the valley. The quantity that finds accommodation in the CA stores does not suffice the need of the customers. On account of non-availability of required number of CA stores, many growers after harvesting apple, store them in orchards with huge spoilage because of dampness, high temperature and humidity problems. Overall 10 to 25 percent of fruits get destroyed in this way. Besides, the quality of the produce is also affected adversely due to lack of cold storage facilities and the chances for damages to the fruits. The grower's capacity to hold stock for better prices during off-season also gets considerably reduced when storage facilities is minimal. These facts compel the growers to dispose off their produce in the shortest possible time. This situation naturally leads to a slump in the market prices and thereby the growers fail to harvest good prices. Extended storages facilities in the potential areas at the block/tehsil level may prolong the marketing season and may prove beneficial to the growers. An important concern CA stores and the processing plants face that they incur high power expenses. The scope lies for cost reduction if power could be supplied to the plants continuously at a realistic rate. At present, the processing plant runs on diesel because of non-availability of continued power supply.

Table 2: Cost of apple storage, 5000 MT cold storage (Rs. in lakhs)

S. No.	Particulars	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	Average
	Capacity utilization	**50%**	**60%**	**70%**	**70%**	**70%**	**70%**	**65%**
1	Revenue	981	1177.2	1373.4	1373.4	1373.4	1373.4	1275.3
2	**Variable Costs**							
A	Purchase of fruit	345	362.25	379.5	396.75	414	431.25	388.13
B	Waxing of fruit	25	26.25	27.56	28.94	30.39	31.91	28.34
C	Utilities	54.10	64.92	90.35	90.35	90.35	90.35	80.07
D	Salaries & wages	75.74	90.89	106.04	106.04	106.04	106.04	98.47
E	Repair & maintenance	1	0.7	0.8	0.8	0.8	0.8	0.82
F	Rent & insurance	1.5	1.2	1.25	1.25	1.25	1.25	1.28
G	Advertising expenses	14.72	23.54	27.47	27.47	27.47	27.47	24.69
H	Pre-Operative expenses	5	0	0	0	0	0	0.83
I	Administrative expenses	2.4	2.88	4.8	4.8	4.8	4.8	4.08
	Total Variable cost	524.46	572.64	637.77	656.40	675.10	693.86	626.70
3	Gross Profit	456.54	604.56	735.63	717.00	698.30	679.54	648.60
4	**Fixed Costs**							
A	Interest on Term loan	135.32	135.32	108.26	81.19	54.13	27.06	90.21
Table 1- B	Contd... Interest on Working Capital	16.17	16.36	16.58	16.58	16.58	16.58	*Contd...* 16.47
C	Depreciation	218.74	218.74	218.74	218.74	218.74	218.74	218.74
5	total fixed cost	370.23	370.42	343.57	316.50	289.44	262.38	325.42
6	total storage cost	894.69	943.06	981.34	972.90	964.54	956.24	952.13
7	NET PROFIT	86.31	234.14	392.06	400.50	408.86	417.16	323.17
8	Return to variable costs	1.87	2.06	2.15	2.09	2.03	1.98	2.03
9	Return to total costs	0.10	0.25	0.40	0.41	0.42	0.44	0.34

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