Strawberry

Strawberry is mostly consumed as fresh table fruit, although there is scope for the FPOs in carrying out value addition activities in strawberry, such as frozen strawberry, strawberry pulp & syrup, and preparation of strawberry candy. Some of the business opportunities that are suitable for FPOs are mentioned below and the technologies related to those businesses are detailed in this document.

S. No.	Business Opportunity	Brief description
1	Fresh Strawberry – Direct to Market	Fresh strawberries with basic value addition such as washing, sorting & grading, and packaging
2	Fresh Strawberry – Store and Sell	Strawberry can be stored for short-term to sell at better prices
3	Strawberry Crush (pulp)	Strawberry can be crush and pulp can be extracted for further processing into juice/ concentrate
4	Strawberry Syrup	Strawberry syrup can be extracted and sold to consumers
5	Strawberry Candy	In continuation to syrup unit, strawberry candy can be manufactured
6	Strawberry IQF	Strawberry can be frozen and sold in international & domestic market

Other business opportunities include ready-to-serve strawberry powder, strawberry milkshake, strawberry wine, strawberry jam, strawberry shrikhand etc. These business opportunities are not detailed in this document as they may not be suitable for FPOs due to high investment costs, significant volume of strawberry required around the year for business viability, difficulties in marketing due to competition in Maharashtra, etc.

1 Fresh Strawberry – Direct to market

Strawberry can be sold directly to market post harvesting with basic post-harvest value addition such as washing, sorting, and packing in clamshell/ flow pack packaging

Technology	Type	Eligible for Matching Grant
Plastic Crates	Implement	Yes
Mobile Pre-cooler	Equipment	Yes
Ice Battery	Consumable	Yes
Packhouse	Civil construction	Yes
Conveyor Lines	Equipment	Yes
Bubble washer	Equipment	Yes
Sorting machine - Mechanical sorter	Equipment	Yes

OR - Optical sorter		
Clamshell packaging	Consumable	No
Controlled Atmosphere Truck	Transport	Yes

Process:

- Harvested strawberries should be arranged in crates at the field to minimize damage to the fruit
- The harvested strawberries should ideally be pre-cooled, within 1 – 2 hours of harvesting, using a mobile pre-cooler or ice-batteries can be used in the plastic crates to bring down the temperature to around 0 °C to minimize any loss immediately post-harvest. If cooling down to the recommended 0°C is an issue for farmers, research has shown that strawberries held at 10°C storage at high humidity will also be beneficial with regards to storage life. In addition, strawberries at 10°C tend to retain their color and glossy appearance better than berries stored at 0°C.
- At the packhouse, strawberry can be washed using a bubble washer (chlorinated water) to remove field dirt, pesticides, and other pests (*if any*)
- Washed strawberries are then sorted either manually or through sorting machines. Low-cost mechanical sorters and high-cost optical sorters are available for sorting process
- Conveyor lines can be used for manual sorting and to move produce from one machine to another
- To prevent damage of produce during transportation, strawberries are packed in clamshell boxes and transported in corrugated fibre boards boxes. If the local markets are more than 1 – 2 hours from the fields, then controlled atmosphere trucks can be used to preserve the shelf-life of the strawberries
- The FPO can also market their product (e.g., frozen strawberry, fresh & graded strawberry, strawberry pulp, strawberry candy through kiosks under their own brand. Brand building activities need to be carried out by the FPOs for which financial and technical assistance will be provided by the MAGNET society

Advantages:

- Washing, sorting, and grading of strawberries helps FPOs to sell the strawberries through appropriate channels and realize higher prices

Disadvantages:

- Strawberries are mostly exported and hence, have to be stored in controlled atmosphere storages prior to be being exported as per buyers' requirement

2 Fresh Strawberry – Store and sell

Strawberries can be stored in cold storage for 7 – 10 days. Pre-fabricated cold storage rooms can be used to store strawberries temporarily prior to export as demanded by consumers. Strawberry can also be stored for 10 – 14 days at 1 °C with CA composition of 3–5% O_2 and 15–20% CO_2. *Too much concentration of CO_2 or too low concentration of O_2 produces off-flavors in strawberries*. Other than lowering respiration rate, one of the most important features of increased CO_2 level in CA storage is the control of decay caused by *Botrytis* and *Penicillium* species. Strawberry can also be packed in ***'Modified Atmosphere' Packaging*** or transported to distant markets in controlled atmosphere enabled reefer trucks.

Technology	Type	Eligible for Matching Grant
Plastic Crates	Implement	Yes
Mobile Pre-cooler	Equipment	Yes
Ice Battery	Consumable	Yes
Packhouse	Civil construction	Yes
Conveyor Lines	Equipment	Yes
Bubble washer	Equipment	Yes
Sorting machine - Mechanical sorter OR - Optical sorter	Equipment	Yes
Controlled Atmosphere Storage	Equipment	Yes
Clamshell packaging	Consumable	No
Modified Atmosphere (MA) Packaging	Consumable	No
Controlled Atmosphere Truck	Transport	Yes

Process:

- Harvested strawberries should be arranged in crates at the field to minimize damage to the fruit
- The harvested strawberries should ideally be pre-cooled, within 1 – 2 hours of harvesting, using a mobile pre-cooler or ice-batteries can be used in the plastic crates to bring down the temperature to around 0 °C to minimize any loss immediately post-harvest. If cooling down to the recommended 0°C is an issue for farmers, research has shown that strawberries held at 10°C storage at high humidity will also be beneficial with regards to storage life. In addition, strawberries at 10°C tend to retain their color and glossy appearance better than berries stored at 0°C
- At the packhouse, strawberry can be washed using a bubble washer (chlorinated water) to remove field dirt, pesticides, and other pests (*if any*)
- Washed strawberries are then sorted either manually or through sorting machines. Low-cost mechanical sorters and high-cost optical sorters are available for sorting process
- Conveyor lines can be used for manual sorting and to move produce from one machine to another
- The strawberries can then be stored in controlled atmosphere storage rooms/ chambers for 10 – 14 days with atmospheric conditions as mentioned above
- When needed the strawberries can either be packed in traditional clamshell packaging or in *Modified Atmosphere Packaging (MAP)*. **Polypropylene packaging** with different perforation sizes can be used to naturally create a mixture of gases in a concentration that resembles the concentrations used for modified atmospheric storage. Polypropylene packages with different perforations stored strawberries at 2°C
- To prevent damage of produce during transportation, the packed strawberries can further be packed in corrugated fibre boards and transported in reefer trucks or controlled atmosphere trucks
- The FPO can also market their product (e.g., frozen strawberry, fresh & graded strawberry, strawberry pulp, strawberry candy through kiosks under their own brand. Brand building activities need to be carried out by the FPOs for which financial and technical assistance will be provided by the MAGNET society

Advantages:

- Washing, sorting, and grading of strawberries helps FPOs to sell the strawberries through appropriate channels and realize higher prices
- The strawberries can be temporarily stored when the FPOs don't find any buyers or when the market prices are low, without the produce getting spoilt

Disadvantages:

- Cold/ Controlled Atmosphere storages require significant initial investment and grid-powered cold storages have high operational cost. The increase in market prices may not be able to compensate for the storage cost incurred if the price increase is not significant

3 Strawberry Crush

Strawberry can be crushed, and pulp can be extracted for further processing into concentrates, powder, or juice. The pulp can be stored in cold storage for bulk sales directly to ready-to-serve strawberry juice / squash processors or to hotels / restaurants.

Technology	Type	Eligible for Matching Grant
Fruit pulper	Equipment	Yes
Steam Jacketed Kettle	Equipment	Yes
Homogenizer	Equipment	Yes
Stainless Steel Storage tank	Equipment	Yes
Aseptic Bottling Unit	Equipment	Yes
Boiler	Equipment	Yes

Strawberry crush production unit should be suggested along with the one of the first two business opportunities suggested above. Higher grade fruits can be marketed as table fruits while lower grade fruits can be processed into strawberry crush.

Process:

Approximately 5000 sq. ft. area is required for the establishment and operationalization of a strawberry crushing facility. The crush facility can be established parallelly with the integrated pack house.

- The washed and graded strawberry (lower grades) are fed into a fruit pulper for crushing the strawberry into pulp
- The pulp is then transferred to a steam – jacketed kettle where it is mixed with sugar syrup. Sugar syrup also acts as a preservative. Steam is generated using a boiler. The pulp is then heated for killing any micro-organism/ pathogens (***Pasteurization***)
- The consistency of the strawberry pulp is then homogenized using homogenizer post mixing of the strawberry pulp with sugar, thinner, acidity regulators (e.g., citric acid)
- The homogenized pulp is then stored in a stainless steel tank for further usage

- The pulp can also be stored in bottles using an aseptic bottling/ packaging machine for sales to consumers/ retailers/ HORECA businesses
- The FPO can also market their product (e.g., frozen strawberry, fresh & graded strawberry, strawberry pulp, strawberry candy through kiosks under their own brand. Brand building activities need to be carried out by the FPOs for which financial and technical assistance will be provided by the MAGNET society

Advantages:

- Lower grades of strawberry fetch very low prices in open-market. Processing them into pulp provides better prices to the FPO

Disadvantages:

- The FPO needs to be develop forward market linkages through tie-ups with retailers/ institutions and invest in developing their own marketing channels to make available the pulp directly to them

4 Strawberry Syrup

Strawberry syrup can be extracted (*as per the process described herewith*) and stored for sales to consumers or hotels and restaurants for preparation of mocktails/ cocktails.

Technology	Type	Eligible for Matching Grant
Filtration Unit (Plate and Frame Filtration unit)	Equipment	Yes
Steam Jacketed Kettle with mixer	Equipment	Yes
Stainless Steel Storage tank	Equipment	Yes
Aseptic Bottling Unit	Equipment	Yes
Boiler	Equipment	Yes

Strawberry syrup production unit should be suggested along with the one of the first two business opportunities suggested above. Higher grade fruits can be marketed as table fruits while lower grade fruits can be processed into strawberry syrup.

Process:

- The washed and graded strawberry (lower grades) are boiled in a liquid solvent (*usually, water*) to extract the strawberry syrup. The strawberry pulp and solvent are filtered to separate out the syrup
- The hot strained liquid is then mixed with sugar (in 1:1 concentration ratio). Acidity regulators and preservatives are also added for improving the shelf life of the strawberry syrup
- The hot syrup is then stored in stainless steel tanks for further marketing
- The syrup, when cooled, is then packed in aseptic (germ-free) environment using an aseptic bottling unit for further sales to consumers and institutional business, e.g., HoReCa
- The FPO can also market their product (e.g., frozen strawberry, fresh & graded strawberry, strawberry pulp, strawberry candy through kiosks under their own brand. Brand building activities

need to be carried out by the FPOs for which financial and technical assistance will be provided by the MAGNET society

Advantages:

- Lower grades of strawberry fetch very low prices in open-market. Extracting syrup from such strawberries can provide better prices to the FPO

Disadvantages:

- The FPO needs to be develop forward market linkages through tie-ups with retailers and invest in developing their own marketing channels to make available the syrup directly to the consumers

5 Strawberry Candy

In combination with the strawberry syrup unit, the strawberry syrup can be further processed to manufacture hard candy. An approximate area of 5,000 sq. ft. is expected to be required for establishment and operationalization of the strawberry candy manufacturing facility. For a small scale, semi-automatic plant of 80kg per hr capacity, an investment of ₹ 34 – 38 lakh is expected to be incurred. With an expected 30 – 35 kW power requirement, the plant needs about 8 – 10 workers (skilled, unskilled, technician and other workers) for smooth operationalization.

Technology	Type	Eligible for Matching Grant
Vacuum candy cooker (batch – type)	Equipment	Yes
Cooling table (Stainless Steel)	Equipment	Yes
Batch Former	Equipment	Yes
Rope sizer machine	Equipment	Yes
Candy molding machine	Equipment	Yes
Cooling conveyor lines	Equipment	Yes
Candy packaging machine	Equipment	Yes

Strawberry candy production unit should be suggested along with strawberry syrup unit, as candy is prepared through further processing of strawberry syrup.

Process:

- Post generation of steam using a boiler for feeding into the vacuum cooker, strawberry syrup, liquid glucose syrup, and sugar are fed into the vacuum cooker
- The strawberry flavored candy mass is then de-panned from the vacuum cooker to a cooling table for cooling the hot mass. Critic acid and powdered sugar are then added to the cooled candy mass and the entire mass mixture is kneaded manually
- The prepared strawberry flavored candy mass is fed into a batch former to give the candy mass a cylindrical form

- The cylindrical candy mass is then converted into thin rope - like cylinders for further processing into candy shapes
- The rope-like candy-shaped strawberry mass is given the final shape of the candy by pressing the roll into the dye in a candy molding machine
- The candies are then cooled by passing them through cooling conveyor lines before they are packed using a candy packaging machine for sales to consumers through retailers/ superstores/ marketing kiosks owned and operated by the FPOs

Advantages:

- Lower grades of strawberry fetch very low prices in open-market. The syrup extracted from such strawberries can further yield better price for the FPOs if it is used in the formation of candies, demand of which is expected to remain fairly stable

Disadvantages:

- The FPO needs to be develop forward market linkages through tie-ups with retailers and invest in developing their own marketing channels to realize higher margins by selling the product to the end users

6 IQF Strawberry

Strawberry has a good export potential with indian strawberry getting exported to countries like United States, Germany, Austria, and Bangladesh. For shipping strawberries to such far geographies, frozen strawberries combined with suitable packaging techniques are helpful for keeping the required quality.

ADVANCED TECHNOLOGY: (Simply) frozen strawberries show changes in color and texture degradation which affect the overall quality attributes. Hence, it is recommended that fresh strawberry be dipped alone or in a mixture of calcium lactate and citric acid during freezing process. Citric acid lowers browning index and improves the ascorbic acid and Total Anthocyanins Content (TAC), while calcium lactate helps in texture maintenance and firmness after thawing. The combination of both citric acid and Ca lactate (0.4% + 1%) showed better quality characteristics, like maintaining vitamin C content, firmness, anthocyanin content while reduction in drip loss improving in color attributes in comparison with other treatments.

Technology	Type	Eligible for Matching Grant
Packhouse	Civil construction	Yes
Bubble washer	Equipment	Yes
Conveyor lines	Equipment	Yes
Vibratory sieve	Equipment	Yes
IQF freezer	Equipment	Yes
Mechanical grader	Equipment	Yes
Automated packaging line – Flow pack packaging	Equipment	Yes

Process:

- Harvested strawberries should be arranged in crates at the field to minimize damage to the fruit

- The harvested strawberries should ideally be pre-cooled, within 1 – 2 hours of harvesting, using a mobile pre-cooler or ice-batteries can be used in the plastic crates to bring down the temperature to around 0 °C to minimize any loss immediately post-harvest. If cooling down to the recommended 0°C is an issue for farmers, research has shown that strawberries held at 10°C storage at high humidity will also be beneficial with regards to storage life. In addition, strawberries at 10°C tend to retain their color and glossy appearance better than berries stored at 0°C
- At the packhouse, strawberry can be washed using a bubble washer (chlorinated water) to remove field dirt, pesticides, and other pests (*if any*)
- Conveyor lines are used for moving the strawberries forward across the different process
- The strawberries need to be dewatered for removing the extraneous water prior to being frozen. The strawberries are, thus passed through a vibrating shaker
- The dewatered strawberries are then frozen using an IQF freezer
- The frozen strawberries are then graded on the basis of size before being sent to an automated packing line where they are packed in clamshell packages. The packed frozen strawberries are then stored in cold storage till export or domestic sales

Advantages:

- Export of strawberries fetch higher price for the farmers and as such, IQF strawberries are most suitable for preserving the strawberries

Disadvantages:

- The IQF freezing equipment require significant initial investment and the texture of strawberries degrade over time if appropriate steps (such as that mentioned above) are not taken, then the price realization will be low which might not make up for the high initial investment

ADVANCE TECHNOLOGIES

Following are a list of advance technologies which the FPOs can adopt for further preserving the shelf life of strawberries and better marketability:

S. No	Technology	Stage	Details of technology
1	Edible coatings	Post - harvest	Edible films or coatings are nontoxic, environment friendly, and food grade formulations used to maintain postharvest quality and increase shelf- and storage life of fruits and vegetables. These formulations are also used as active packaging to reduce dehydration, microbial attack, skin browning, and tissue softening. Edible coatings are applied in solution form, whereas edible films are first molded into sheets and then wrapped around food products. Edible films or coatings are based on carbohydrates, protein, lipids, or their different combinations. The bioactive and functional benefits of edible coatings include slow rate of respiration and tissue softening, extended postharvest life, biodegradability, and lower microbial infestation
2	Chemical Treatments	Post - harvest	Frozen strawberries show changes in color and texture degradation which affects the overall quality attributes. Fresh strawberry was dipped alone or in combination of calcium lactate and citric acid during freezing process. Citric acid clearly lowers browning index and improves the ascorbic acid and total anthocyanins content (TAC), while calcium lactate in texture maintenance and firmness after thawing. The combination of both citric acid and Ca lactate (0.4% + 1%) showed better quality characteristics, like maintaining vitamin C content, firmness, anthocyanin content while reduction in drip loss improving in color attributes in comparison with other treatments
3	Heat treatment	Post - harvest	Heat-treated strawberry fruit treated with heat at 45°C for 3 h showed high firmness, reduced activities of enzyme like *β-Xyl 9 β-xylosidase*), *EGase* (endo-1,4-β-d-*glucanase*) which delayed hemicellulose deprivation in both zones (external and internal fruit zones).
4	Essential oils	Post – harvest, *viz.*, packaging	Essential oils have strong antimicrobial activities and have been incorporated in edible coatings and films not only to improve texture of coatings but also as antimicrobial agents. Essential oils of clove, cinnamon, and oregano were used in paraffin coatings of paper packaging materials that totally inhibited the growth of Candida albicans, Aspergillus flavus, and *Eurotium repens* on strawberry fruits for 7 days at 4°C
5	Application of Tea Tree Oil (TTO)	Pre – harvest (*viz.*, just prior to harvest)	- TTO reduced the decay, and delay firmness, decreases number of microorganisms during storage. It also reduces the accumulation of H2O2 with increasing antioxidative activities of various enzymes including catalase and ascorbate peroxidase as well as β-1,3-glucanase - TTO application before harvest significantly reduced decay, microorganisms, delays fruit senescence, and improves the defense proteins
6	UV irradiation	Post - harvest	**Blue light illumination at 5 °C** increased ascorbic acid, total sugar, titratable acidity, total phenolic, and DPPH (1,1-diphenyl-2-picrylhydrazy) radical-scavenging activity in strawberries during the course of storage. In addition, higher activities of reactive oxygen species like APX, SOD, and CAT maintained lower amounts of superoxide anion (SO2), hydrogen peroxide (H2O2), and malondialdehyde (MDA). Thus, for maintenance of quality attributes and improvement in nutritional quality of strawberry fruit, exposure to blue light illumination might be affective due to the enhancement of their antioxidant systems and free radical-scavenging abilities