Post-Harvest Handling Protocol for Honey

Broad Guidelines for use of FPOs

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1. Background

Ministry of Agriculture & Farmers' Welfare, Government of India has launched a Central Sector Scheme for formation and promotion of 10,000 Farmer Producer Organizations (FPOs) with following objectives:

- To provide holistic and broad-based supportive ecosystem to form new 10,000 FPOs to facilitate development of vibrant and sustainable income-oriented farming and for overall socio-economic development and wellbeing of agrarian communities.

- To enhance productivity through efficient, cost-effective, and sustainable resource use and realize higher returns through better liquidity and market linkages for their produce and become sustainable through collective action.

- To provide handholding and support to new FPOs up to 5 years from the year of creation in all aspects of management of FPO, inputs, production, processing and value addition, market linkages, credit linkages and use of technology etc.

- To provide effective capacity building to FPOs to develop agriculture entrepreneurship skills to become economically viable and self-sustaining beyond the period of support from government.

2. Farmer producer Organization (FPO)

FPO is a generic name, which means and includes farmer- producers' organization incorporated/ registered either under Part IXA of Companies Act or under Co-operative Societies Act of the concerned States and formed for the purpose of leveraging collectives through economies of scale in production and marketing of agricultural and allied sector. However, FPOs registered under Cooperative Societies Act of the State (including Mutually Aided or Self-reliant Cooperative Societies Act by whatever name it is called) for the purpose of this Scheme, is to be insulated from all kinds of interference including in election process and day to day management through suitable provisioning in their Memorandum of Association and Bye-laws with a view to encourage healthy growth and development of FPO.

3. Broad Services and Activities to be undertaken by FPOs

The FPOs may provide and undertake following relevant major services and activities for their development as may be necessary: -

i. Supply quality production inputs like seed, fertilizer, pesticides, and such other inputs at reasonably lower wholesale rates.

ii. Make available need-based production and post-production machinery and equipment like cultivator, tiller, sprinkler set, combine harvester and such other machinery and equipment on custom hiring basis for members to reduce the per unit production cost.

iii. Make available value addition like cleaning, assaying, sorting, grading, packing and also farm level processing facilities at user charge basis on reasonably cheaper rate. Storage and transportation facilities may also be made available.

iv. Undertake higher income generating activities like seed production, bee keeping, mushroom cultivation etc.

v. Undertake aggregation of smaller lots of farmer-members' produce; add value to make them more marketable.

vi. Facilitate market information/intelligence about the produce for judicious decision in production and marketing.

vii. Facilitate logistics services such as storage, transportation, loading/un-loading etc. on shared cost basis.

viii. Market the aggregated/value added produce with better negotiation strength to the buyers and in the marketing, channels offering better and remunerative prices.

4. Honey FPO Programme

The Honey FPO Programme was inaugurated by Minister of Agriculture and Farmers' Welfare on 26th November 2020. Beekeeping in India is highly predominant in the unorganized sector among the rural and tribal population. Despite having a huge potential of honey production in the country, the beekeeping industry is still underdeveloped. The adoption level of beekeeping is also quite less due to various constraints.

To address these issues the honey programme was designed to filling up the gaps between the elements of the beekeeping supply chain and also ensure price remuneration to the beekeeping farmers. Honey FPOs will also work for promotion of beekeeping as an occupation for unemployed women and tribal populations and uplift their livelihood. It is expected that Honey beekeeping will change the lifestyle of small and marginal farmers and help in achieving the goal of increasing farmer's income.

This tool kit on Honey handling protocol is an attempt to provide the simple and clear guidelines to the FPOs formed under the central sector scheme / Honey FPO programme and engaged in production and marketing of Honey with respect to practices to be adopted in pre and post-harvest handling of Honey to ensure growing high quality of produce and preserve its quality and freshness. The following discussion on honey harvesting and processing is intended for the producer in order to clarify the necessary precautions to be taken to assure a high-quality primary product. Only if the raw material is of good quality then the end product be of good quality.

5. Definition of Honey

According to the Codex standard for honey adopted by the Codex Alimentarius Commission, Honey is the natural sweet substance produced by honeybees from the nectar of plants or from secretions of living parts of plants or excretions of plant sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store, and leave in the honeycomb to ripen and mature.

According to FSSAI, Honey is the natural sweet substance produced by honeybees from the nectar of plants or from secretions of living parts of plants or excretions of plant sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store, and leave in the honeycomb to ripen and mature.

5.1 Categories of Honey

Monofloral honey is where the bees have been foraging predominantly on one type of plant and is named according to that plant. (> 45% pollen from one plant). Few examples are

- Thyme Honey
- Jamun Honey
- Acacia Honey
- Lychee Honey
- Clover Honey
- Ajwain Honey
- Acacia Honey
- Buckwheat Honey
- Clover Honey
- Dandelion Honey
- Clover Honey
- Heather Honey
- Lavender Honey
- Orange Blossom Honey

Uni-floral honey's price is always several times higher than multi-floral honey, this is because, the dominant blossom's nectar and pollen determine the taste, flavor and properties. The premium quality of unifloral honey also depends upon geographical area and plant species e.g., Manuka honey from New Zealand. Unifloral honey is the result of two conditions. First, the target plant must predominate so the bees have little choice of plants. Second, the beekeeper must time the introduction of the hive and the actual harvesting of the comb to coincide with this blooming period. This is done by carefully observing the blooming period of the chosen plant as well as possible overlapping blooming periods of other nectar-producing plants as well. Proportions of flowers are usually determined by the percentage of its pollen in the honey. Pollen tends to be unique for each species of plant and can be identified and counted. Since different flowers have more or less pollen, there are often different pollen content requirements. A pollen percentage of 45% or better is common but it can be as low as 15% for certain types of single flower honeys that have low pollen counts (such as Lavender). This percentage is often set by the country of origin for more common single flower honeys such as Acacia. The main unifloral honey produced in the EU is acacia honey, as the black locust tree from which it is obtained is widely spread in Europe. The main producers of acacia honey in Europe are Hungary, Bulgaria, and Romania, although it is also produced in other EU countries. Other types of unifloralhoney commonly produced in the EU are rapeseed, sunflower, linden blossom, heather, lavender, rosemary, thyme, orange blossom, chestnut, and forest honey.

Multifloral Honey (also known as polyfloral) has several botanical sources, none of which is predominant (<45% pollen from one plant). This definition should not be seen as a lack of identity or minor quality.

There is not only one single type of multifloral honey because there are endless possible floral combinations which may exist in honey. Every kind of multifloral honey has its own specific features that repeat themselves year after year with a smaller or greater degree of variability. However, its basic distinctive features are always recognizable. Sometimes multiflower honey is made of a dominant plant species that makes up its core, but which is not enough to define it as monofloral but at the same time it is not always accompanied by a constant concurrent flora.

5.2 Designation of Honey according to Production

Extracted honey is the most basic and widespread hive product. It is obtained by centrifuging decapped broodless combs. Honey extraction is the central practice of removing honey from honeycomb so that it is isolated in a pure liquid form. The honey is stored by honeybees in their beeswax honeycomb.

Pressed Honey is honey obtained by pressing brood less combs with or without the application of moderate heat. Although this is more complex but also more gentle than the usual spinning. Pressed honey has a very intense aroma and contains a lot of flower pollen.

Drained Honey is honey obtained by draining decapped broodless combs. Honey may be designated according to the following styles according to the processing procedure:

Comb Honey, which is honey, stored by bees in the cells of freshly built broodless combs and which is sold in sealed whole combs or sections of such combs.

Figure 1: Comb Honey

Chunk Honey which is honey containing one or more pieces of comb honey

Figure 2. Chunk Honey

Creamed (or creamy or set) Honey is honey which has a fine crystalline structure, and which may have undergone a physical process to give it that structure and to make it easy to spread.

Figure 3: Creamed Honey

6. Honeybee Species of Economic Importance

Honeybees belong to Phylum- Arthropod, Class- Hexapoda / Insecta, Order- Hymenoptera and Family- Apidae. There are five species of honeybees which are of great economic importance.

- Apis dorsata (Giant / Rock honeybee)
- A. florea (Little/ Dwarf honeybee)
- A. cerana (Indian/Asian / Eastern honeybee)
- A. mellifera (Italian/ European honeybee)

- Trigona iridipennis (Stingless bee/ Dammer bee)

The first three species are indigenous, while the fourth species A. mellifera was introduced in India in 1962 from European country. A. dorsata and A. florea are wild bees as they construct nest in open and cannot be domesticated in wooden hives. Trigona sp. is wild but is rear in peculiar beehive. Whereas A. cerana and A. mellifera are hive/ domesticated bees as they can be hived inside the wooden hives.

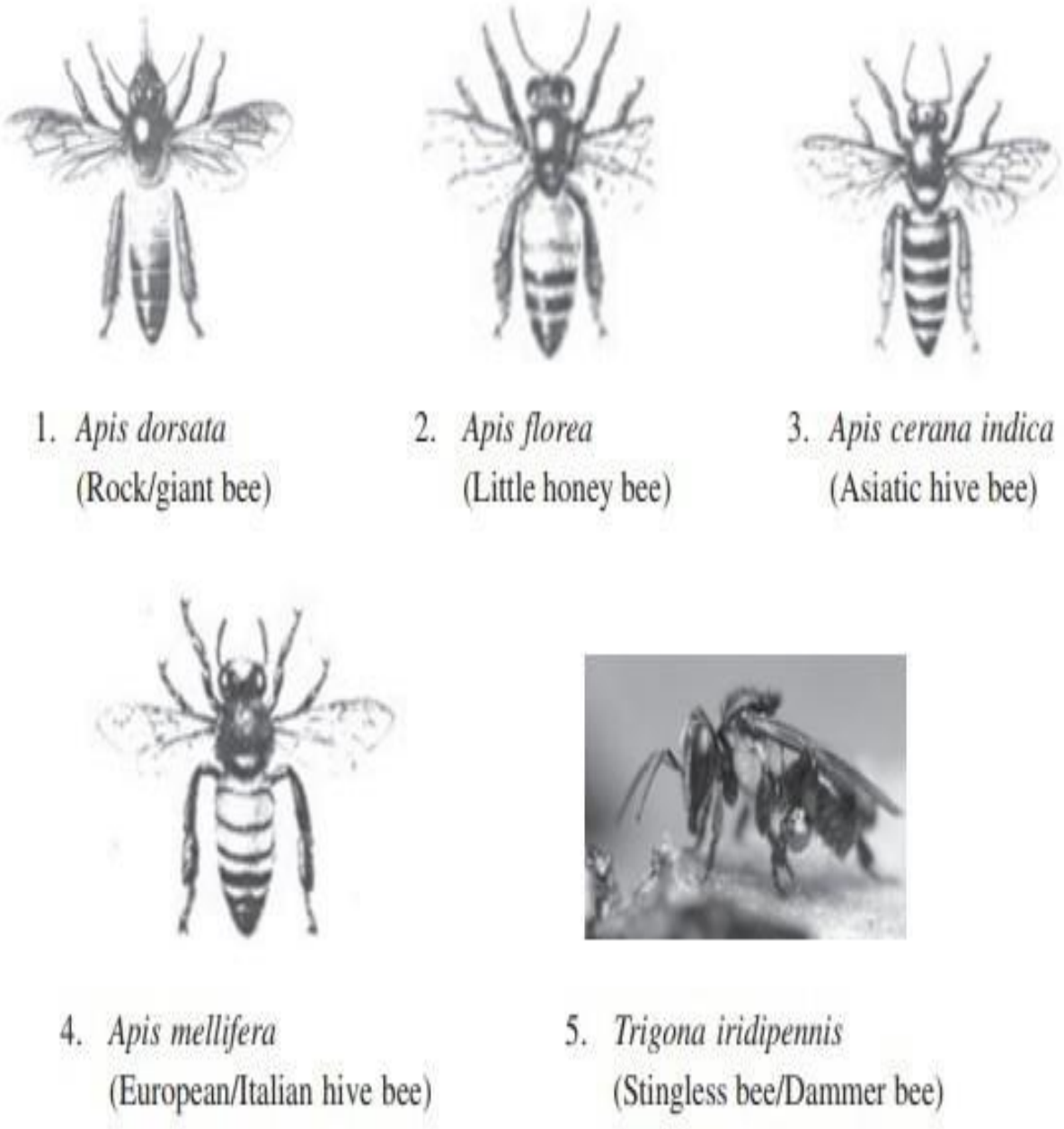

Figure 4: Five species of honeybees

6.1 Caste of Bees

We live in society and work for society. Similar are the bees, a social insect. Like us, each individual in the bee colony has to work for the welfare of others and the colony which we termed as 'division of labour'. A bee colony consists of different types or 'castes' of individuals, who cooperate in collecting food, taking care of young ones and production of honey. A normal bee colony has (i) a Queen bee, (ii) 2000- 70000 Workers, (iii) 0-500 Drones.

Figure 5: Castes of Honeybees

(a). Worker bees

- The workers are sterile females which developed from fertilized eggs.
- Workers are smaller than the drones and have yellowish and dark brown abdominal stripes.
- The workers are the main group in a colony, with 60,000 –70,000 in an Apis mellifera colony and 25,000 –30,000 in an Apis cerana colony. They have specialized structures, such as hypopharyngeal glands, scent glands, wax glands, and pollen baskets, which allow them to perform all the labors of the hive.
- All the work in a honeybee colony is performed by the worker bees, including honey and pollen collection, brood rearing, building combs, feeding the drones and queen, cleaning the hive, and defending the colony.
- The specific activities are defined by the age of the bee, with tasks inside the hive for the first 3 weeks after emergence (comb building, brood care, hive cleaning, thermoregulation, queen care, honey ripening) and then outside (foragers and scouts). Under special circumstances, workers can perform any kind of task irrespective of age as per the need of the colony.
- When the colony is active in spring and summer, worker bee may live as long as 5- 6 weeks. During inactive period in winter a worker bee lives five months or more.

Figure 6: Worker Bees

(b). Queen bee

- Each colony has a single queen bee irrespective of the colony size.
- The queen bee is larger than the worker and drone bees, has a black and shiny cylindrical and longer body, and a round and comparatively small head.
- She is the only perfectly developed female and is the mother of the colony.
- Her primary function is reproduction. She produces both fertilized and unfertilized eggs. During peak production, queens may lay up to 2000-2500 eggs per day. One queen may produce up to 250,000 eggs per year and possibly more than a 10, 00000 in her lifetime.
- The second major function of a queen is secreting pheromone known as queen substance, required for the stability of the colony including inhibition of ovaries of worker bees.
- The average productive life span of queen is 2 to 3 years.

Figure 7: Queen Bee

(c). Drone

- Drones (male bees) are the largest bees in the colony and are blackish and hairy.
- A colony will usually have a few hundred drones.
- They develop from unfertilized eggs and complete their life cycle in 24 days.
- They lead a life of leisure, doing no work while being fed by the workers.
- Their sole purpose is to mate with a new queen and also useful to reduce the temperature of the colony by wing beating. They die after mating or are expelled from the hive as winter approaches.

Figure 8 : Drone

6.2 Stages in Honeybee's Development

Each bee caste goes through four developmental stages viz. egg, larva, pupa and adult. But the time needed to complete each stage differs.

(i). Egg

- Queen lays pearly white, slightly curved eggs in the cells singly and vertically with the thin end attached to the bottom of the cell.
- Queen bee lays both fertilized (giving rise to females i.e., worker or queen bee) and unfertilized eggs (giving rise to males i.e., drone bees).
- The egg stage lasts for 3 days. At the start, the egg stands vertically on the base of the cell, then slants, and finally lies flat on the base before hatching.

(ii). Larva

- Small, shiny white larvae hatch from the egg after 3 days.
- Initially the larvae are loop shaped lying on the bottom of the cell but towards cell capping, they get stretched on their back in the cell with head facing distal end of the cell.
- Larvae of all the castes moult four times
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- Initially the larvae are loop shaped lying on the bottom of the cell but towards cell capping, they get stretched on their back in the cell with head facing distal end of the cell.
- Larvae of all the castes moult four times.
- The average larval period is 5 days for a queen, 6 for a worker, and 7 for a drone.
- After the cell is sealed (at the end of 8th day) and the cocoon has been spun (at the end of 9th day) the larva passes gradually and without moulting into pre-pupa.

(iii). Pupa

- The pupal stage is the dormant stage. Worker bees seal the cells with a porous beeswax cap and the larva spins a cocoon around itself.
- The developing bee remains inside the cocoon without eating or moving.
- The pupal stage lasts for 7–8 days for a queen, 11–12 days for a worker, and 14 days for a drone.
- Worker cells are a little smaller than drone cells. The comparative sizes are five worker cells per linear 25.4 mm of comb and four drone cells per linear 25.4 mm of comb in case of Italian bee.
- During this stage, the internal organs and body appendages develop. Finally, the adult bees emerge.

(iv). Adult

- The adults emerge from the cocoon and bite a hole in the top of the sealed cell to come out. Immediately after emergence, the adult workers are a light colour, and then become darker.
- The total time taken to develop from egg to adult is 15–16 days for a queen, 20–21 days for a worker, and 24 days for a drone. Honeybee life cycle as follow:

Figure 9: Life Cycle of a Honeybee

7. Apiary Site Selection

Bee lives in beehive which is located in an apiary. Thus, an apiary is a place where beehives are placed and managed to allow maximum food gathering by bees. It is also termed as “bee yard”. The nector flow in an area at a particular time is dependent on the plant species of the locality and weather conditions. Hence, the selection of site is very important to ensure regular flow of nector by bee colony. While as a beekeeper we can do few efforts to enhance the nector flow. A good management of bee colony may be one of the important efforts. It is recommended to maintain strong colonies at the time of maximum nector flow to maximize honey production.

(a). Locating an Apiary: The selected site should be in proximity for easy and regular supervision. There are several factors should consider while selecting a site to place beehives. Few are as follows

- Apiary should be located in areas of sufficient sources of nectar and pollen yielding plants. Bees usually forage within a 2-3 km radius of their hives, so make sure there are food sources within that radius.
- The site should be dry without dampness. High relative humidity will affect bee flight and ripening of nectar.
- Easy access to an apiary site throughout the year, with a hard path down to the apiary.
- Apiary should be established away from roads and other busy places.
- A flat site is easier to place hives.
- Apiary should not be located in animal grazing areas because beehives may be toppled.
- The site should receive sun rays in morning and evenings and shade during hottest part of the day.
- The site should be sheltered from wind, so that foragers don't struggle to land at the hive entrance and the roof stays on. A hedge provides good cover against the wind.
- Clean fresh running water should be available in the apiary or nearby apiaries.
- Dense foliage cover can make hives too wet and cold; however, some shade in the afternoon helps the bees to work less to cool the hive or even dying from heat exhaustion or collapsing honeycombs. Hence, avoid placing hives under dense foliage.
- Enclose the apiary with a barrier of some sort, such as a hedge or fence to force the bees to fly in above head height. Avoid establishment of apiaries in poor drainage areas and heavy pesticide use areas.
- Keep the area around the hives clear of tall weeds or grass. Cut grass and weeds – don't use spray of any kind.
- The distance between two hives should be atleast 3 meters.
- An apiary should not have more than 25-40 hives. If too many hives are placed into an apiary the bee colonies compete with each other.
- Facing the hive entrance to the East is the best way to get the most work out of bees as they usually fly from morning until early afternoon. If the bees see the sun early, they will start work earlier.


Figure 10: Selection of Apiary Site

7.1 Apiary management

The goal of apiary management is to aid the colony to build up to its maximum during the main nectar flow and to survive the dearth. Well-managed colonies assure the greatest possible return for the beekeeper.

Management of colonies: A general apiary management practices should follow in an apiary

(a). Colony Inspection: Inspect the beehives at least once in a week during the honey-flow seasons preferably during the morning hours to observe the presence of healthy queen, brood development, storage of honey and pollen, presence of queen cells, bee strength, growth of drones and presence of bee enemies like wax moth, mites, and diseases.


Figure 11: Colony Inspection

(b). Cleaning in Beehive: Clean hive in the following sequence: roof, super chamber, brood chambers and bottom board. Use thin knife to scrape and destroy eggs of wax moth laid in slits or cracks of beehive.


Figure 12: Cleaning in Beehive

(c). Feeding Bees with Sugar Syrup: Provide sugar syrup (1 part sugar and 1 part water) to feed bees during dearth period. Feed all the colonies in the apiary at the same time to avoid robbing particularly in dearth period.

Figure 13 : Feeding Bees with Sugar Syrup

(d). Addition of Artificial Comb Foundation Sheets: Comb foundation sheets are thin sheet of beeswax with the cell bases of worker cells embossed on both sides in the same manner as they are produced naturally by honeybees. The comb foundation sheets are fixed in the empty wooden frames (one in each) so that bees raise them as worker combs for laying eggs or storing honey, which increases the honey yield.

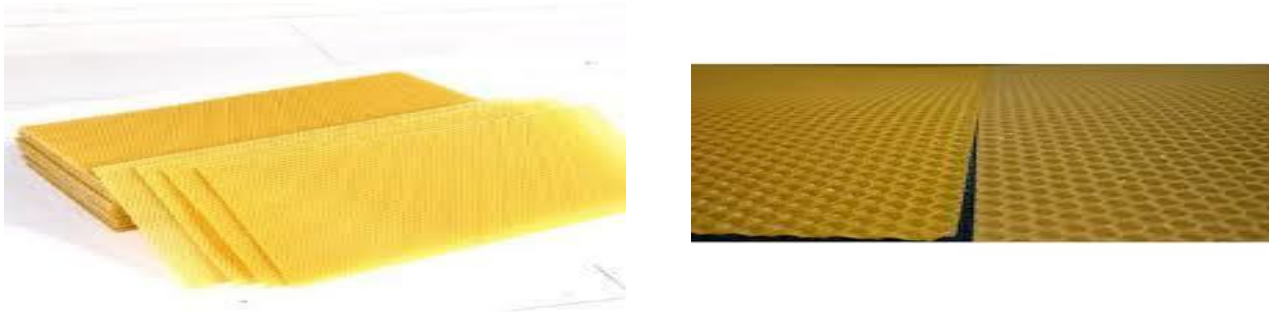

Figure 14: Addition of Artificial Comb Foundation Sheets

Using comb foundation sheets has a number of advantages-

- Comb foundation sheet saves the bee's time and energy in building new combs.
- It helps in production of straight regular combs which are easy to handle and fits well in honey extractor.
- Combs are stronger and will not be damaged during migration.
- Drone production in a hive can be minimized as the foundation sheets does not have the larger cells needed for drone rearing. When the bees want to rear drones, they adapt the foundation and make larger cells.

8. Bee Swarming and Management

Swarming is the natural process of multiplication of honeybee colonies. In this process the old queen bee accompanies the swarming bees, leaving behind a cross-section of the old population, having a

few queen cells from which the new queen bee emerges. In case the swarming colony is not managed properly and timely, it may issue secondary and tertiary swarms and causes great loss to the beekeeper. Sometimes, when bees swarm in the end of the breeding season the new queen in the mother colony remains unmated and ultimately bee strength dwindles. Even if the queen mates after some days, the colony is unable to build up to a desirable strength for the full exploitation of ensuing main honey flow.

The appearance of drones, queen cells and over-crowded condition in the brood nest are essential pre-requisites of a swarming colony. The presence of larger cells with coarse surface on the periphery of the comb also indicates that the colony is going to issue a swarm.

A. Control method of Swarming

(a). Preventive measures: Prevention of swarming in a colony is concerned with the steps that need to be taken to prevent over-crowding and queen cell construction in the honeybee colony.

(i) Removal of congestion: To avoid congestion in a colony, the timely and adequate provision of space is the most important and vital operation to be carried out. As a good beekeeper you should always remain ahead of bees in providing the space. The drawn combs if available should be inserted, otherwise frames with comb foundation sheets be added. Foundation sheets should be properly fixed in the frames and embedded on wires so that bees may accept them easily. These new frames should be put in between the middle bee frames having honey or brood so that these are immediately accepted. After inserting new frames, push all the frames towards one side to ensure proper bee space. The colony which is already full with 10 bee frames may be provided with a super if division of the colony is not desired. While providing super, to make the bees accept new chamber easily, baiting in the form of one or two bee frames with some food reserves or brood should be provided in between empty drawn combs/frames with foundations in the super.

(ii). Reversing: When the colonies are at super, reversing the chambers (brood chamber with super and vice versa) is the simplest and easiest method of swarm prevention. It should be done at fortnightly interval. The queen bee has a tendency to restrict her activities in one chamber only. Consequently, that chamber usually becomes over- crowded with the brood and sometimes with food. By reversing the chambers, more space becomes available for laying. The queen bee in the due course of time will shift to the lower chamber, thus relieving the immediate congestion and deterring the construction of queen cells.

(**b). Remedial Measures**

(i). Measures such as clipping of queen which involves cutting the wings of the queen by half especially one wing; caging the queen by putting wire entrance guard or by placing queen excluder in between bottom board and brood chamberand destruction of queen cells can delay the swarming but cannot completely prevent the colony from issuing a swarm.

(ii). The urge of swarming gets subsided by dividing the colonies. You can make more colonies either for own apiary or to sell them out to beginners. However, if your aim is not the

multiplication, then the divided colonies can be re-united just before the start of honey flow. By that time the swarming urge gets subsided. During uniting, the older queen should be killed and new one which would then lead the colony would show less swarming urge.

8.1 Collecting Swarms

There are various methods to capture a swarm. When the swarm first settles down and forms a cluster it is relatively easy to capture the swarm in a suitable box. Swarms normally cluster on a tree limb, shrub, fence post, or on the side of a building. When possible, remove the swarm gently, disturbing the cluster as little as possible, and put it directly into a hive or enclosed container (a cardboard box with a tight-fitting lid works well) to transport it to a new hive or location. When a swarm settles in a very high tree or on any other inaccessible structure, it is best to leave it there. Such swarms may be an after- swarm with one or more virgin queens and their successful capture can be very difficult. Sometimes you can knock these high swarms into a bucket at the end of a long pole and then lower it to a collecting box. The success rate, however, is very low.

Once you have successfully captured a swarm, introduce the swarm into your own equipment by either shaking or dumping the bees into an open hive with several frames removed or simply by shaking it in front of the hive. If you are successful in getting the queen with the rest of the swarm, the bees will adopt the hive. Using drawn combs is better than foundation when introducing swarms to an empty hive, but one or two drawn combs, preferably with pollen, brood, and/or honey (from a disease-free colony), combined with foundation also works. Instead of waiting for swarms to simply appear, you can try baiting swarms. Pheromone lures (available from beekeeping supply companies) placed in special light-weight bait hives or empty hive bodies (with or without drawn comb) can be used to lure swarms. Place trap boxes in exposed locations 8–15 feet off the ground (with entrance reduced to keep birds and squirrels out) and check weekly during the swarm season (April–June, depending on your location). This way you can transfer any swarms into a standard hive in a timely fashion

Precautions: Following precautions while swarming:

- Release the swarm in the beehive during evening hours.
- Smoke is not recommended to calm a clustered swarm. Smoke will have the opposite effect on a clustered swarm as many bees will become agitated and fly about instead of settling down.
- The colonies should be kept in shade as shade makes the bees to tolerate lesser ventilation and overcrowding to some extent.
- Bee colonies headed by older queen are more prone to swarming. Efforts to change the queen in early spring are remunerative in reducing swarming.

9. Seasonal Management

The climate and vegetation in different areas is different from season to season. Hence, follow specific management tactics as follows:

(a). Honey Flow Season Management:

- Provide more space for honey storage by giving artificial comb foundation sheets.

- Place queen excluder sheets in between brood and super chamber to confine the queen to brood chamber to prevent egg laying in super chamber as it is meant for honey production.
- Prevent swarming.
- Prior to honey flow, use sugar syrup to stimulate the queen to start laying in the spring.
- Divide strong colonies into 2-3 new colonies, if colony multiplication is required.
- Artificial queen grafting technique may be followed to produce new queens for new colonies. By following this technique, queens can be produced throughout the year. In normal case queen cells are constructed only in honey flow season.

(b). Summer Management:

- To reduce the effect of high temp in summer the colonies are kept under shade of trees or shade provided with sheds.
- Place gunny bags on all sides of beehive except entrance and sprinkle water twice a day.
- Increase ventilation by introducing a splinter between brood and super chamber.
- Provide sugar syrup and pollen supplement.
- A source of fresh water within a short distance of an apiary is essential. Water is required to blend with the food and to lower the temperature of the hives during hot weather

(c). Winter management

- Strong colonies perform well in winter as more bees produce heat.
- All cracks' crevices and holes should be closed.
- The direction of hives should be in such a way to avoid winds entering.
- Artificial diet should be given to maintain strong and disease-free colonies.
- Provide new queen to the hives.
- Winter packing in cooler areas

(d). Rainy Season/Monsoon Management

- A regular examination of the colony immediately after rains.
- Clean the hive to reduce undue water contents inside the hive.
- While raining when bees are confined to the hive, feed them with sugar syrup.

10. Equipment Needed for Honey Extraction

Most tools can either be found around the house or are relatively inexpensive to shop. Let's take a look at what we should have on hand before harvesting honey. Beekeeping equipment's: -

1) Bee box

2) Frames

3) Protective Clothing

4) Smoker

5) Hive Tool

6) Knife

7) Honey Extractor

1. **Bee box:** - This is the box where the bees live in and used to store honey. There are three different sizes: deep, medium, and shallow. Various parts of box.

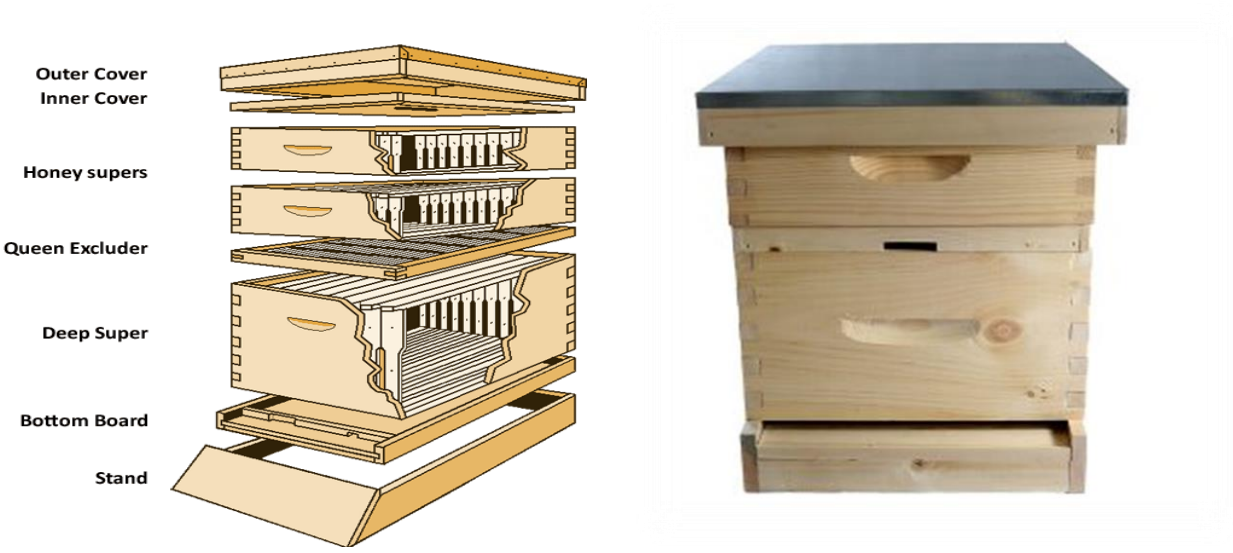

Figure 15: Bee Box

a. **Outer cover**: - The outer cover is the “roof” of hive used to prevent the box from rain.
b. **Inner cover**: - Helps in increase the ventilation and makes sure the bees do not glue the outer cover to your hive.
c. **Honey supers**: - Honey super is the box where your bees collecting surplus honey for harvesting.
d. **Queen excluder**: - A queen excluder is a grate that is used to keep the queen in the hive body and out of the honey super.
e. **Deep super:** - The lower boxes of the hive where they brood are raised, sometimes referred to collectively as the brood chamber.
f. **Bottom board:** - The bottom board is the base on which the hive sits and provides the entrance and landing board for the bees to enter in.
g. **Stand:** - Stand is generally used for the maintaining safe distance between box and land.

The hack between the deep super and bottom board is remained for the travelling of bees in and out.

2. **Frames: -** These are the structures where the bees create the honeycomb, which they then fill with eggs, nectar, or pollen. These have a delicate beeswax wafer in the center, called foundation

Figure 16: Frames

3. **Protective clothing:** To protect beekeepers' eyes and nose from stings at the time of work near the apiary, proper cloths are required. As novice beekeepers you should always wear gloves and a hooded suit or hat and veil. The face and neck are the most important areas to protect, hence you should wear at least a veil.

   Defensive bees are attracted to the breath, and a sting on the face can lead to much more pain and swelling than a sting elsewhere, while a sting on a bare hand can usually be quickly removed by fingernail scrape to reduce the amount of venom injected. The protective clothing is generally light colored and of a smooth material. This provides the maximum differentiation from the colony's natural predators. 'Stings' retained in clothing fabric continue to pump out an alarm pheromone that attracts aggressive action and further stinging attacks. Washing suits regularly and rinsing gloved hands in vinegar minimizes attraction. The important clothing and accessories are as follows:

   (a) **Bee veil:** It is a cap made of cloth and wire or fabric net. It is worn over face for protection against stings. It should be made up of black nylon netting screen (12-mesh). Veils should be made to fit snugly around the hat and to fit tightly to the shoulder leaving enough space between veil and face.

Figure 17 : Bee veil

(b). **Gloves:** Bee gloves are made of tightly knit cloth (or) soft leather. They cover the fore arms. The gloves are useful for the beginners to develop confidence in handling bees. But handlings of frames will be cumbersome if gloves are worn

Figure 18: gloves

(c). **High boots:** A pair of gum boots will protect the ankles and prevent bees from climbing up under trousers.

Figure 19 : High Boots

(d). **Overalls:** Also known a bee suit, is a protecting garment worn loosely over the clothes so that the bees cannot get under the clothes. Light coloured cotton. materials are preferable since they are cooler and create less risk for antagonizing bees. It should be worn bee-tight so that the bees are not able to enter from the sleeves.

Figure 20: Overalls

4. **Smoker:** - Smoker is used for the pretending the honeybees from the hive. So that is the opportunity for the beekeeper to open the beehive and work while the colony's defensive response is interrupted

Figure 21: Smoker

5. **Hive tool:** - Hive tools are used to separate hive bodies and frames that have been stuck together by the bees with Propolis (bee glue), scraping extra comb built up in the incorrect place (burr comb).

Figure 22: Hive Tool

6. **Knife:** An uncapping knife can be any kind of knife that has been warmed in water. However, you can also purchase uncapping knives that are heated by electricity, so you don't have to continuously dip your knife in water before continuing the uncapping process. This implement removes the wax covering that the bees deposit over the honey.

Figure 23: Knife

7. **Honey extractor: -** This equipment consists of cylindrical drum containing a rack or box inside to hold the super frames. The box is fixed to a rod at the centre, and it can be rotated by a set of two gear wheels. The frames with honey cells are decapped by a sharp knife after dipping it in hot water and fixed to the slots provided in the box which is rotated by the handle. The rotation should be very gentle and slow at first and the speed of revolution increased gradually. With some experience the correct speed can be learnt. The honey in the cells is forced out in droplets by the action of the centrifugal force and can be collected in vessels through an exit in the drum. As cells are constructed on both sides of the comb, by changing the sides of the frames and again rotating, the honey contained in the cells on the other side can also be drained off. Particular care should be taken while handling heavy combs or those which are flimsily attached to the frames.

Figure 24: Honey extractor

11. Honey Processing

Flow diagram of Honey Processing

Harvesting and Transport of Raw Honey

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Liquefaction of Granulated Honey

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Straining

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Filtration

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Moisture Reduction

↓

Pasteurization

↓

Cooling

↓

Bottling

↓

Labelling

11.1 Harvesting and Transport of Raw Honey

Some procedures for harvesting and transport of honey must be followed, so that there should be efficient collection, to maintain its original characteristics and composition, hence its quality. In rainy days or when the relative humidity is high, harvest of honey is not recommended, because this would lead to increased moisture content in the honey. When harvesting, care should be taken not to throw smoke directly on the honeycombs; this should be performed at small amounts, by using the bee smoker far away from the frames of honeycombs. These procedures are followed so that there is reduction of the incorporation of the smoke able smell into honey. High colony yields are only possible with well populated colonies in areas with abundant nectariferous flora. The honey needs to be harvested before the bees can consume it for further colony development, but sufficient quantities have to be left to provide for the basic needs of the colony. However, the different management and harvesting techniques can influence the final quality of the honey.

Honeycombs that are at least two-thirds capped are uncapped using a long-handled uncapping fork, the beekeeper scrapes the caps from both sides of the honeycomb onto a capping tray. The honeycombs are inserted into an extractor, a large drum that employs centrifugal force to draw out the honey. The extractor is started at a slow speed to prevent the breaking of combs. As the extractor spins, the honey is pulled out and up against the walls. It drips down to the cone-shaped bottom and out of the extractor through a spigot. Positioned under the spigot is a honey bucket topped by two sieves, one coarse and one fine, to hold back wax particles and other debris. The honey is poured into food grade plastic buckets or drums and taken to the Industrial processor.

Composition of fully Ripned honey

Constituents	Per cent (Approx.)
Levulose	41.0
Dextrose	35.0
Sucrose	1.9
Dextrin	1.5
Minerals	2.0
Water	17.0
Undetermined (Enzymes, vitamins, pigments, etc.)	16.0

Pigments: Carotene, chlorophyll and xanthophyll are the important pigments present in honey.

Minerals: Potassium, Calcium, Phosphorus, Sodium, Magnesium, Manganese, Copper, Sulphur, Silica and Iron are the minerals present in honey.

Vitamins: Vitamin B1 (Thiamine), B2 (Riboflavin), Nicotinic acid, Vitamin K, Folic acid, Ascorbic acid and Pantothenic acid are the vitamins present in honey.

Physical Properties of Honey

- Honey is hygroscopic. If exposed to air it absorbs moisture.
- Honey is a viscous fluid.
- Heating of honey reduces viscosity.
- Specific gravity of pure honey is 1.35 to 1.44 gm/cc.
- Refractive index of honey helps to find moisture content which is measured using refractometer.

Purity Test for Honey

- Measure specific gravity of honey using hydrometer.
- If the specific gravity is between 1.25 to 1.44, honey is pure.

Aroma and Flavour of Honey

- It is acquired from the nectar of the flower.
- It is lost if heated or exposed to air for long time.

Colour of Honey

- Depend upon the nectar of flower and the plant species.
- Dark honey has stronger flavour.
- Lighter honey has more pleasant smell.

The vehicle used in transporting the honey to the processing area must be subjected to a hygienic process. It is necessary that the vehicle did not recently transport any material that might have left some type of toxic residue, or otherwise has strong odor. Long distance transport and keeping the honey buckets in open before processing may lead to the deterioration in quality as it may lead to increase in the hydromethyl furfural and decrease in Diastase activity.

11.2 Liquefaction of Granulated Honey

Honey crystallization or granulation is a natural phenomenon by which honey turns from liquid (runny) state to a semi-solid state. Crystallization of honey is neither the adulteration of honey with sugar nor it is an unnatural product. Most pure raw or unheated honey has a natural tendency to crystallize over time. Crystallization does not affect the honey except for colour and texture. Crystallized honey is not spoiled and preserves the flavour and quality characteristics of the liquid honey. Some honeys crystallize uniformly; some will be partially crystallized and form two layers, with the crystallized layer on the bottom of the jar and a liquid on top. Honeys also vary in the size of the crystals formed. Some form fine crystals and others large, gritty ones. The more rapid honey crystallizes, the finer the texture will be. Crystallized honey tends to set a lighter/paler colour than when liquid. This is due to the fact that glucose sugar tends to separate out in dehydrating crystals form, and that glucose crystals are naturally pure white. Darker honeys retain a brownish appearance.

Heating is the most widely used processing method in the honey because of granulation, high viscosity at low temperature and existence of yeast. According to the various honey regulations, it is forbidden to heat honey as it impairs its quality significantly. Therefore, honey should be liquefied in such a way as to avoid heat damage to its various constituents. The liquefaction time depends on the glucose concentration: the higher the glucose content and the larger the crystals, the longer the liquefaction time. Heating should be applied indirectly, not by direct flame to a container. Heating at higher temperatures of for a longer period of time will cause honey damage, development of hydroxymethylfurfural, loss of diastase, decrease of aroma and in extreme cases building of a caramel like taste because of maillard reaction. Overheating is determined most easily by the measurement of hydroxymethyl furfural (HMF) and honey enzyme activity. Honey should be heated with care to prevent overheating.

Heating by water bath:

a) This is best for the batch process and also from point of optimal heat transfer. The care should be taken that temperature should not go beyond 40oC to 45 oC. The time required will depend upon amount of honey taken, the extent of granulation and kind of honey. Stir occasionally to even the heat throughout the honey, as crystallized honey is a poor conductor of heat. It is a lengthy process and may take several hours. There are only few commercially available heating water bath systems.

b) Honey can be liquefied by using the double jacketed vat. Hot water was circulated in a water jacket around the honey container to heat honey. The temperature of the circulated water should be maintained in such a way that maximum temperature of honey should be around 45 degree Celsius.

c) Immersion heaters can be placed on the granulated honey, which progressively sink upon honey melting. This high-quality food-grade stainless steel immersion heater can be used. Simply hang the heater on the top of the honey drum with the heat coils resting on the inside of the tank. The temperature controller is also there, and a heat range from 30oC to 80 oC can be adjusted.

d) Honey can be liquefied by placing the vessels on electric plates or directly placed on the wood fire. Although an air gap is maintained between the electric plates or the wood fire and the honey drum, but still it is a kind of direct heating of honey and is not recommended. This type of heating is widely used by small beekeepers.

Water bath method utilizing geothermal water

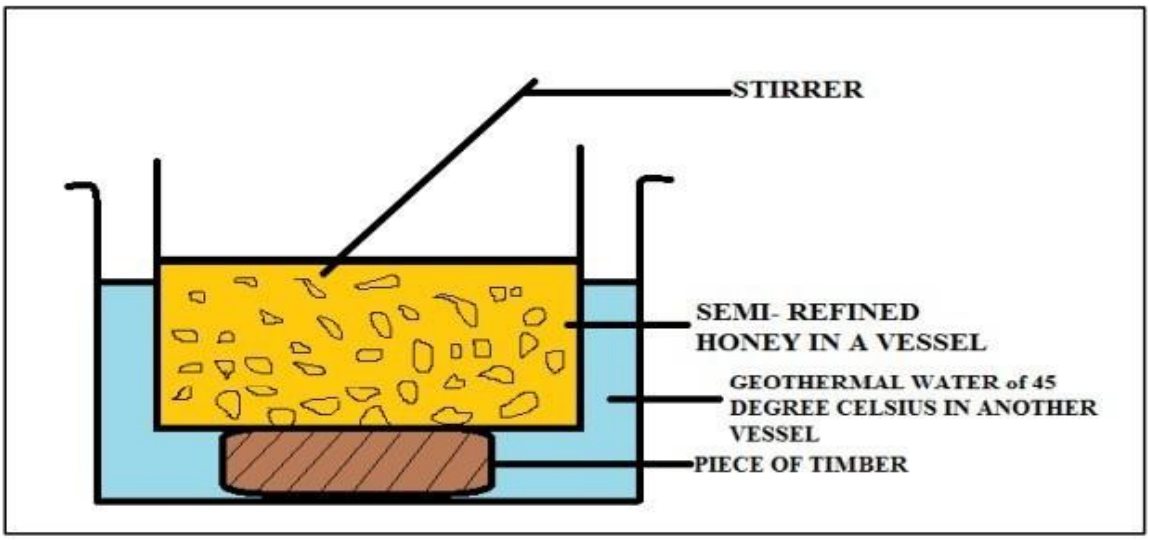


Figure 25: Water bath

11.3 Straining

The straining operation to remove suspended solids (including large wax particles) is carried out either manually or by mechanical means. The method and the equipment used for straining depend on the size of the operation. In small-scale operations, straining is done using cloth or nylon bags, which are frequently cleaned to remove the suspended particles. In large-scale operations, the straining operation is combined with the preheating (up to 40°C) operation in a jacketed tank fitted with a stirrer. The uncapped honey is allowed to strain through a cotton cloth or net into a dry suitable container. After that the folded straining net or cloth is tie over the mouth of the container. Than allow the liquid honey to settle overnight. The scum needs to be removed from the surface of the honey through spoon before the honey is packed.

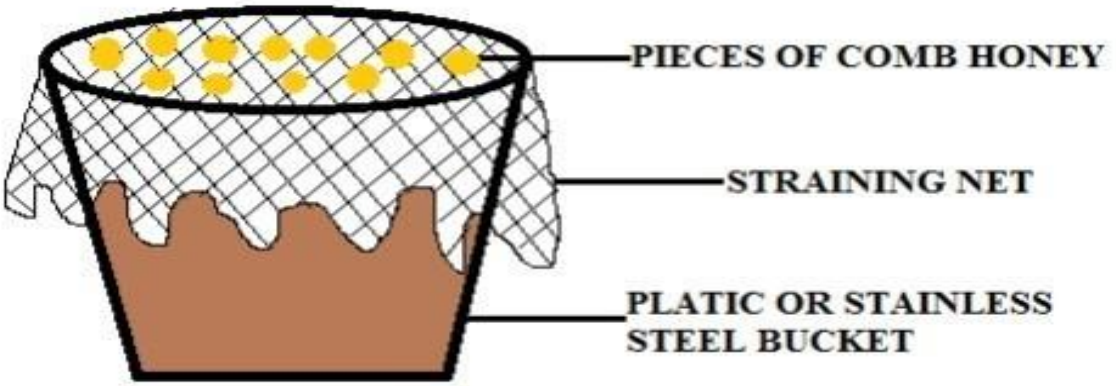


Figure 26: Straining Process

11.4 Filtration

The strained honey is further processed using pressure filters. Typically, a polypropylene micro filter of 80 µm is used as a filter medium. The honey temperature is maintained between 50 – 55°C, which prevents the melting of the beeswax. Large-scale processors subject honey to coarse filtration, centrifugal clarification, fine filtration, and blending, prior to filling. The filtration should be done carefully so that required pollen count in the honey must be retained. The various types of filtration units which are available are filter press, sparkle filters etc.

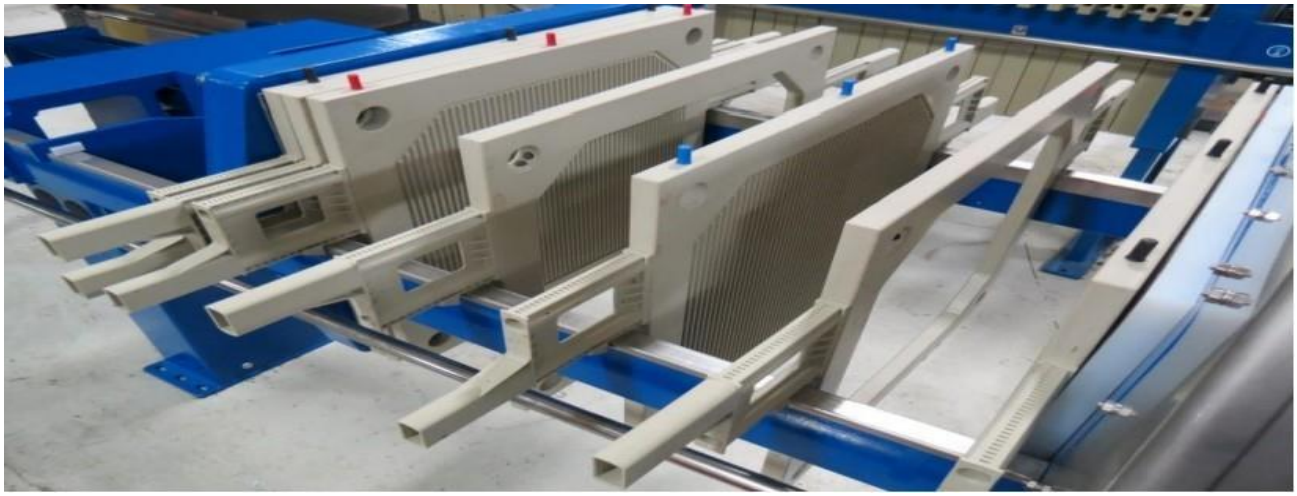


Figure 27: Filter press

11.5 Moisture Reduction

Moisture is one of the most important parameter of honey quality. Most of the extracted honeys are having the higher moisture than the prescribed standards because of extraction of unripened honey. The amount of water present in honey determines its stability against fermentation and granulation. Honey having high water content ferments easily with time. So, it is necessary to process the honey by subjecting it to thermal treatment to prevent fermentation by sugar tolerant yeasts. Treatment in a closed system minimizes losses of volatile aroma during heating. The honey streams help in increasing the exposed surface area of honey in contact with drying air. In this multiple effect evaporation system, raw honey was preheated (40–45 °C) and then filtered through 80 lm polypropylene micro-filter. This honey was heated up to 60–65 °C in first effect to destroy osmo-phillic yeast cells, held at 60°C for evaporation of water under vacuum and Then cooled in third effect before passing into settling tanks for bottling.

Equipment consisted of a closed housing with an inlet port on the top side and an outlet port on the bottom edge. The honey will enter the inlet port and flows downward across a series of trays arranged in a zigzagged manner up to the outlet port. A metal screen is used on each tray to spread the honey evenly throughout the tray. There is a coil and an evaporator heater used to dry and warm the air circulated over the honey layer to remove moisture.

11.6 Pasteurization of Honey

Honey can be consumed pasteurized or not. Honey is low in humidity and high in acidity, which means that bacteria cannot survive in it. Honey is pasteurized for quality reasons. Pasteurization of honey reduces the chance of fermentation and also delays granulation. Different Temperature and Time combinations are suggested. Heating the honey to 63°C for 30 minutes or 65.5°C for 30 minutes or temperature be brought to 77° C momentarily and followed by the rapid cooling.

Figure 28: Pasteurization uni

11.7 Bottling

Depending on the market requirement, honey may be bottled directly into small containers for retail sale or into large drums for storage or export to another countries. In an effort to appeal to a wide range of consumers, honey is packaged in containers of many different sizes and styles. These include glass, plastic containers, honey tubs, or even squeeze bottles, Like most aspects of honey processing, bottling can involve automation in large operations, or manual labour such as a hand valve on a plastic pail in smaller operations. Presence of air bubbles in the packaging containers can provoke nucleation and crystallization of honey. The filling of honey in the bottles is normally done at the high temperature. Filling

at higher temperatures eliminates air bubbles and avoids air incorporation during packing due to low viscosity.

Figure 29: Bottling

11.8 Labelling

The label on a honey container in a retail outlet should include the word "Honey" or, possibly, an indication of a floral source, such as “Mustard Honey. “It also needs to state the net weight, the name and address of the honey dealer and the FSSAI registration number of the packer, as well as the nutrition facts table. The label should also identify the country of origin and indicate whether the honey is creamed, liquid or pasteurized. Honey sold at a Apiary or farmers' market does not need to meet the same labelling requirements because it's usually coming directly from the producer

11.9 Storage

Honey quality deteriorates during storage with time which is actually governed by the storage temperature, moisture content of honey, storage structure and ambient relative humidity. During storage honey becomes darker in colour particularly at higher temperatures. Sugars and vitamin content in honey decrease and acidity increases during storage. The breakdown of various sugars results into increase in hydroxyl methyl furfural (HMF) which is a very sensitive indicator of honey quality. Higher HMF is also an indication of heated honey. During prolonged storage, flavour of the honey is also lost. Honey with moisture content above 19 per cent is known to ferment if stored at temperatures between 11-20°C. Following points should be noted to ensure that honey doesn't deteriorate during storage:

- Honey should be stored in food grade glass or stainless-steel containers.
- The honey stored under refrigerated conditions does not spoil and shelf life remains quite long.
- Honey should be stored in an airtight container and the pack should immediately be closed after its use. It is so because honey being hygroscopic, may absorb moisture in an atmosphere with more than 20 percent relative humidity, which may trigger off some fermentation and spoilage may occur. The colour and taste may also change.
- Care should be taken to ensure that stored honey is free from contaminants.
- The room used to store honey should be dry, clean, and closed. The ideal room temperature for storing honey is 20°C.
- Always label the stored containers and include details of the harvesting date, treatment, and expected storage life.

- Studies on various unifloral melliferous honeys have revealed that the honeys do not conform to the quality when stored at 40°C even for 3 months, and the honey start losing their quality after 9 months when stored at room temperature. So, it is always better not to store the honeys for too long and should be finished at the earliest possible

12. Honey by Products

We mostly believe that honeybees only make honey. However, they also make other highly beneficial products like Bee Pollen, Beeswax, Propolis, Royal Jelly and Bee venom. These products are collectively called BEE PRODUCTS. **Honey** is the primary food for honeybees for their survival and sustainability. Along with honey, bees store **Bee Pollen** for protein, make **Wax** for the honeycomb, **Royal Jelly** – a royal food for the queen and young bees, **Propolis** – a sticky material to prevent insects from entering the honeycomb and the **Bee Venom** to sting.

The necessity of making these products is a natural instinct of honeybees. These products of honeybees have unique purposes and usage. For human beings, these products contain various medicinal benefits. Which is getting proved from recent scientific studies. These bee products are in use for centuries in every civilized society as it promotes health nourishment and immunize from various infectious diseases.

12.1 Beeswax

Beeswax is the material that bees use to build their nests. It is produced by young honeybees that secrete it as a liquid from special wax glands. Worker bees secrete wax when they are 14 to 18 days old. On contact with air, the wax hardens and forms scales, which appear as small flakes of wax on the underside

of the bee. About one million wax scales make 1 kg of wax. Bees use the wax to build the well-known hexagonal cells that make up their comb, a very strong and efficient structure. Bees use the comb cells to store honey and pollen; the queen lays her eggs in them, and young bees develop in them. Beeswax is produced by all species of honeybees, although the waxes produced by different species have slightly different chemical and physical properties.

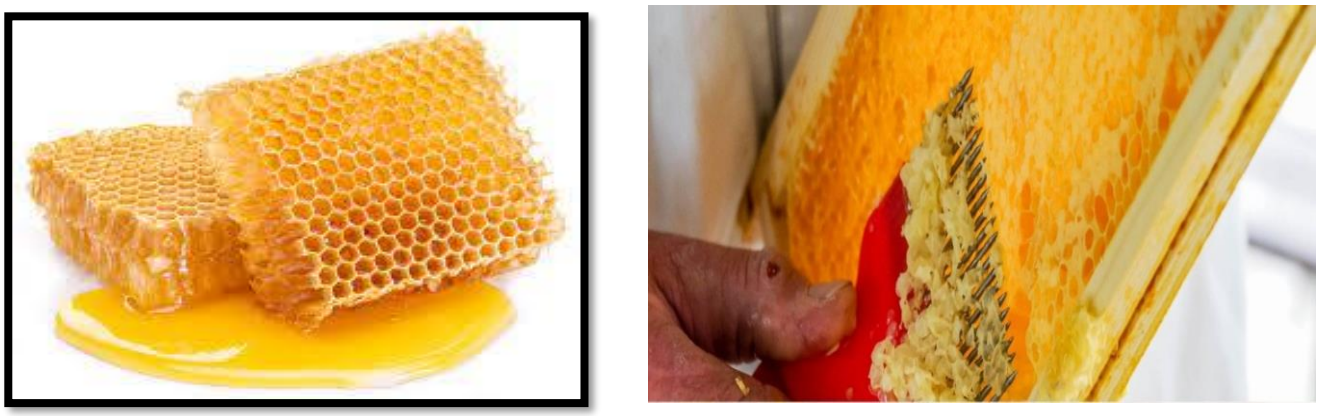


Figure 30: Beeswax

12.1.1 Composition and Properties

- Alcohols and fatty acids 70 to 74 per cent
- Free acids 13 to 15 percent.
- Saturated hydrocarbons 12 to 15 percent
- Vitamin A 40961U
- Specific gravity 0.95

12.1.2 Processing

Beewax is obtained from the cappings collected during honey extraction. Wax is obtained from old combs that are unfit for use and from combs damaged during honey extraction. Best grade wax is obtained from cappings where the recovery per cent is higher. In India, major proportion of wax is from combs of *Apis dorsata.*

12.1.3 Uses

- Mainly used by candle industry
- Used for preparing comb foundation sheets
- Used in cosmetics like cold creams, lipsticks, and rouges
- Used in pharmaceutical and perfume industry (ointments, capsules, pill coating and deodorants)

- Used for preparing shoe polish, furniture etc. for water proofing
- Used in adhesives, chewing gums and inks etc.

It is used in the manufacture of very many items of cosmetics like beauty lotions and creams, lipsticks, ointments, and pomades and of polishes for boots, floor and furniture, of lubricants, paint and varnishes, inks, electrical insulating apparatus and candles.

12.2 Bee Venom

Venom itself defines that the honeybees use this when they are at risk of an invader's attack. Sting of worker bee is attached to a poison sac where venom is stored. Newly emerged bee is unable to sting because she cannot insert the sting which is not fully chitinized. Also, little amount of venom is stored in the venom sac. A bee, when two weeks old has maximum venom in her poison sac

Figure 31 : Bee venom

12.2.1 Properties

Bee venom contains histamine, apamine, acithinase, hydrochloric acid, formic acid, orthophosporic acid, sulphur, calcium, copper and magnesium sulphate

12.2.2 Production

Bee venom is commercially obtained by the use of electric shock. An electric current is passed through copper wires at 12 volts. The bees get shock, irritated and release venom by inserting the sting into a thin nylon cloth below the copper wires. Venom is deposited on a glass plate placed below the nylon sheet. The venom on drying is scrapped from the glass plate. One *Mellifera* colony yields about 50mg of venom.

12.2.3 Uses

- Rheumatism can be cured by *apitherapy where* bees are made to sting the patient
- Venom can be used as sub-cutaneous injection for treating rheumatism
- Ointment made by mixing apitoxin, vasaline and salicylicacid (1:10:1) can be applied on affected areas.
- It has stimulating effect on heart muscles and decreases cholesterol level and lowers blood pressure.
- It can cure neurosis, endoarteriosis, endoarthritis and neuraglia
- Antihistamine creams or injections are used as anti-allergents

12.3 Propolis

Bees make Propolis by using the sticky resins from the tree buds, sap and other plant sources. Beekeepers call it bee glue. Its usage is to seal the gaps or cracks in the beehive. Therefore, it reduces the entrance of the beehive to stop the invader. Propolis gathered by bees from resinous exudes of tree. In the bee colony propolis is used for sticking frames, sealing cracks and crevices but it is a contaminant of comb wax. Propolis is obtained by scrapping it from the frames

Figure 32: Propolis

12.3.1 Properties

It contains resins and balsams 55 per cent, ethanol, and scented oils 10 per cent and pollen 5 per cent.

12.3.2 Uses

- Used in preparing ointments for treating cuts, wounds and abscesses in cattle.
- Mixed with vasallne to soothen burns.

12.4. Royal Jelly

Royal jelly is secreted by gland of nurse bees of the age of 6 to 12 days when the glands are fully active. It is very nutritious food and is fed to the young worker larvae and the queen larva and adult. Royal jelly is milky or light pale in colour.

Figure 33: Royal jelly

12.4.1 Properties

It contains proteins 15 to 18 per cent. Proteins are mainly amino acids (alanine, arginine, aspartic acid, gultonic acid, glycine, isoleucine, lysine, methionine, phenyl alanine, tryptophane, tyrosine and serine). It also contains lipids 2 to 6 per cent, carbohydrates 9 to 18 per cent (glucose, fructose, melibiose, trehalose, maltose and sucrose) and ash 0.7 to 1.2 per cent. Vitamin A, B and C, iron, copper, phosphorus, silicon and sulphur are also present.

12.4.2 Production

The queen cell is trimmed to the level of the royal jelly. After 2 or 3 days of grafting, larvae are gently removed with forceps and the royal jelly is removed with royal jelly spoon. This is stored in refrigerated conditions. In case of *Apis mellifera* 200mg of royal jelly is obtained from a queen cell.

12.4.3 Uses

- Responsible for queen determination
- Very nutritious food for human beings

12.5 Pollen

Pollen is a male reproductive substance of the flower that honeybees carry while collecting the nectar from the flowers. This way Honeybees play a significant role in the pollination of crops across the world. It is collected by pollen trap from ingoing pollen foragers. Pollen is a rich protein source for human diet.

Figure 34: Bee pollen

12.5.1 Uses

In addition to providing man with very valuable materials as honey and beeswax, the honeybees are also useful to him in aiding in pollination of many of his crops. In fact, it has been claimed that the value of bees in pollination of crops is ten to twenty times the value of honey and wax they produce. Certain crops like apples, alfalfa and clover almost entirely depend upon bees for their pollination. Even among some regularly self-pollinated crops, the yield is considerably increased after visit of bees.

13. Pest and disease in Beehive

Honeybee colonies are vulnerable to various pests and diseases for bee brood, adult bees and hive products. Honeybee colonies are affected by a variety of parasitic mites. Wax moths are the major pests of honeybees in tropical and sub-tropical regions and cause greater damage especially during dearth season. Similarly, several species of ants and wasps are known to predate on the brood and adult honeybees. Many species of birds and mammals including monkeys have an impact on beekeeping industry in many parts of the world.

Among bee diseases, only a few viral, bacterial, fungal and protozoan diseases are catastrophic to beekeeping industry. However, a successful, least expensive and ecofriendly management of pests and diseases is indispensable for overall development of beekeeping for honey production and effective crop pollination.

13.1 Parasitic mites attacking honeybees and their management

Parasitic mites are economically important as they cause significant loss to honeybee colonies. These are categorized into endoparasitic and ectoparasitic mites. Acarapis woodi, Varroa destructor, Varroa jacobsoni and Tropilaelaps clareae are found to be destructive parasites on honeybee colonies

(a). Acarapis woodi (Tracheal mite)

Acarapis woodi is an endoparasite mite which inhabits the tracheae and air sacs of adult bees. It infests tracheae that would lead from the first pair of thoracic spiracles of adult bees. The damage caused by this mite is commonly called as Acarine or Isle of Wight disease.

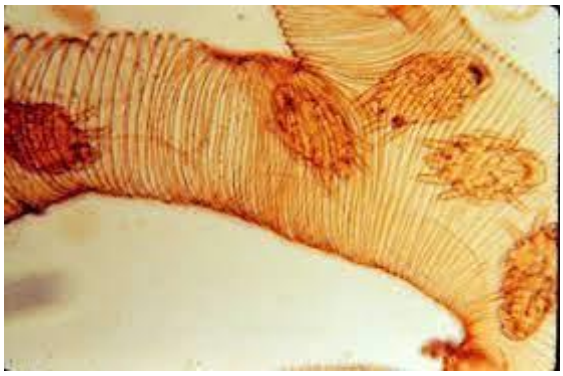


Figure 35: Acarapis woodi

(i)Symptoms:

- The infested bees have distended shining abdomen. They generally crawl on the ground with disjointed K-shaped hind wings.
- Presence of dark brown spotting on the tracheal wall which become blackened, brittle and also damages the flight muscle fibres.
- A secondary coating on the interior part of the trachea of infested bees leads to insufficient supply of oxygen.

(ii) Diagnosis

- About 10 suspected bees with K-shaped wings are anesthetized and pinned on their back to a piece of cork through the thorax.
- The head and a chitinous ring like structure around the opening to the thorax are removed with a pair of forceps under microscope.
- On exposing the trachea by teasing, various developmental stages of mites can be seen. z Serological technique such as Enzyme Linked Immunosorbent Assay (ELISA) is also effective in detecting the acarine mite.
- Acarine infestation spreads through emerging mites, robber bees, drifting bees, and beekeepers.

(iii) Management

- Treatment with 85% formic acid (5ml/day) regularly for three weeks.
- Six weeks of continuous exposure of bee colonies to the vapors of menthol and thymol controls the mite infestation.

(b). Varroa jacobsoni and Varroa destructor

Varroa destructor is widely distributed on the colonies of A.mellifera. Adult female Varroa mites are 1.4 to 1.9 mm long and 1.6 to 1.7 mm wide. They are dorsoventrally flattened pilose, reddish brown, crab shaped and could be seen with the naked eye. Males are ovoid much smaller than females and pale in colour. Several morphological features of them have made Varroa as a successful ectoparasite.

Figure 36 : Varroa jacobsoni and Varroa destructor

(i) Symptoms

- Varroa infested bee colonies become weak and show a spotty brood pattern with punctured capping.
- The mites pierce the soft intersegmental tissues of the abdomen and feed on the hemolymph.
- The bees become stunted with deformed legs and wings.
- The bees infested with many mites usually become crippled or die.
- Parasitized pupae would appear to have small pale or reddish-brown spots on their normal white bodies.

(ii) Diagnosis

- Presence of sealed brood cells with perforations.
- Mites are detected by pulling up capped brood cells using a scratcher.
- Mites can be observed on a plastic sheet smeared with sticky material such as petroleum jelly placed on the bottom board.
- Guanine, the faecal material of Varroa could be seen as white spots on the walls of brood frames in highly infested colonies.
- Varroa mites can be detected by shaking bees in liquids like absolute alcohol, ether etc. in a rotatory shaker.

(iii) Management

- Hand removal of sealed drone brood from freshly infested colonies.
- Creating the colonies broodless by caging queen for three weeks.
- Dusting of wheat flour/sugar powder on bee combs at an interval of 10 days.
- Allowing of mites to move on the culture isolates of the entomopathogenic fungi such as Hirsutella thompsonii and Metarhizium anisopliae is found effective in control of population.
- Thymol based fumigants, Api life var and apiguard are also effective.

(c)Tropilaelaps clareae

Tropilaelaps clareae is a native parasite of the giant honeybee, A.dorsata and recently it switched over to the colonies of western honeybee, Apis mellifera on its introduction in to the Asian continent.

It is an ectoparasitic mite that exploits the brood of Apis dorsata andApis mellifera. The adult females are 1.0 mm long and 0.55 mm wide, elongated, and light reddish brown in colour.

Figure 37: Tropilaelaps clareae

(i) Symptoms

- A scattered brood patterns.
- The brood cells have sunken capping
- The adult mites can be seen often running on the combs.
- Partly eaten pupae with deformed and mutilated wings and stunted abdomen of the worker bees.

(ii) Diagnosis

- The most reliable method of diagnosis is to open large number of sealed brood cells and examine the nymphs and adult mites.
- Presence of dead mites on a thick sheet of paper inserted on the bottom board.
- The debris collected from infested colonies are placed in a jar filled with alcohol and mites may float on the jars surface on shaking.

(iii) Management

- Creating broodless conditions in bee colonies for 2 to 3 weeks by caging the queen.
- Application of effective doses (200 mg/frame) of sulphur for four weeks.
- Fumigation of 85% formic acid for three weeks during infestation.

13.2 Insects and Pests

Honeybee colonies are prone to different insect pests which cause serious losses to beekeeping. The wax moths, ants and wasps are the major insect pests in Indian conditions.

(a) Greater Wax Moth

The greater wax moth, Galleria mellonella is a serious pest of honeybee colonies in India. The dearth season results in the food scarcity to bees. Under such conditions, bee colonies become weak and are attacked by wax moth. It infests combs of all honeybee species throughout the world.

Figure 38 : Greater Wax Moth

(i) Nature of damage

- The wax moth larvae burrow into the comb by producing silken tunnels along with their excreta.
- They feed on the propolis, pollen and beeswax in the combs.
- During severe infestation, the combs are seen covered with silken web with numerous black faecal particles by destroying the combs.
- The grownup larva spins a dense silken cocoon, which are usually attached firmly to the hive parts.

(ii) Management

- Keep bee colonies strong, hygiene and healthy with adequate food storage.
- Minimize cracks and crevices in the hive, providing artificial feeding during dearth season and removal of unoccupied old combs.
- Keep the bottom board clean. Collect and burn the debris periodically.
- Control diseases and other pests that make the colony weak.
- Avoid pesticidal poisoning which otherwise weaken the colonies.
- Remove extra combs from the hive, especially during dearth period.
- Destroy the silken tunnels to kill wax moth larvae in initial stages.
- Destroy severely attacked combs and melt them in water to render bees wax.
- Spray multiple embedded nuclear polyhedrosis viruses (NPVs) in a suspension on empty infested combs.
- The lethal concentrations of many commercial products of B. thuringiensis and M.anisopliae are found to be effective.

- The braconid wasp, Apanteles galleriae and the parasitic wasps, Trichogramma spp parasitize on the egg and larval stages of wax moth.
- Ethylene dibromide (EDB), paradichlorobenzene (PDB) and carbon dioxide (CO_2) are effective fumigants against wax moths in stored comb. Do not apply these in live colonies.
- Fumigation with following chemicals is very much effective in killing the larvae in stored combs in air tight rooms/containers/ chambers:
  – Smouldering sulphur @ 250-300 g/m3 space
  – Aluminium phosphide @ 0.75g/ m3space
- Chlorosol, a mixture of methyl bromide and carbon tetrachloride kills all the stages of wax moths including eggs.

(b). Wasp

Wasps are widely distributed highly destructive predators of honeybees. They attack on bees at hive entrance and also on the flowers. The giant hornet, Vespa mandarina, yellow banded wasp, Vespa tropica, the oriental hornet, Vespa orientalis, the brown wasp, Vespa velutina are the major wasp predators of honeybee colonies. They take over both brood and adult bees to feed their young ones in their nests.

Figure 39 : Wasp

(i) Management

- Collect and kill adult wasps during active predation.
- Locate and destruct wasp nests by fumigation with calcium cyanide or aluminum phosphide and spray carbaryl on their nests.
- The poisoned jaggery packed in gelatin capsules are glued to the thorax of the trapped foragers. On reach to the nests, the poisoned jaggery would be shared by the nest mates by killing the entire wasp colony.

14. Honey Standards by FSSAI

Honey shall comply with the following amended requirements and limits:

S. No	Parameters	Limits
1.	Specific gravity at 27° C, Min.	1.35
2.	Moisture percent by mass, Max.	20
3.	Total reducing sugars, per cent. by mass, Min. (a) For the Honey not listed below (b) Carviacallosa and Honeydew honey (c) Blends of Honeydew honey with blossom honey	 65 60 45
4.	Sucrose, per cent, by mass, Max. (a) For the Honey not listed below (b) Carviacallosa and Honeydew honey, Max.	 5.0 10
5.	Fructose to Glucose ratio (F/G Ratio)	0.95-1.50
6.	Total Ash, per cent. by mass, Max.	0.50
7.	(a) Acidity expressed as formic acid, per cent. by mass, Max (b) Free Acidity milliequivalents acid/ 1000 g, Max.	0.20 50.0
8.	Hydroxymethylfurfural (HMF) mg/kg, Max.	80.0
9.	Diastase activity, Schade units per gram, Min.	3
10.	Water insoluble matters, per cent. by mass, Max. (a) For the Honey not listed below (b) For Pressed honey	 0.10 0.5
11.	C4 Sugar, per cent. by mass, Max.	7.0
12.	Pollen count and plant element/g, Min.	5000
13.	2-Acetylfuran-3-Glucopyranoside (2-AFGP) as Marker for Rice Syrup	Absent**
14.	Foreign oligosaccharides (Max. Percent Peak]	0.7
15.	Proline, mg/kg, Min.	180
16.	Electrical Conductivity: (a) Honeys not listed under Honeydew, Max. (b) Honeys listed under Honeydew, Min.	 0.8 mS/cm 0.8 mS cm
17.	(a) $\Delta\delta^{13}C$ Max*. (Maximum difference between all measured values $\delta^{13}C$); per mil (b) $\Delta\delta^{13}C$ Fru - Glu (The difference in $^{13}C/^{12}C$ ratio between fructose and glucose); per mil (c) $\Delta\delta^{13}C$ Protein - Honey (The difference in 13C/12C between honey and its associated protein extract); per mil	± 2.1 ± 1.0 ≥ - 1.0

*$\Delta\delta^{13}C$ Max. is the maximum difference observed between all possible isotopic ratios measured ($\Delta\delta^{13}C$ fructose-disaccharides / $\Delta\delta^{13}C$ fructose-trisaccharides / $\Delta\delta^{13}C$ fructose-protein $\Delta\delta^{13}C$ glucose disaccharides / $\Delta\delta13C$ glucose-trisaccharides / $\Delta\delta1^{3}C$ glucose-protein/$\Delta\delta^{13}C$ disaccharides-trisaccharides/ $\Delta\delta13C$ disaccharides-proteins $\Delta\delta13C$ trisaccharides-protein).
**Minimum Required Performance Level- 1mg/kg

14.1 FSSAI specific provisions for labeling of honey

In addition to the labeling provisions as given in Food Safety and Standards (Packaging and Labeling) Regulations, 2011, the following specific provisions shall be applicable for labeling of honey:

(a) Honey shall be labeled as:

1. Honeydew Honey – If the product complies with the definitions given in by FSSAI “Honey which comes mainly from excretions of plant sucking insects (Hemiptera) on the living parts of plants or secretions of living parts of plants”

2. Blend of Honeydew Honey and Blossom Honey – If the product is mixture of Blossom or Nectar Honey and Honeydew honey

3. Carvia Callosa Honey – If the honey is derived from flower of Carvia callosa plant which is described as thixotropic and is gel like extremely viscous when standing still and turns into liquid when agitated or stirred.

Pressed honey–If the honey is obtained by pressing brood-less combs, honey shall be labelled as “PRESSED HONEY”. If honey belongs to any of the categories mentioned at (a) above and also falling into the category of pressed honey, it shall be labelled as “Pressed Honeydew Honey” or “Pressed and Blend of Honeydew Honey and Blossom Honey” or “Pressed Carvia Callosa Honey”.

(b) Honey may be labeled as follows, as per floral or plant source, if it comes from any particular source and has the organoleptic, physicochemical and microscopic properties corresponding with that origin. It shall be in addition to the labeling requirements as given at (a) above:

1. Mono-floral Honey – If the minimum pollen content of the plant species concerned is not less than 45 percent of total pollen content.

2. Multi-floral Honey – If the pollen content of any of the plant species does not exceed 45 percent of the total pollen content;"

14.2 FSSAI standards to control authenticity of Honey

Plants can be divided into C3 and C4 plants based on the metabolism of carbon dioxide during photosynthesis. Most of flowering plants including wheat rice etc belongs to the C3 plants (Low c13 to c12 ratio) whereas corn and sugarcane belongs to the C4 plants (high C13 to C12 ratio).

These differences in the carbon-13 to carbon-12 ratios observed between honey and cane syrups can be precisely measured using a stable isotope ratio mass spectrometer. The sensitivity of the method is limited by the natural variation in honey and sugar syrup's stable carbon isotope ratios. This can be improved by extracting the protein from the honey and using it as an internal isotopic reference point. When C4 sugar is added to pure honey, the 13C/12C ratio will be altered, whereas it corresponding 13C/12C ratio protein extract will remains constant. The difference accepts in 13C/12C results between honey and its associated protein extract is -1δ‰ deviation, which provides the international benchmark of 7% of C4 sugar added. This is the international tolerated limit established to consider the honey pure or not. FSSAI also fixed the same value in the standards. A negative result of 13C –EA-IRMS method is not a proof of authenticity of honey but only exclusion of C4 Plants.

(a) LC-IRMS: Rice syrup /Beet syrup/ other (C-3 sugars)

Liquid chromatography coupled to molecular mass spectrometry (LC/MS) has been a standard technique since the early 1970s, but liquid chromatography coupled to high-precision isotope ratio mass spectrometry (LC/IRMS) has only been available commercially since 2004. This development has, for the first time, enabled natural abundance and low enrichment δ13C measurements to be applied to individual analytes in aqueous mixtures creating new opportunities for IRMS applications, particularly for the isotopic study of biological molecules (McCullagh, 2010). C3 sugars derived from plants like wheat, sugar beet, rice or tapioca. The absolute δ13C isotopic values cannot be used for differentiation of honeys and C3 sugars in this case because the isotopic values of nectar and honeydew from which the honey is produced is also derived from C3 plants. A specific feature of honey can be utilized: the δ13C values of honey protein and the individual sugars of honey are almost identical in authentic honeys. By comparing the individual deviations between the δ13C values of the different honey fractions it can be evaluated whether the honey is authentic or has been manipulated with foreign sugars (C4/C3) (δ13C values of authentic honey should be fall in the naturally range of ± 1% for δ13C (fructose–glucose) and ± 2.1% for δ13C (%) max. (Maximum difference between all measured δ13C values) (Elflein and Raezke, 2008) The proper technical solution for this analytical problem is the online hyphenation of liquid chromatography (LC) with IRMS (LC-IRMS). This test method is now used as the main generic C3 sugars adulterated honey detection in the International trade for many years.

(b) Specific marker substances to check adulteration

There are methods detecting specific marker substances indicating the presence of sugar syrups in honey by GC-MS, LC-MS or LC-ELSD. For example, the honey foreign oligosaccharides (oligosaccharide ≥ DP4) which are a remainder of the enzymatic starch degradation and do not occur naturally in flower or honeydew honey. The disadvantage of these specific marker methods is that they can only detect and prove one certain type of adulteration.

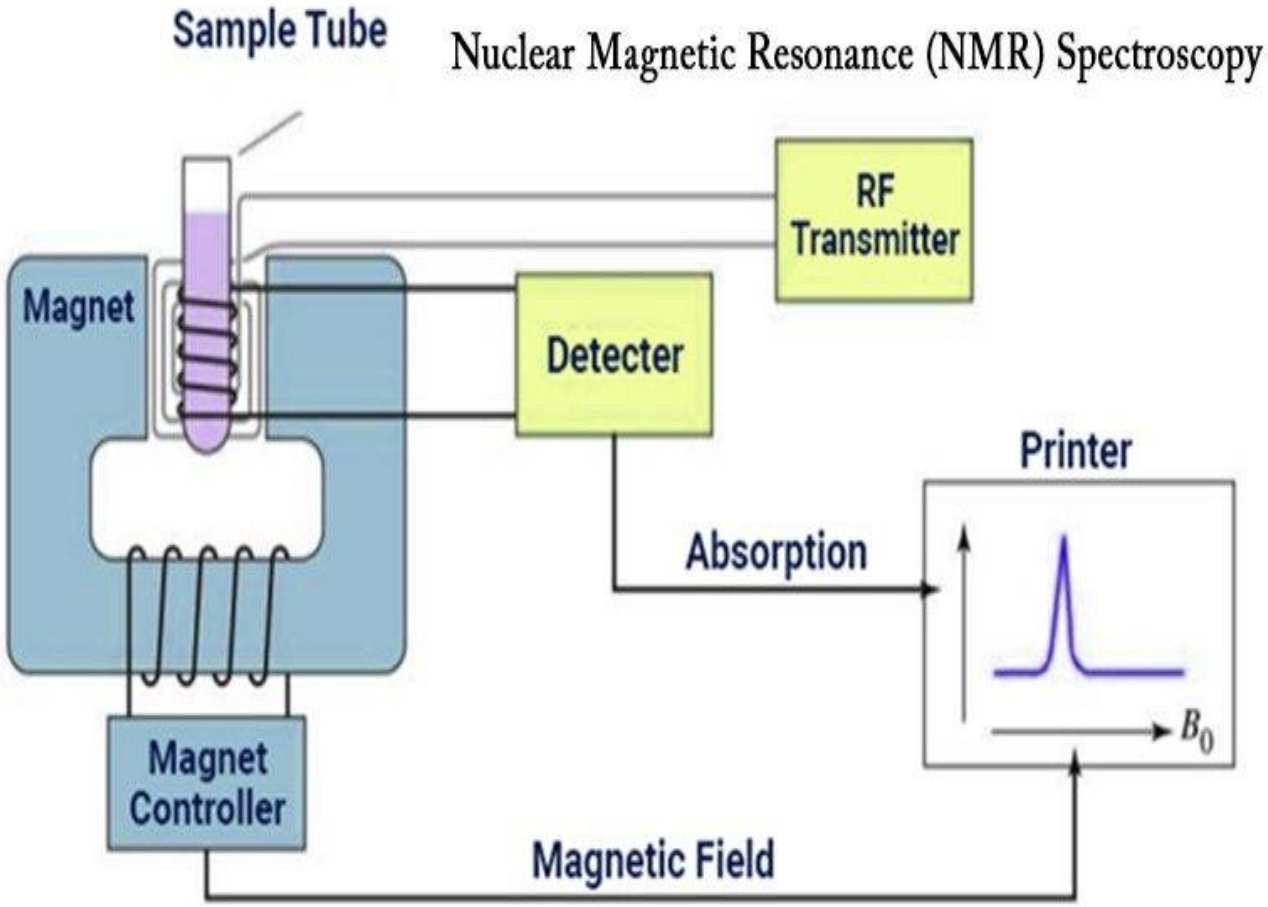
(c) Nuclear Magnetic Resonance to check adulteration

NMR test is a universally accepted test for identifying honey adulteration. The reason is that the NMR testing instrument undergoes honey profiling. This means it has created a powerful and large-scale database to run the test for detecting honey adulteration with great success.

NMR test has been acknowledged and regarded as a fingerprint test for detecting honey adulteration throughout the world. It detects all forms of sugar syrup adulterants from C4 plants like corn and sugar cane. Similarly, C3 plants like rice, beet, and wheat sugar syrups. NMR test has nearly 60 markers which are applied for per honey sample. This means the NMR test scans through 60 various signs of any adulteration at the molecular level in honey. Thus, no adulterants can skip this test.

14.3 NMR Equipment

Figure 40 : NMR Equipment



15.0 List of Manufacturers/Vendor of Honey processing machines/equipment (Annexure -1)

S. No	Supplier Name	Registered Address
1	Sudershan Equipment and Design	S No.-13/6A/A/1, Nanded Phata, Sinhagad Road, Pune, Maharashtra - 411041, India
2	Krishna international	Naroda, Ahmedabad, Gujarat, Ahmedabad, Gujarat - 400064, India
3	SSP Pvt Limited	13 Milestone, Mathura Road Faridabad, Haryana - 121003, India
4	Best Engineering technologies	Plot No. 69-A, No. 5-9-285/13, Rajiv Gandhi Nagar, Industrial Estate, Kukatpally, Hyderabad - 500037, Telangana, Thiruvananthapuram, Kerala - 695010, India
5	Sudershan Ceramics Private Limited	5th Km, Meerut Road, Muzaffarnagar, Uttar Pradesh - 251001, India
6	Anpharma Equipment's	Balaji Nagar., Pune, Maharashtra - 411046, India
7.	J.P. Engineer	C-163, Mayapuri Industrial Area, Phase-II, NEW DELHI -110064, Delhi, Delhi - 110064, India)
8	Adarsh(int)system	Balaji Nagar., Pune, Maharashtra - 411046, India

9	Good Food Industries	1070, Sector-9, Karnal, KARNAL, Haryana, India
10	SSP Private Limited	13 Milestone, Mathura Road, Mathura Road, Faridabad
11	Gardens Honey	#1246, Level 1, Sector 22-B, Chandigarh, Sector 2, Chandigarh
12	Star Engineering Works	Plot No. 95, Focal Point, Focal Point Industrial Area, Dist. Amritsar, Punjab, Focal Point, Amritsar
13	Theeni Organic Farm	32, Nethaji Salai, 5th Street, Anna Nagar, Vilar Road, Vilar, Thanjavur
14	Umech Engineering Private Limited	J3186 Dsidc Narela, Narela, Delhi
15	Yogi agro	Rajpura. Gt road, gt road, Chandigarh
16	Shobhna Industries	S- 107, MIDC, Bhosari, Bhosari Midc, Bhosari, Pune
17	Lalitha	1-38-33, nazer pet, tenali, ap, Tenali, Guntur
18	Madhusree Honey	Perumal Pallikunnel Alakode, Kannur, Kerala - 670571, India
19	Ylem Energy	29/21, GALI NO -6, Anand Parbat Industrial Area New Delhi - 110005, Delhi, India

16.0 Exports – Comparison of various standards in Honey (Annexure 2)

Parameters	Specification					
	AGMARK (India)			PFA (India)	BIS (India)	Codex Alimentarius (international)
	Special	Grade A	Standard		3 Grades	
Moisture (% by mass)	20 (max)	22 (max)	25 (max)	Not more than 25	20, 22, 25	Not more than 20 (honey)
						Not more than 23 (heather honey)
Ash (% by mass)	0.5 (max)	0.5 (max)	0.5 (max)	Not more than 0.5	0.5	–
Total reducing sugar (% by mass)	65 (min)	65 (min)	65 (min)	Not less than 65.0	70,65,65	–
For Carbia colossa and honeydew				Not more than 60.0		
Sucrose (% by mass)	5 (max)	5 (max)	5 (max)	Not more than 5.0	5.0 in all	Not more than 5 g/ 100 g (honey)
For Carbia colossa and honeydew				Not more than 10.0		Not more than 10 g/100 g (other types of honey)
						Not more than 15 g/100 g (lavender, borage)
F/G ratio (% by mass)	1.0 (min)	0.95 (min)	0.95 (min)	Not less than 0.95	1.0 in all	Not less than 60 g/ 100 g (honey)
						Not less than 45 g/ 100 g (honeydew honey)
Acidity (% by mass) expressed as formic acid	0.2 (max)	0.2 (max)	0.2 (max)	Not more than 0.2	0.2 in all	Not more than 50 milliequivalents acid/ 1000g
Specific gravity at 27°C	1.40 (min)	1.35 (min)	1.35 (min)	Not less than 1.35	1.37 in all	–
Water insoluble solid (% by mass) (max)	Not prescribed			–	–	Not more than 0.1 g/100 g (honey)
						Not more than 0.5g/100 g (pressed honey)
Optical density	–	–	–	–	0.3 in all	–
Fiehe's test	Negative	Negative	Negative	Negative If Fiehe's test is positive and HMF content is more than 80 mg/kg, then F/G ratio should be 1.0 or more	If FT test is negative then honey is genuine if FT test is positive perform HMF content, if more than 80, then F/G ratio should be more 1.0	–
Aniline Chloride Test	Negative	Negative	Negative	–	–	–
	If both tests are positive, the sample shall be rejected for grading					
Diastase activity	–			–	–	Not less than 8 Schade units (honey after normal processing)
						Not less than 3 Schade units (honey with low natural enzyme content)
Hydroxy methyl furfural	–			Not more than 80 mg/ kg	80 in all max	40 mg/ kg (honey after normal processing)
						80 mg/ kg (honey from countries with tropical ambient temp.
Electrical conductivity	–					Not more than 0.8 mS/ cm (honey)
						Not less than 0.8 mS/ cm (honeydew and chestnut honey)

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