CHAPTER 1

INTRODUCTION
INTRODUCTION

Apiculture plays an important role in the development of hilly areas as it increases the economy without changing environmental balance. It also bestows multifarious benefits by the production of important hive products such as honey, beeswax, royal jelly, bee venom and propolis etc. and helps in augmentation of the yield of agricultural and horticultural crops through cross pollination of bees (Crane, 1975; Martin, 1979). The aim of this thesis is to study and analyse the physico-chemical properties of honey (one of the important hive products produced by the honey bees) from the samples collected from different locations in the northwest Himalayas of India.

The chapter is introduced by defining honey, its composition and the various characteristics such as colour and taste, granulation and fermentation. The general reference to honey resources such as nectar and honey dew, specified honeys, poisonous honey and methods of honey collection and quality of honey have been made as it influences the physico-chemical properties of honey. The introduction to various honey bee species, the producers of honey, is made to highlight the variation in types of honey produced, hence accounting for different physico-chemical characteristics.

A brief description of the northwest Himalayas is made with reference to importance of apiculture and honey production within the context of India. The description of apiculture in the northwest Himalayas is justified being the study area for collection of honey samples for studying their physico-chemical characteristics. The
objectives of the study are stated and the relevance of the thesis is related to the significance of studying the physico-chemical properties of honey for improving its quality, storage and yield.

1.1 Defining honey

Honey is not easy to define, and definitions are usually formulated only for standards or legislation relating to honey as an article of trade (FAO, 1986). The proposed World-wide standard (Codex Alimentarius Commission, 1969; FAO, 1984) has following definition:

"Honey is the unfermented, sweet substance produced by honeybees from the nectar of blossoms or from the secretions of or on living parts of plants, which they collect, transform and combine with specific substance, and store [and ripen (or mature)] in honey combs. Honey shall not have any objectionable flavour, aroma or taint absorbed from foreign matter during its processing and storage and shall not contain natural plant toxins in an amount which may constitute a hazard to health."

A biological definition might be attempted as follows:

"Honey is a substance produced by bees and some other social insects from nectar or honeydew that they collect from living plants, which they form by evaporating water and by action of enzymes they themselves secrete. As a rule, honey-bees seal the ripened honey in cells of their comb."

The honey has also been defined in literature as "an aromatic sweet viscid material derived from the nectars of plants through the collection of honey-bees and modified and stored by them as a denser liquid." According to Svensson (1991) honey is
a concentrated food source which also contains small quantities of enzymes and minerals.

In FAO (1986) report, there are subsidiary definitions and designations of honey as defined below;

(a) **According to origin**

"Blossom or nectar honey is the honey which comes mainly from nectaries of flowers."

*Honeydew honey* is the honey which comes mainly from secretions of or on living parts of plants. Its colour varies from very light brown or greenish to almost black.

(b) **According to mode of processing**

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

(ii) Extracted honey is the one obtained by centrifuging decapped broodless combs.

(iii) Pressed honey is that which is obtained by pressing broodless combs with or without the application of moderate heat.

(c) **According to mode of production**

i) Hive honey. Produced through apiaries managed for producing honey.

ii) Wild honey: Collected from forests and feral bee species.
1.1.1 Description

Honey is perhaps the sweetest and most nutritious natural food fabricated by the honeybees and also by a few species of wasp, pouched ants and innumerable other species of bees (FAO, 1986). It is naturally converted and pre-digested form of thick sugary syrup, systematically collected and assembled from the nectar of certain flowers and other plant exudations, by the untiring toiling of worker bees driven by sheer instinctive culture, the worker-bees operate, in almost perpetuity, days after days, trip by trip, for collecting the sugary secretions bit by bit, from flowers, to provide food for the young-ones and the member of the colony, and to make provisions from a rainy day. Nectar is a watery solution of sugars which originates from floral and extra floral nectaries of plants. Besides nectar, pollen is another important hive product brought by honey bees from the flowers. It is practically the sole source of proteins, lipids, minerals and vitamins that are needed by honeybees for the development of newly emerged bees (Gary, 1979).

Honey consists essentially of different sugars, predominantly glucose and fructose. Besides glucose and fructose, honey contains proteins, amino acids, enzymes, organic acids, mineral substances, pollen and other substances, and may include sucrose, maltose, melezitose and other oligo-saccharides particles resulting from the process of obtaining honey. The colour of honey varies from nearly colourless to dark brown. The consistency can be fluid, viscous or partly to entirely crystallised. The flavour and aroma vary, but usually derive from the plant origin (White, 1975 a, b, c).

The foraging worker bees suck nectar from the flowers in their honey sac, where it undergoes chemical changes due to intermixing with saliva and is converted into
dextrose/glucose (grape sugar) and levulose (fruit sugar) by the enzymatic action of the invertase. Before being regurgitated as honey, some ingredients of the bee’s own elaboration’s are also added to the secretion of the plant nectar. Large and variable content of the nectar, collected from different sources is also reduced considerably by dehydration and stored in sealed wax bottles of honey comb (Thakur, 1991).

Honeybee requires 40,000-80,000 trips and visit too many times the number of flowers, to search and assemble nectar enough to make one pound of honey. The average trip is supposed to be about 1.6 to 2.4 km, thus to collect a pound of honey, a single honeybee will have to travel at least twice the distance around the world (Metcalf and Flint, 1979; Crane, 1990).

1.2 Composition and characteristics of honey

The major components of honey are the sugars (about 80 per cent) and water (17 to 20 per cent) in which sugars are dissolved. In addition, so far 181 different substances have been identified in honey and some of them are unique and do not exist anywhere else. These substances make up only a small part of total components of honey. Important minor elements are: minerals, enzymes, lipids, amino acids, proteins organic acids etc. (White, 1975 a, b, c). These minor components of honey determine its aroma, flavour and colour. Physico-chemical properties of honey are determined by its major and minor elements (Crane, 1975; White, 1975 a, b, c). The composition of honey determines its value as a nutritional and medicinal product.

The composition of the honey varies very slightly from the original source of the nectar, except for the flavour, humidity and time of storage in the hive. In general, the bulk of honey comprises chiefly of three sugars, viz., glucose (dextrose or grape sugar),
fructose (levulose or fruit sugar) and sucrose (cane sugar), moisture and mineral constituents

The composition of a typical sample of the honey, with a density of 1.52 at 15° C is as follows (Pant, 1985) viz., fructose 40 percent; dextrose (glucose) 35 percent; sucrose 1.9 percent; dextrin 1.5 percent, mineral 0.2 percent; water (moisture) 17 percent and undetermined 3.4 percent. These figures however, vary within certain limits according to season, geographical position and the floral composition of a locality. The composition of honey produced by different species of honeybees has been reported in wealth of India (Anon, 1988).

Pure honey is laevorotatory as it contains more of fructose. It also contains occasionally several other trace elements, most predominant being calcium, phosphorus, magnesium, iron and silica. In fact, as many as 26 trace elements have been detected in willow herb and raspberry honey in South Urals (USSR). The caloric value is about (on an average) 3500 calories/kg, and when pure, honey has a specific gravity of 1.45 to 1.49 at 20° C (Pant, 1985)

1.2.1 Composition of honey produced by various bees

The composition of honey produced by different species of honey bees as reported in wealth of India are given in Table 1.1. For comparison the corresponding values of honey from different countries are also presented.
Table 1.1 Composition of honey produced by various bees' and comparative data from various countries

<table>
<thead>
<tr>
<th></th>
<th>A. dorsata</th>
<th>A. florea</th>
<th>A. cerana²</th>
<th>Trigon a sp</th>
<th>English honey³</th>
<th>American honey³</th>
<th>Pakistani honey⁴</th>
<th>Honey dew honey⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>14 8</td>
<td>17 5</td>
<td>13 93</td>
<td>15 1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(R)</td>
<td>4 0</td>
<td>3 1</td>
<td>4.73</td>
<td>6 1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sp gr 27°</td>
<td>1 387</td>
<td>1 445</td>
<td>1.399</td>
<td>1 390</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Polarisation</td>
<td>-2° 21'</td>
<td>+1° 18'</td>
<td>-2° 20'</td>
<td>+6° 24'</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Moisture %</td>
<td>20.89</td>
<td>16.5</td>
<td>20.89</td>
<td>24.05</td>
<td>14.48</td>
<td>17.7</td>
<td>19.5</td>
<td>15.58</td>
</tr>
<tr>
<td>Dissolved Solids</td>
<td>75.22</td>
<td>83.5</td>
<td>77.57</td>
<td>75.50</td>
<td>74.43</td>
<td>-</td>
<td>70.0</td>
<td>66.53</td>
</tr>
<tr>
<td>Non-reducing sugars (%)</td>
<td>3 20</td>
<td>1.83</td>
<td>3.37</td>
<td>0 33</td>
<td>1.52*</td>
<td>1.9*</td>
<td>2.5*</td>
<td>6.51*</td>
</tr>
<tr>
<td>Levlulose (%)</td>
<td>37 43</td>
<td>38.94</td>
<td>36.48</td>
<td>32.34</td>
<td>-</td>
<td>40.50</td>
<td>39.0</td>
<td>-</td>
</tr>
<tr>
<td>Dextrose (%)</td>
<td>32.13</td>
<td>32.34</td>
<td>33.39</td>
<td>20.05</td>
<td>-</td>
<td>39.02</td>
<td>31.0</td>
<td>-</td>
</tr>
<tr>
<td>L/D ratio</td>
<td>1 167</td>
<td>1 209</td>
<td>1 097</td>
<td>1.58</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dextrins (%)</td>
<td>1.569</td>
<td>8.66</td>
<td>1.996</td>
<td>5.89</td>
<td>-</td>
<td>-</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td>Acidity (%)</td>
<td>0 251</td>
<td>0 268</td>
<td>0.188</td>
<td>0.228</td>
<td>-</td>
<td>-</td>
<td>0.10</td>
<td>-</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>0.388</td>
<td>0.728</td>
<td>0.187</td>
<td>0.518</td>
<td>0.15</td>
<td>0.18</td>
<td>0.20</td>
<td>1.2</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>1 070</td>
<td>1 138</td>
<td>0.556</td>
<td>0.781</td>
<td>-</td>
<td>-</td>
<td>0.36</td>
<td>-</td>
</tr>
<tr>
<td>Undetermine d %</td>
<td>2 141</td>
<td>3 187</td>
<td>2.184</td>
<td>3.581</td>
<td>-</td>
<td>-</td>
<td>5.0</td>
<td>-</td>
</tr>
</tbody>
</table>

Source Thakur (1991)

The main characteristics of honey are its colour and taste, granulation and fermentation.

There are some specified and poisonous honeys due to their single source of collection by honey bees (Crane, 1990)

1.2.2 Colour and taste

Honey is prized for its delicate flavour and fragrance which can be better enjoyed than described. The colouring matter includes carotene, chlorophyll, anthocyanin and tannin. The organic acids, though present in very small quantities (less
than 1%), profoundly affect the flavour in the honey (Crane, 1980, Thakur, 1991)

However, the colour and the tastes are no simple guides to the purity and quality of
honey, because it assumes different colours and varied flavour and aroma, depending on
the floral source. Heather (Calluna sp) honey is a deep golden yellow, while the one
obtained from Plectranthus rugosus, Sapindus mukorossi is lighter in colour (white,
sometimes with the greenish tinge) and mild in flavour Berberis lycium and Fagopyrum
esculentum yield dark colour honey with strong flavour and is suggestive of molasses.

Similarly, the honey obtained from Shisham (Dalbergia sissoo) is of dark amber colour
with strong flavour. Honeys of unifloral type may also vary similarly in their physico-
chemical characteristics. For example, the colour of ‘Burambi’ honey is white and of
Neem (Azadirachta indica) honey dark amber and the one obtained from Terminalia
spp. light yellow. Taste may be delicious as in ‘Litchi’ and ‘Sahajan’. Flavour in Litchi
chinensis is rosy, mild in Moringa oleifera and pungent in Syzygium cumini (Thakur,
1991)

1.2.3 Granulation

Granulation also referred to as crystallisation, is a natural process, occurring as a
result of partial or complete separation of dextrose as solid, from the levulose content in
liquid form. The process is further accelerated by storage, cold weather conditions,
presence of air bubbles, colloids, pollen and other impurities (White, 1975 a, b, c)

The rate and percentage of granulation vary from one type of honey to another,
depending upon the floral pasturage available and its composition of dextrose and
levulose. Granulation in good honeys however, is not permanent and can be reversed by
keeping in warm water for sometimes. Addition of some fatty acids is also supposed to aid in preventing crystallisation (Hameed and Adlakha, 1973).

Granulation can be avoided, or at least minimised, by heating the honey to 170°F for five minutes, followed by rapid cooling first to room temperature, and then maintaining the same for five weeks at 32°F and subsequently at 37°F (Anon., 1976). Honey thus processed can be kept well for over two years without granulation or fermentation. In USA clear and sparkling honey is obtained by warming and mixing with some quantity of diatomaceous earth for facilitating easy filtration under moderate pressure (Thakur, 1991).

Honey in which glucose predominates tend to granulate rapidly, while high-fructose honey tend to remain liquid. Granulation, which is the formation of hard glucose crystals in the honey, has no effect on honey taste, but this fact is not generally appreciated by consumers, who tend to believe that granulated honeys have been adulterated by the addition of “sugar”, i.e. sucrose. This is one reason that why high-fructose honeys generally command a higher price on the market in number of countries. Honeys that are granulated can be re-liquefied by gentle heating, although care must be taken never to expose honey to direct heat, which burns the fructose it contains and destroy its flavour. Granulation is, indeed only a real problem as it can be an indirect cause of fermentation because granulated sugar crystals contains only about 12 percent of water. This means that the moisture content of the unregulated honey in the container can rise to a point where the yeast cells once again begin to grow. The liquid fraction of honeys that granulate uniformly throughout the container is dispersed in such a way that
fermentation does not take place, but fermentation threatens honeys that granulate only slowly or partially.

1.2.4 Fermentation

Unripe and poorly processed honeys are often liable to fermentation. Partly granulated honeys are also liable to fermentation more easily than the liquid honeys because of formation of dextrose hydrate crystals (with 9.09 percent moisture). The excess moisture is released to the rest of the honey, thinning down the levulose and making it susceptible to fermentation (Thakur, 1991).

Presence of excess moisture in honey provides ideal conditions for the growth of sugar tolerant osmophillic yeast such as *Saccharomyces mellis Fabian & Quinet*, *S. rouxii* and *Schizosaccharomyces octospous Beijer*, which decompose the sugars in honey into acetic acid, CO$_2$ and water. Scientifically processed fully ripe honey containing about 80 percent of sugars and less than 22 percent moisture does not ferment easily. However, if exposed to atmosphere or granulated, it may ferment in due course (Anon., 1988).

Fermentation in honey results in acidity and consequent loss in its nutritional value. The honey turns sour with a foamy layer covering the top of honey surface. The decomposed honey erodes the metallic cover of the containers producing undesirable and irritating substances. Some of the precautionary measures recommended for preventing fermentation in honey include extraction of only ripe honey proper processing on scientific lines and avoiding exposure to atmosphere (Kumbhojkar, 1969; Hameed & Adalakha, 1973; Anon., 1988).
Fermentation is honey's greatest undesirable trait. It is caused by a yeast, different from those used in baking and brewing, which can grow only in concentrated sugar solutions; in honey the yeast cells grow, fermenting the product, only when the water content of the honey is 19 percent or more in temperate regions, or about 18 percent or more in the tropics, where higher temperature tends to activate them earlier. Honey whose water content lies below these percentages is considered ready for harvesting, and therefore, is called ripe honey. The yeast cells remains alive, however, even if they are not active, in honeys with a lower moisture content, and if moisture percentage increases, they begin to grow, and honey ferments and is lost. The yeast cells can be destroyed and fermentation thus prevented, by pasteurising the honey, just as some brewery and wine products, for example, are pasteurised for the same reason, but the product must thereafter be stored in sealed containers, least yeast cells in the air enter and re-infect it. Since fermentation is a direct consequence of the moisture content of the honey, it is clear that for beekeeper this moisture content is honey's most important technical characteristics, and that under normal circumstances honey intended for the trade should be harvested when it is ripe, i.e. when, in tropics, it does not contain more than 18.5 percent of moisture (FAO, 1986).

1.3 The honey plant resources

Honey is a nectar or plant sap collected by bees, concentrated by them and stored in combs. Honey hunting insects such as aphids feed on large quantities of plant sap which they excrete almost unchanged (except for protein content). This sap collects on the leaves of plants and if collected by honeybees is known as honeydew. Monofloral
honey is that produced by bees foraging predominantly on a single flower species (Mishra, 1995; Partap, 1997)

1.3.1 Nectar

Most honey comes from nectar, a water solution of various sugars, which constitutes from as little as 3 percent to as much as 87 percent of the total weight, and 90-95 percent of the total dry matter. Nectar originates from floral and extra floral nectaries of plants. Besides nectar, pollen is another important hive product brought by honeybees from the flowers. It is practically the sole source of proteins, lipids, minerals and vitamins that are needed by honeybees for the development of newly emerged bees (Gary, 1979).

Nectar also contains very small amounts of nitrogen compounds, minerals, organic acids, vitamins, pigments and aromatic substances, but sugars are generally believed to be what attracts bees to nectar, even if it is aromatics that communicate to honey its distinctive flavours (FAO, 1986).

Bees can produce much more honey from nectar if its sugar concentration is high (say 50 percent) than if the concentration is low (say 15 percent). And they can recognise the sugar concentration of different nectars by their sweetness, in the course of their evolution they have developed a good ability to assess the relative “cost-effectiveness” of the various food sources available at any one time, and they forage accordingly.

1.3.2 Honeydew

Honeydew, like nectar is a mainly carbohydrate material which bees collect and convert into honey. Its composition involves both plants and plant sucking insects of the
order Homoptera. Such insects have mouth parts that can pierce plant surfaces, the sap inside the plant then being forced out by the plant's internal pressure and by the insect’s own pumping. Excess fluid secreted by the insects is deposited on leaves, twigs etc. in small droplets known as honeydew; it is collected by other insects, including bees and ants. Honeydew is often produced high up in the tree canopy, and one is more likely to hear bees working a honeydew flow than to see them (FAO, 1986).

Honeydew differs in composition from nectar, and honeydew honey, therefore, has certain constituents and characteristics that are different from those of nectar honey. The most apparent differences are, usually a more pronounced flavour and a darker colour. Honeydew honey fetches a high price where it has traditionally been produced, and where it, therefore, enjoys consumers preference. Coniferous forests of northern Europe are one of the main known areas of production. It is likely that honeys in many areas of the world are partly derived from honeydew without beekeepers being aware of the fact and even prolific sources of honeydew honey may still be recognised. Almost nothing is known about the production of honeydew or honeydew honey in tropics and sub-tropics. It is quite possible that possibly at higher altitudes, it may be a rich source that should be systematically exploited (FAO, 1986).

Sawyer (1988) described some physical and chemical features of honeydew honey as follows:

(a) Honeydew honey has the property of rotating the plane of polarised light. A polarimeter shows that honeydew honeys are dextro-rotatory, whilst most floral honeys are laevo-rotatory.
(b) The electrical conductivity of honeydew honey is lower than that of floral honey (Vorwohl, 1964)

c) The ash content is greater in honeydew honeys than in most floral honeys.

d) Characteristics small square crystals occur in some samples of honeydew honey. Lime (*Tilia* sp.) honeydew appears to be frequent source of these.

1.3.3 Some specified honeys

The honeybees collect nectar from a single source till it is exhausted and then it shifts to another source. The honey derived from a single plant species, is referred to as unifloral honey and that obtained from different floral sources, as ‘multifloral honey’. Some of the unifloral honeys, from specific plant species, are known by the plant names from which the honey is obtained e.g. ‘Akra honey’ (*Nilgirianthus heyneanus*); ‘Karvi honey’ (*Carvia callosa*); ‘Jambhul honey’ (*Syzgium cuminii*), ‘Litchi honey’ (*Litchi chinensis*); Neem honey (*Azadirachta indica*), ‘Padma lotus honey’ (*Prunus cerasifera*) (Chaubal and Deodikar, 1965)

Honeys from *Eucalyptus ficifolia* and *Opuntia engelmanni* possess a characteristics property called spinnability. It can be drawn into thread, (as in silkworms into several meters long thread. The much published ‘padma’ or ‘lotus honey’ which is being marketed at prohibitively exorbitant rates, has been till recently, mistaken to have been derived from the lotus flowers (*Nelumbo nucifera*) (Syn. *Nelumbium speciosum*), though it is a well known fact that lotus flowers do not produce any nectar. May be that the honey being obtained from Padma tree (*Prunus cerasifera* or *P. puddum* or *P. cerasoides*) being marketed under the name ‘Padma’ or lotus honey, *Plectranthus*

Similarly honeys obtained from specific plant species in other countries are known by plant names such as Lavender honey, Rosemary honey, Heather (*Calluna sp.*) and Erica honey, Sweet chestnut (*Castanea sativa*) honey, *Pinus spp.* and *Picea spp.* honey, *Acacia* honey from *Robinia pseudoacacia*, Lime honey from *Tilia* sp. and from the plants grown such as Rape honey (*Brassica napus v. oleifera*) and marketed under names of plant from which they are derived as for example in France (Marchenay, 1981).

Sawyer (1988) classifies floral honeys from species as for example Acacia honey, Clover honey form clover plants such as *Trifolium pratense, Melilotus* spp., *Lotus* spp, Heather honey, Lime honey (*Tilia* spp), Orange honey (*Citrus* spp.) and Rape honey.

Sawyer (1988) reported that specialised honeys of the USA are Basswood (*Tilia americana* and other spp.), Galberry (*Ilex glabra*), Milkweed (*Asclepias syriaca*), Sourwood (*Oxydendron arboreum*), Sumac (*Rhus spp.*), Tulip poplar (*Liriodendron tulipifera*) and Tupelo (*Nyssa ogeche*)

**1.3.4 Poisonous honeys**

Certain honeys are poisonous to man. Krochmal (1994) reported that throughout history, honey poisoning has occurred. One of the best known cases was related by Xenophon, concerning the Greek army in Georgia, a former Soviet republic. The soldiers encamped on the shores of the Black sea were poisoned after eating the honey of *Rhododendron ponticum*. After eating the honey they lost their senses,
vomited and could not stand up and were intoxicated. The Trabozan region of Turkey near Black sea is notorious for poisonous honey. In Japan the shrub *Tripetalia paniculata* yields poisonous honey. In North America, mountain Laurel (*Kalmia latifolia*), yellow Jasmine (*Gelsemium sempervirens*) and also possibly species of *Pieris*, *Andromeda* and *Leucothoe* yield poisonous honeys and have natural intoxicants (Howes, 1949, White, 1981). Povchenko (1950) reported from Russia that honey from azaleas (*Rhododendron* spp) were poisonous. Bees were attracted to flowers from the beginning of April for 1.5 to 2 months and many die while collecting nectar. The honey affects man after eating 2-3 tablespoonfuls which produced headache and dizziness. Phadke et al. (1970) reported that some of honey samples were found to contain pollen grains of a few well known poisonous plants such as Dhatura (*Datura metal*), Rametha (*Lasiosiphon* sp.), Dhaval (*Lobellia nicotinaeplia*) and Marvel (*Clematis wightiana*).

1.4 Honey collection

The honey is collected from wild areas through honey hunting and from hives of honey bees from apiaries is known as hive honey.

1.4.1 The honey flow period

During certain periods of the year, the plants blossom profusely and there is copious availability of the floral nectar and pollen in bee flora and which, with the passage of time, dwindles down at other time of year. The period when the nectar yield is copiously high, is referred to as ‘Major honey flow’ period and this is the characteristics of bee flora of lower hills during spring (January- April) and in higher ranges and plains during autumn (October-November). The period when the amount of the honey yield is small tending towards lower ebb is called as ‘Minor honey flow’
period. The lean period when practically no honey flow, is known as 'Dearth’ period (Sharma, 1958) who also reported that in higher hills, September-October is the major honey flow period, whereas, in lower hills and plains of Punjab region mid March to Mid May is the major honey flow period. Brar et al. (1992) reported seasonal variation in honey stored by Apis mellifera in different agro-climatic regions of Punjab. The peak period of honey flow is March-May and November and June to September and June to February are dearth periods in two different locations.

1.5 The Honeybees: Producers of honey

The family of bees, the Apidae occurs indigenously in Africa, Asia and Europe. The European honey bee Apis mellifera L. has been introduced in many parts of the globe.

In India, three indigenous species of the genus Apis, collectively referred to as the Asian honeybees and a few endemic species of Dammer or stingless bees of genera Melipona Illiger and Trigona Jarine (family Meliponidae) are found widely distributed all over India and some adjacent countries, exhibiting maximum biological diversity. The European honeybee, Apis mellifera has been introduced in many parts of the world, including India where it has been introduced successfully nearly three decades ago. The three native Asian species, viz. Apis dorsata F., Apis cerana F. (or = Apis indica F.), Apis florea F. and the European species Apis mellifera L. has been described briefly as their role in honey making and hence mentioned.

1.5.1 Apis dorsata F.

Commonly referred to as Giant bee, rock bee, Dumna, Bhandaur or Bhanwar, this species is the largest of the indigenous species complex of Apis and occurs all over
India, in wild state, at low altitude in the submontane region (up to 1067 m above sea level) and in dry forests and wet regions as well as in the mangrove forests of Sunderbans (Beeson, 1941) Occasional reports of nesting of these bees at higher altitudes for example, Shimla 2100 metres and 3000 metres are not uncommon (Singh, 1962, Verma, 1990). The species builds a single comb, measuring about 1.50-1.80 m from side to side and 0.60-1.20 m from top to bottom, though highest recorded dimensions of a comb of this species (2.1×1.2×0.30m) is also available in literature (Pant, 1985). The combs normally occur high up in open, in suspended form on the faces of precipitous rocks, ceiling of neglected and uninhabited houses, walls and other high places of buildings or on branches of tall trees, such as Banyan tree (*Ficus bengalensis*), Pipal tree (*Ficus religiosa*), Jaman (*Syzigium cumini*), Mango (*Mangifera indica*), Semal (*Bombax ceiba*), etc. Of these, *S. cumini* constitute an important source of honey and most of the honey from this species in North India comes from this source.

The species, like nomadic tribes, is migratory in nature and shifts at regular intervals, from place to place in search of bee pasturage and better nestling sites, avoiding extreme weather conditions. In Doon valley (Uttar Pradesh) and lower hill regions of Himachal Pradesh (Kangra) its colonies arrive during mid winter (February-March) or early spring (early April) and descends to lower plains in late June, just before the monsoon. During migration schedules, the swarms are known to make temporary halts en-route. The species swarms fairly high, crossing even mountain barriers (Thakur, 1991).
1.5.2 *Apis cerana* F.

*Apis cerana indica* popularly known as Indian honeybee, is variously called in vernacular language as *Darohla, Mahun, Mauna*. It occurs practically all over India upto an altitude of about 2000 meters or more in the Himalayas, except perhaps in the central hot plains. It is the only widely known species, which is capable of domestication and establishment in apiaries.

There are several regional varieties or strains referred to as “ecotypes” of this species, broadly divided into hill and the plain varieties. The plain variety is comparatively smaller in size and is dark brown with yellow tinge in colour. It is also commonly referred to as ‘lighter indica’ strain by some authorities (Pant, 1985). This strain is confined mostly to lower plains, up to an altitude of 300-450 meters above sea level. Both the varieties, however resemble each other in habits.

In the Himalayan hill region of Northwest India, *Apis cerana var. indica* comprises two distinct ecotypes or geographical populations, referred to as varieties or strains by some authorities. They are (i) Himachali ecotype or 'pironi strain', being confined to Himachal hilly region more commonly found at altitude up to 900-1500 meters, with 22-23 worker brood cells in four linear inches and yielding about 10-15 pounds of honey annually, and (ii) ‘Kashmiri ecotype’ or ‘picea strain’ commonly found at higher elevations, up to an altitude of about 1500-2100 meters with 21-25 cells in four linear inches and yielding honey, varying from 10-30 pounds annually. This ecotype is considered to be a probable link between *Apis cerana indica* and its equivalent, European hive bee, *Apis mellifera*. This strain is superior to the exotic species under similar conditions. The egg laying capacity of the Kashmiri bee is the

The Indian honeybee nest singly in sheltered places, such as cavities in trees, within thick bushes, termite mounds, between rocks and often inside the walls or roofs of houses, and even in discarded boxes and cupboards. It makes a series of several parallel (mostly 7-8) combs, about a foot across placed side by side. It is common, easily obtainable almost everywhere within its range of distribution and can be hived easily in modern movable frame beehives in apiaries for honey production.

*Apis cerana indica* can coexist with other native bee species and requires least chemical treatment of colonies to control epidemics. However, it has also some drawbacks. It is prone to robbing and production of large number of laying workers, which leads to lower yield in honey productions. Such defects, however, can be rectified with suitable manipulator practices. Their sting is comparatively less painful (Singh, 1962; Phadke & Nair, 1973; Verma, 1990).

1.5.3 *Apis florea* F.

The little Bee or *Chottimakhi*, as commonly referred to, is a small native honeybee. Its workers are exceptionally small, when compared with its drone and queen. *Apis florea* is a non-gregarious plain species, occurring all over India up to an altitude of about 300 meters above sea level, though occasionally it has been recorded at higher elevations beyond this altitude. It builds a single small comb usually not more than the palm of the hand (usually less than 15 cm across), though occasional records of larger combs measuring nearly 45 cm long and 30 cm deep are also known. The comb is suspended, in the walls, roof or eaves of buildings. The bee is not exploited for
commercial honey production, even though the honey is of excellent taste, probably because the production per colony is too low and economically enviable, however, they are good pollinators (Thakur, 1991).

1.5.4 *Apis mellifera* L.

This bee is found all over Europe and has a large number of well recognised varieties and strains. This bee has many desirable traits and exhibits, many similarities in habits and behaviour to the Indian honeybee, *Apis cerana indica*. It nests in enclosed spaces or cavities and builds parallel combs. Introduction of exotic bees into India dates back to the last quarter of nineteenth century, when Italian bees were imported in 1880. The European honey bee (Italian strain) was first introduced in India from USA in April, 1945 and crossbred with Indian honeybee (Thakur, 1991).

1.5.5 Species diversity in Asian honeybees

Most of the bee workers till recent years prior to 1980, recognised only four species under the charismatic genus *Apis* and ecologically divided into two groups (i) Cavity-nesting species, the European honey bee, *Apis mellifera* and the Indian honey bee, *Apis cerana* and (ii) Open-nesting species, the giant or rock honeybee, *Apis dorsata* and the tiny dwarf honeybee, *Apis florea*. However, extensive researches in recent years have demonstrated that the genus *Apis* is far more complex and diverse than it was previously believed to be for example the *dorsata* complex consists of at least two and possibly as many as four to five species. *Apis laboriosa* from the Himalayan region is the largest honeybee. It appears to be ecologically distinct from dorsata, although the male endocephalli of the two taxa are indistinguishable and the
mechanism of reproductive isolation are currently unknown (McEvoy & Underwood, 1988)

The native Indian Honeybee *Apis cerana* exhibits a great deal of genetic diversity. Current studies indicate that, as of today, the whole complex of *Apis cerana* can be pooled into two groups—namely, the North-western Himalayan group, represented by *Apis cerana* comprising two separate ecotypes or geographic populations. These have been arbitrarily named as 'Himachali' and 'Kashmiri'. While the latter ecotype occurs at higher elevations in Kashmir valley, the Himachali is comparatively small and confined to Himachal Pradesh and lower elevations. The other group of *Apis cerana* from the North-Eastern Himalayas, form a distinct cluster and constitute a separate race, named *Apis cerana Himalayan*, with three distinct geographic populations/ecotypes, viz. (i) The foot hill of Himalayas, (ii) The Brahmaputra valley and Khasi hills, and (iii) The Naga and Mizo hills (Mattu & Verma, 1983, Mattu and Verma, 1984 a, b, c, Singh et al, 1990, Verma, 1990).

Each sub-species of *A. cerana* can further be divided into different geographic ecotypes. These ecotypes are biologically meaningful because they occupy the adjacent geographic areas. So far seven such ecotypes of *A. cerana* have been identified in India, but there may be a much greater number of ecotypes representing in different geographical conditions (Verma, 1990).

Chinese bee resource co-ordination team, in a survey conducted from 1976 to 1983, revealed that *A. cerana* is found in all the provinces of China, except the Xinjian autonomous region. *A. cerana* in China can be classified into five sub-species, namely *A.*

1.6 Special nature of honey

Explanation on special nature of honey is necessary due to following reasons:

a) Three sugars are of primary concern in the world market. The first and most important of these sucrose which is obtained primarily from sugarcane and the sugarbeet and is the sugar in most general use; widespread in nature, it can withstand high temperature and harsh treatment because it is chemically stable.

b) The glucose obtained in particular from maize is least sweet of the sugars; it is preferred by sweetmeat manufactures because more of it can be consumed at a time.

c) The fructose, is the sweetest and most delicate of the three. As its name implies, it is found largely in fruit; it is chemically less stable than the others.

The nectar that honeybees collect is predominantly made up of water and sugars, most commonly sucrose, so that the honey it produces contains only about 1% of sucrose. The proportions of glucose and fructose in the honey vary according to a number of factors, and it is largely this fact that accounts for differences in honey sweetness; differences in honey taste on the contrary, are explained for the most part by the origin of the nectar collected; Acacia honey and Heather honey, for example have very different tastes, as will be discussed below.

Honey is a delicate, relatively high-priced luxury product in the developed countries. Stored properly, it has reasonably long life and retains its delicate flavour, although after several years the fructose may tend to decompose, and the honey turns black, loses its delicate taste and becomes unsaleable (FAO, 1986).
Honey being hygroscopic (i.e. tending to absorb water readily from air), it can when atmospheric humidity is high, lose its ripeness and be once again in danger of fermentation. The proper timing of harvesting is thus of the utmost importance, especially in the tropics.

The nectar as collected by honeybees may contain from 50 to as much as 90% of water, and as it leaves the bee's honey stomach it still contains an excessive amount of moisture. By evaporating some of this moisture, the bees can reduce the volume needed to store their honey, which they intend to use as their food reserve. This they do by spreading the honey around the storage combs in small droplets and then, acting as a group, by fanning their wings, thus forcing air through the hive. This action can usually reduce the moisture content of the honey to an acceptable label in 24 to 48 hours, although temperature, atmospheric humidity, the amount of honey to be ripened, the surface area and the hive population all have a considerable effect on what actually takes place. Thus, if the relative humidity is high, the water in the honey will evaporate less quickly, while if there are many bees in the hive to fan the honey, it will be ripened sooner than if there are only relatively few. When the honey reaches the necessary concentration, the bees cap the storage cells with wax.

1.7 Honey quality

Honey is a much esteemed food whose appeal to the consumer depends upon its flavour, aroma and presentation. It is therefore commercially and legally essential that a honey must conform with the traditionally accepted characteristic properties of its type, and reported that the assessment of honey and its certification can be done on the basis
of organoleptic properties, aroma, taste and colour, physical and chemical properties and microscopic characteristics (Sawyer, 1988).

Since honeys are produced for sale in countries all over the world, and honeys from a wide range of climatic zones are candidates for sale on the world market.

Objective criteria that determine honey quality include:

1. purity, absence of adulterants, and conformity with standard definition of honey;
2. maximum water content of 18-19%, to ensure that the honey is not likely to ferment,
3. no toxicity to man, or impurities such as metals from containers,
4. absence of unhygienic components that might present a health hazard,
5. absence of fermentation
6. absence of change in the honey as the bees produce it, resulting from maltreatment.

Other criteria on which honey quality is assessed are more subjective, and largely of traditional and ethnic origin. It is necessary to understand something of this situation in order to work out a programme for promoting sales of developing country honeys, whether for local consumption or for export. Subjective criteria include;

7. flavour
8. aroma
9. consistency, including type and speed of granulation
10. inclusion of other bee-produced materials such as beeswax.

As overheating and contamination with metals can darken honey, dark honeys are often suspected in the trade as being damaged, or of poor quality. Sometimes this is quite
unjustified. Well produced honey is not necessarily of inferior quality because it is dark. Some excellent honeys are by nature light.

According to Kevan, Morse and Akratanakul (FAO, 1984), “There is some argument over how the public views honey flavour and colour. In most parts of the world, honey that is light in colour and mild in flavour commands a ‘premium price as table honey. There has been no taste studies of which we are aware, but packers will testify that repeat sales depend upon delivering this type of honey for the table market. On the other hand, most of the honey that moves into the bakery trade is dark in colour and strong in flavour. In baked products the stronger flavour is preferred. Price is not the primary consideration what the beekeepers thinks they want, or what he prefers, and to deliver that product to the market.

Honey production in the tropics and sub-tropics has to operate under certain real disadvantages compared with the operation in temperature zones. One inherent disadvantage is that high temperatures can damage honey; they can impair its flavour and aroma, alter its colour (making it darker), reduce the active enzymes it contains, and bring about other chemical changes in it.

Another inherent disadvantage in the tropics is that the water content of certain honeys can not always be reduced to the 18-19 percent level that protects them against fermentation. If the relative humidity of the air is very high, the bees can not evaporate sufficient water from the honey. It is possible also that bees native to tropics, not needing to store honey for long periods, lack the instinctive behaviour of temperate-zone bees to continue evaporating water in the hive until the honey contains only 18-19 percent water.
1.7.1 Honey standards and legislation

Honey is understandably the hive product to which most attention has been paid in the matter of legislation, regulations, recommendations, grading schemes and standards. There are a number of national and regional standards regarding honey. Fasler (1975) has summarised food regulation of eighteen countries and three regional standards as far as they apply to honey and artificial honey.

1.7.2 Codex standard for honey

Codex standard of honey for world wide standard in joint FAO/Food standard programme (1969) having its essential composition and quality factors are given below:

**Essential Composition and Quality Factors**

**Composition Criteria**

Apparent reducing sugar content, calculated as invert sugar:
- Blossom honey, when labelled as such: not less than 65 percent
- Honeydew Honey and blends of Honeydew Honey and Blossom Honey: not less than 60 percent

Moisture content:
- Heather Honey (*Calluna*): not more than 21 percent
- Honeydew Honey, blends of Honeydew Honey and Blossom Honey, *Robinia*, Lavender and *Bankesia meziesii* Honeys: not more than 23 percent

Apparent sucrose content:
- Honeydew Honey, blends of Honeydew Honey and Blossom Honey, *Robinia*, Lavender and *Bankesia meziesii* Honeys: not more than 5 percent

Water-soluble solids content:
- Pressed Honey: not more than 0.1 percent
- Honeydew Honey and blends of Honeydew Honey: not more than 0.5 percent

Mineral content (ash):
- not more than 0.6 percent

Acidity
- Honey and Blossom Honey: not more than 40 milli-equivalents acid per 1000
Diastase activity and hydroxymethyl furfural content

Determined after processing and blending not less than 8 diastase figure on Gothe scale

provided the hydroxymethylfurfural content is. not more than 40 mg/kg

Honeys with low natural enzyme content, e.g. Citrus, diastase content on Gothe scale not less than 3

provided the hydroxymethylfurfural content is: not more than 15 mg/kg

Specific Prohibitions

- Honey must not have any objectionable flavour, aroma or taint absorbed from foreign matter during the processing and storage of honey.
- Honey must not have begun to ferment or be effervescent.
- Honey must not be heated to such an extent as to inactivate greatly or completely the natural enzymes it contains.
- The acidity of honey must not be changed artificially.

1.7.3 Indian standards for honey

Indian standard specifications (Table 1.2) have been formulated for Indian honeys obtained from apiaries on the basis of the classification provided by the agricultural marketing and incorporated in the “Agmark” (Grading and Marketing) Rules and prevention of Food Adulteration Act, 1965. For comparison, the corresponding values of honey from other countries are also presented.
Table 1.2 Indian Standards of Honey

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>P.F.A *</th>
<th>Agmark Grade</th>
<th>ISI** Standards</th>
<th>I.P. 4</th>
<th>B.P.C 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1965</td>
<td>Grade I</td>
<td>Grade II</td>
<td>Special Grade</td>
<td>Standard</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.4</td>
<td>1.41</td>
<td>1.41</td>
<td>1.37</td>
<td>1.36</td>
</tr>
<tr>
<td>Moisture (% max)</td>
<td>25</td>
<td>20</td>
<td>20</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>Reducing Sugar (%)</td>
<td>60</td>
<td>75</td>
<td>70</td>
<td>65</td>
<td>60</td>
</tr>
<tr>
<td>Sucrose (% max)</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>L/D ratio (min)</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>-</td>
</tr>
<tr>
<td>Acidity (% max)</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Ash (% max)</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Fiehe's Test</td>
<td>-ve</td>
<td>-ve</td>
<td>-ve</td>
<td>-ve</td>
<td>-ve</td>
</tr>
<tr>
<td>Polarization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+0.6 to-3.0</td>
</tr>
<tr>
<td>Aniline chloride test</td>
<td>-ve</td>
<td>-ve</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Prevention of Food Adulteration Act  ** Indian Standards Institution

1 Phadke and Nair (1970)
2 Indian Standard : 4941 (rev.)-1974
3 Indian Pharmacutics (1966)
4 British Pharmaceutical Company (1968)

1.7.4 Adulteration (Purity standards)

Adulteration in honey is a perpetual dilemma /problem which an average customer faces, particularly when purchasing honey from seasonal professional honey extractors who collect honey from wild colonies. Ordinarily there is no full proof ‘rough and ready’ method for testing the purity of honey. The best and most safest way is to purchase standard specified honey from a reliable shopkeeper or reputable firm. In India, there are many unfounded beliefs for ascertaining the purity of honey. For example, there is a most popular notion that pure honey is not eaten by dogs or it does not burn readily. These notions lack scientific explanations. Similarly, no reliance can be placed on the presence of pieces of honey combs in the so called honey. Most commonly, the honey is adulterated with sucrose (cane sugar), corn syrup or
commercially manufactured invert sugars. Since both these sugars are dextrorotatory, their presence in honey which is otherwise laevorotatory, can be detected successfully by Benzidine for calorimetric (quantitative estimation of 5 hydroxymethylfurfural (HMF) in honey in micro quantities by paper chromatography (Rao and Taiwade, 1966) and by thin layer chromatography using chloroform (Pramanik, 1972).

Another method commonly employed in testing the purity of honey is positive ‘Fiehe’s test’ for the presence of HMF, a decomposed product of levulose formed during the manufacturing of invert sugars by a process of acid hydrolysis. However, invert sugars manufactured by enzymatic hydrolysis, which have composition much similar to sugars present in genuine honey, are difficult to test by above test.

It has been suggested that HMF should be considered as a quantitative test for the purity of honeys and the grading of honeys should be carried out on the basis of HMF values (Deodikar and Phadke, 1966). Pure honey, unless overheated or stored for a long time, does not exhibit HMF positive reaction and which imparts flavour and odour to honey (Mitra and Mathew, 1968).

1.8 Honey production in Asia

Asia has three native tropical species of Apis: the hive bee Apis cerana and the wild bees Apis dorsata and Apis florea. Apis cerana is similar to Apis mellifera, but smaller; in general it is less productive than the latter but it is very good at exploiting its native flora and can thrive in zones where some races of Apis mellifera can not survive (Verma, 1990).

The Apis cerana bees that colonised high Himalayan valleys, and regions north of the eastern end of these mountains, are able to survive the cold winters by forming a
cluster within the nest and regulating the temperature inside it. This characteristic is also highly developed in European *Apis mellifera* but apparently not at all in tropical Africa, except possibly in high altitudes. The most productive Asia bee, *A. dorsata*, builds a single comb nest in the open. It can not be kept in a dark hive, and its honey is still harvested from wild nests as in prehistoric time. Finally, there is a very small species, *A. florea*, which also builds a single-comb nest in the open. A form of beekeeping is practised with it in Oman and in parts of India (FAO, 1986).

### 1.8.1 Apiary honey production in India

There are at present four species of genus *Apis* found in Asia namely *Apis cerana* F., *Apis dorsata* F., *Apis florea* F. and *Apis mellifera* L. First three species are native to Asia and *A. mellifera* has recently introduced in several parts of Asian subcontinent for experimental use. The exotic European species is allopatric in distribution, while other three native species are sympatric in distribution (Ruttner, 1987). *A. cerana* and *A. mellifera* are considered to be complementary to each other for the full development of apiculture in India (Goyal, 1974).

Figure 1.1 depicts the comparative share of different honey producing states in the Indian Union. From this, it is quite apparent that major share of honey production (nearly 70 percent) comes from three southern states of Tamil Nadu (30.56 percent), Kerala (19.44 percent), Karnataka (18.44 percent) while remaining 30 percent is shared by the other eleven states in descending order Bihar (6.94 percent), Assam (5.56 percent), Orissa (4.17 percent), Manipur (2.78 percent), Andhra Pradesh (2.2 percent), Maharashtra (1.39 percent), Himachal Pradesh (1.11 percent). The data presented
shows that large portion of nectar and pollen resource remains untapped and that the honey production in the country is concentrated in South India.

According to Goyal and Gupta (1992), India produces about 7759 metric tones of apiary honey annually values at Rs 233 million (Rs. 30/kg) and the output of honey from Himachal Pradesh is about 150 metric tonnes.

Wakhle (1997) has given statewise production of honey in India from various sources which is given in Table 1.3.
### Table 13 Statewise production of honey in India

<table>
<thead>
<tr>
<th>States</th>
<th>Production of honey</th>
<th>Quantity (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td></td>
<td>104.20</td>
</tr>
<tr>
<td>Arunachal Pradesh</td>
<td></td>
<td>0.20</td>
</tr>
<tr>
<td>Assam</td>
<td></td>
<td>401.15</td>
</tr>
<tr>
<td>Bihar</td>
<td></td>
<td>360.97</td>
</tr>
<tr>
<td>Goa</td>
<td></td>
<td>0.16</td>
</tr>
<tr>
<td>Gujarat</td>
<td></td>
<td>2.02</td>
</tr>
<tr>
<td>Haryana</td>
<td></td>
<td>6.96</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td></td>
<td>60.00</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir</td>
<td></td>
<td>96.70</td>
</tr>
<tr>
<td>Karnataka</td>
<td></td>
<td>662.59</td>
</tr>
<tr>
<td>Kerala</td>
<td></td>
<td>3,658.52</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td></td>
<td>86.32</td>
</tr>
<tr>
<td>Maharashtra</td>
<td></td>
<td>78.24</td>
</tr>
<tr>
<td>Manipur</td>
<td></td>
<td>207.50</td>
</tr>
<tr>
<td>Meghalaya</td>
<td></td>
<td>57.92</td>
</tr>
<tr>
<td>Mizoram</td>
<td></td>
<td>2.50</td>
</tr>
<tr>
<td>Nagaland</td>
<td></td>
<td>19.22</td>
</tr>
<tr>
<td>Orissa</td>
<td></td>
<td>590.06</td>
</tr>
<tr>
<td>Punjab*</td>
<td></td>
<td>540.00</td>
</tr>
<tr>
<td>Rajasthan</td>
<td></td>
<td>13.96</td>
</tr>
<tr>
<td>Sikkim</td>
<td></td>
<td>1.46</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td></td>
<td>1946.00</td>
</tr>
<tr>
<td>Tripura</td>
<td></td>
<td>2.72</td>
</tr>
<tr>
<td>Uttar Pradesh*</td>
<td></td>
<td>97.33</td>
</tr>
<tr>
<td>West Bengal</td>
<td></td>
<td>496.96</td>
</tr>
<tr>
<td>Total Apiary honey</td>
<td></td>
<td>9254.33</td>
</tr>
<tr>
<td>Total Forest honey</td>
<td></td>
<td>18,000</td>
</tr>
</tbody>
</table>

* Grand total 27,254.33

* Includes honey from *A. mellifera*.

According to Thakur (1991) Honey production in India is influenced because of varied climatic conditions and bee-pasturage which vary both with latitude and altitude. Due to this reason, the Indian sub-continent has been divided as per the apiary management patterns into the following four distinct regions.

(i) Northern Himalayan region
(ii) Indo-Gangetic plains
(iii) North-Eastern region
(iv) South-peninsular region

1.8.2 Northern Himalayan region

This region comprises all hilly areas, occurring within the Himalayan ranges, in west, central and eastern parts of India. The bee forage is mainly wild arboreal species. As winter are quite severe in this region, the winter management of bee-colonies predominates, requiring special care and arrangements, not only for overcoming the harsh over wintering problems, but also preparing them for following major honey flow period. One way to overcome these extreme conditions is to transfer the colonies to adjacent foot-hills or plain area (Anon., 1988).

Management of bees during winter, particularly in the Himalayan and Sub-Himalayan temperature zones, with long spell of cold, is a major management problem. Some of the common problems, requiring attention are (i) to ensure strong and young bee colonies, free from diseases, and headed by young and virile queens (ii) ample supply of food to carry through the winter and early spring and finally (iii) insulation of their abodes by winter packing. For example strong colonies of *Apis cerana indica* (hill varieties) require approx. 15 kg of unextracted honey and artificial feed as well as good pollen resource.

Honeybees, like other social insects, live in a hermetically-sealed thermoregulated environment (between 90-95° F). For this, the bees spend a large quantity of honey for fanning in summer and for muscular movements in bee-clusters to
produce heat in winter. Artificial insulation of bee-hives can save energy and honey consumption in bees.

Indian continent (Apian tract) has been divided into four different thermo-climatic zones for the purpose of insulation of bee-hives (Singh, 1962).

(i) Zone-A: with equitable temperature throughout the year, with minimum temperature not falling below 50°F at any time of the year.

(ii) Zone-B: With three cold months (December-February), generally with bright and warm days and cold nights with frosty mornings as in northern plains. The diurnal temperature fluctuations vary between 40°F-70°F in the open and honeyflow predominantly from Brassica spp.

(iii) Zone C: With four cold months (November-February), with more intense cold and prolonged frosty days (lower hilly tracts), a zone with a characteristics of minor honeyflow during this period, predominantly from plant species of Brassica, Prunus and Litsea etc.

(iv) Zone-D: Comprising the entire Himalayan range (1200 m and above) with a prolonged five cold months (November-March) and severe cold and snow fall in higher ranges (from mid December-mid February), cold wintry winds from northern ranges and with no honey flow occurring during this period. Therefore, the problems pertaining to beekeeping in the different zones vary and so do the management practices in each zone thus affecting the physico-chemical properties of the honey produced.

1.8.3 Apiculture and honey production in the northwest Himalayas

The practice of modern apiculture occurs in the mountain regions of all continents ranging from zero degrees at the equator to at least 50° and 30° South
The whole Hindu Kush Himalayan region has a rich tradition of apiculture. In this region, the native domestic hive bee, *Apis cerana*, occurs at an altitude of 3,012 m in Kashmir and 2,970 m in Himachal Pradesh (Mattu and Verma, 1983). It is also believed, that the other wild honeybee species, such as *Apis laboriosa*, occurs at even higher altitudes than these. Apiculture with native, *Apis cerana*, has been practised for at least 2000 years, and this species has been exploited extensively by mountain honey hunters and beekeepers. Indigenous log and pot hives, still in use in the Hindu Kush Himalayan region, are relics of honey collection techniques used with this native bee species (Verma, 1990).

In all of the above major mountain regions of the world, modern apiculture evolved in a similar way. Primitive honey hunting has given way to traditional beekeeping and, in some areas, traditional beekeeping is gradually being replaced by modern movable hive beekeeping.

Mountain apiculture is dependent upon different environmental factors, and amongst these the climate of region is most important because of its effect on honey plant resources. Flowering plants, which support honeybee colonies and provide surplus honey to the beekeepers, occurs from the equator to a height of 3,000 m above sea level. The final vegetation belt providing bee forage consists of Fir and Pine forests which extends up to a latitude of 650 or up to height of 4,000 m above sea level. From the Fir and Pine trees, honeybees collect honey dew, as an alternative to nectar, and honey dew is produced by aphids on such trees.

Verma (1990) noted that unlike in the green revolution, modern hive beekeeping first developed in the temperate Hindu Kush Himalayan region, and it has now spread
to the lowland plain areas of the sub-tropical region. This may have happened because of the following reasons:

- Honey is the only sweetening source in the hills as sugar cane does not grow in temperate climates. Transport from the plains is difficult due to inaccessibility and inadequate transport facilities.

- In the hills, more useful races of the native bee, *Apis cerana* are found. These are larger in size, more productive, and less prone to negative traits like frequent swarming and absconding found in the plains.

- The wild bee, *Apis dorsata/laboriosa*, build its nest in difficult and inaccessible sites, such as rock cliffs and this makes honey harvesting a risky exercise in mountain areas. This necessitated the need to introduce modern hive beekeeping in the mountain areas first.

- All the temperate fruits grown in the Hindu Kush Himalayan region require honeybees for cross-pollination to ensure a good crop.

- During the British rule in the Indian subcontinent, several British officials preferred to settle in the hills. They played an important role in introducing modern apiculture as many of them kept bees as a hobby. Thus, owing to ideal climatic conditions, great diversity of bee and floral resources, the mountains provides an excellent niche for beekeeping development.

- Mountain honey produced from diverse flora, is considered better in quality than honey from lowland areas, as a result of which it fetches a higher price and produces effective upland-lowland trade links.
• Honey in the mountain areas is used, even today as barter commodity in exchange for other life-sustaining essential and precious commodities.

Mountain communities in the region through trial and error over the generations, have evolved traditional methods of beekeeping with the basis concept to build beehives providing maximum natural conditions. For example, beekeepers in the mountain areas have devised fixed wall or log hives generally located in the kitchen room or in front of it to keep the bees warm in cold climate and also to protect them from predators and other enemies. However, with the introduction of modern bee management technology, such traditional bee hives are now placed by modern movable frame hives.

1.9 Uses of honey

Muttoo (1951) reported that there is an abundance of ancient and authoritative literature in India on honey, its kinds, and its uses as food and medicine. The ancient Indian texts place honey on highest pedestal as a life giving sacramental article (amrit) and as a medicine.

American honey institute has reported some facts about honey (Anon., 1951).

• Honey is an energy food for children as well as adults.

• Honey helps in the retention of calcium by young infants, and contains minerals which are necessary for the growth and health of the body.

• Honey has in limited quantities all the important constituents of the vitamin B complex, vitamin C, some hormones, and amino acid.

• Recent research shows that honey contains some biotin and folic acid.

• Honey places no tax on the digestive system.
- Honey is a safe food since bacteria which cause diseases in human beings can not grow in it.
- Honey is an appetising and economical food for all ages and all income groups.

1.9.1 Honey as a food

Honey can be a vital food for the rural poor of developing countries because:

a) In a diet limited in protein or mineral content, a regular honey intake may be vital, although the quantity of honey consumed is not large. This is because in areas with limited technology honey is often harvested by pressing whole combs, the result is a mixture of honey, pollen and bee-brood, which has a high pollen content. Traditional beekeepers or honey hunters often consider pollen stores and bee-brood as delicacy. This has recently been filmed among the Gurung of Nepal and the Baka tribe of Cameroon.

Sometimes bee-brood is grilled and eaten, and separated from the wax combs. In Southeast Asia and Japan, grilled bees are considered a delicate snack. Commercialisation of these products would be difficult in developing countries because special preservation technique are required.

b) Honey is a useful dietary component, particularly for children and the old people, because it tastes, sweet, yet has antibacterial properties, a valuable micro-nutrient content, and is believed to stimulate appetite. It also improves water absorption in children with diarrhoea.

c) Seasonally it can provide a useful addition to the diet, as it is often gathered or harvested when other food is limited or monotonous. It also keeps well, and can therefore be stored for use in times of food shortage.
In all societies honey is valued as sweet and flavoured food, in areas of food shortage honey is a useful carbohydrate source, adding nutritional diversity to poor diets (Bradbear, 1990).

Honey often has an important place in traditional food preparation, and in Islamic countries honey is particularly highly prized because of the emphasis the Koran gives to the value of honey and honeybees.

1.9.2 As a medicine or tonic

In many parts of the world, honey is used as a medicine or tonic food. Honey does have some antibiotic activity because,

- It is a sterile solution (its high sugar concentration prevents growth of micro-organisms).
- the enzymes present in honey produce bactericidal hydrogen peroxide.
- it is highly acidic.

1.9.3 Honey as a cash crop

Once harvested, honey does not require further processing other than to ensure that it is free from any debris introduced during harvesting. Only simple equipment as used in other forms of food preparation is required: bowls, sieves, staining cloths and containers. Honey is a stable commodity with a long shelf-life if harvested carefully it will remain wholesome for deferral years (Bradbear, 1990).

1.9.4 Honey as an export crop

In industrialised countries honey is regarded as health-giving, luxury food. as standards of living rise, honey consumption increases and most industrialised countries import honey to meet the demand. This requirement can provide developing countries
with a useful source of foreign exchange from honey export. The three countries exporting most honey are Mexico, China and Argentina all three have large beekeeping industries which play an important part in their agricultural economy. However any developing country can consider honey export if production is in excess of local requirements. Because beekeeping does not use land, production of honey for export need not conflict with crop growing for local consumption.

1.9.5 Other uses

Honey is widely used as a source of sugars for making honey wines and beers. Eating or anointing of honey forms part of many traditional ceremonies and fresh, local honey is required for this purpose (Bradbear, 1990).

1.10 Objectives

Many investigators have studied the different physico-chemical characteristics of honeys in various parts of the world (Anderson and Perold, 1964; Fini, 1967; Vorwohl, 1969, Petrov, 1970; White, 1975, Gonnet et al., 1986, Motegi et al., 1987; Bonvehí et al., 1993; Rodriguez et al., 1994), only a few investigations have been made on Asian honeys (Perti and Pandey, 1967, Phadke, 1967; Fernando, 1978, Ebrahimzadeh and Haghchenasse, 1979; Ghoshdastidar and Chakrabarti, 1992, Chang et al., 1994, Wakhle, 1997). But practically no work has been reported on physico-chemical properties of honeys from the northwest Himalayas. The present investigations of honey samples were therefore undertaken with the following objectives:

1) To study the physico-chemical characteristics of honey samples collected from different localities of the northwest Himalayas.
2) To study the effect of season, temperature and storage on different physico-chemical characteristics of honey

3) To investigate whether there exists any significant correlations between physico-chemical characteristics and geographical positions as related to altitudes

4) To find out the correlations among different physico-chemical characteristics

5) To study the regional variations in the physico-chemical characteristics of honeys from different parts of the northwest Himalayas

1.11 Significance of the study of physico-chemical properties of honey

Physico-chemical properties of honeys are influenced by both major and minor elements and these determine its value as a nutritional and medicinal product. Several of these physico-chemical characteristics like refractive index, density, viscosity, electrical conductivity, surface tension etc. are of great importance in the honey industry as they influence its keeping quality, granulation, texture etc. Thus, physico-chemical studies can be helpful in improving the management technology for the production of different hive products and solving marketing problems.

The analysis of physico-chemical properties of honey has following aims namely quality control, purity control and detection of adulteration. The main purpose of this study was to elucidate the general physical and chemical composition and to explain the main factors responsible for its variation. The observation of the properties made it easy to understand the regional variation in the composition and properties of honey.