Introduction

Honey bees are one of the most fascinating and beneficial creatures in the animal kingdom. They are the holometabolous insects showing high degree of social organization and well developed division of labour and caste system. There are four major bee-species reported from India namely *Apis cerana*, *Apis florea*, *Apis mellifera* and *Apis dorsata*. Among these four bee species, *Apis cerana*, *Apis florea* and *Apis dorsata* are the natives of Asian sub-content while *A. mellifera* is an exotic one. Honey bees are the source of various valuable products like honey, wax pollen, propolis, sting venom and royal jelly. The scientific beekeeping has successfully evolved in last 150 years, which made it possible to save the bees and harness their products (Mishra, 1995).

Honey is one of the major products from honey bees. It has been defined as the sweet, viscous liquid produced by honey bees from the nectar of flowers or from secretion of living plants which the bees collect, transform into honey and store in honey combs. Honey has been used by man in various ways since time immemorial. It was the first and most reliable sweet substance used by human beings as a taste enhancer and source of energy. Honey contains about 80 different substances but 75 to 80 percent of honey is sugar. Besides high concentration of sugars, it contains other useful nutrients *i.e.* vitamins, proteins, minerals, enzymes and several phyto-nutrients. Honey is a “Super-food”, as it contains very high amount (75-80%) of sugars, vitamins, minerals & enzymes. It can also be considered as “Functional Food”, as it contains a no. of functional food ingredients that can regularize body functions & supplement one / more nutrient deficiencies.

India is a major honey producing country. According to an estimate, out of 350000 tons of honey imports to Germany, United States, Japan, United Kingdom, Italy, more than 20% comes from India, occupying the second position as exporter country (Sabio, 2005). Punjab, Haryana, UP, Bihar, J&K, Himachal Pradesh, Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Pondichery, Andman, Nicobar, Best Bengal, Orissa, Chhattisgarh, Jharkhan, Rajasthan, Gujarat, Madhya Pradesh and Maharashtra are major honey producing regions. Madhya Pradesh has good of diversity of bee flora & varied agro-climatic conditions, thus has enormous potential for profitable beekeeping. Due to high
yield of mustard, Gwalior-Chambal region is popular for migratory beekeeping. A no. of Bee-hive groups can be seen during mustard flowering. Annual apiary honey production in Chambal region is about 4899 tones (KVK Morena, 2014). Morena district is no. one in Madhya Pradesh for honey production.

It is well known for having excellent health promoting and healing properties. Even today, in many Indian families the first food to be given to new born baby is a drop of honey followed by mother’s milk. Even then the rate of consumption of honey in India is very low in comparison to other countries and it is being used as traditional medicine rather than as excellent food and ingredient of other food stuffs. There is a growing demand for natural products in the human diet due to increasing awareness of their health benefits, deteriorating quality of foods produced by extensive use of agricultural chemicals and possible negative effects of synthetic food additives on human health. Honey is one of such natural substances which can be consumed directly as well as in different food items to make them more delicious and healthy.

The physical properties of honey vary, depending on water content, the type of flora used to produce it (pasturage), temperature and the proportion of the specific sugars it contains (Krishna et al., 2015). The composition of honey is rather variable and primarily depends on the floral sources; however, certain external factors also play the important role, such as seasonal and environmental factors and processing (Bryant, 2001 & Whitmyre, 2007).

The colour, flavor and aroma are the important quality characteristics of honey from consumer’s point of view. The market requires a honey that will not ferment, remains liquid and has attractive appearance. Heating of honey is the only practical method to obtain these objectives. But the delicate aroma and fine flavor of honey are particularly vulnerable to heat and improper storage. In addition to the loss of volatile components, excessive heat can introduce off-flavours due to the effect of heat on the sugars, acids and protein material present in honey (White, 1975). Defects like granulation, fermentation, loss of colour, flavor and aroma in honey during storage lower its value in the national and international market. Darkening in colour is also one of the major changes that occur especially during storage at elevated temperatures. The price of honey in the world
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market is largely determined by its colour. Many factors influence darkening of honey, which include, processing and storage temperature, moisture content, pH, nitrogen, free amino acid content and colloidal constituents (Schade et al., 1958). The quality of honey is also affected by the contamination of agricultural chemicals especially the organochlorine pesticides, so heavily used for the control of pests in the agro-ecosystem (Chawla and Goyal, 1988). Due to antiseptic, therapeutic, antioxidative and anticancerous properties, the standardization of the quality of honey is of great significance both from consumer’s point as well as that of the beekeepers to get proper remuneration. Such standardization on quality would also attract foreign market for the Indian honey. In order to stop the spoilage of raw honey (extracted or squeezed). Various honey processing techniques have been suggested by many workers (White and Mahr, 1954; White, 1980; Wakhle et al., 1996; Vit et al., 2009). The recent modern processing techniques have been suggested that prove to be very costly and beyond the pocket of the low-profile entrepreneurs (Wakhle et al., 1996). The honey processing is suggested at 105°C with moisture reduction arrangement (William et al., 2009; Ramnath and Venkataramegowda, 2012), while filtration is done by a very fine mesh or vacuum-press-filter. As a result, the vital pollen grains are removed from the honey and its basic quality gets hampered (Haydak et al., 1943). There are some extensive studies on quality control and physico-chemical characteristics of honey was done by several authors (Latif et al., 1956; Phadke, 1967, 1968; White, 1975; Cortopassi-Laurino and Gelli, 1991; Laude et al., 1991; Piazza et al., 1991; Vit et al., 1994; Thrasyvoulou and Manikis, 1995; Karabournioti and Drimjias, 1997; Vinci et al., 1997; Joshi et al., 2000a; Tsigouri and Katrali, 2000; Bogdanov and Martin, 2002; Terrab et al., 2002; Bogdanov et al., 2004, Iftikhar et al., 2011; Fasasi, 2012, Ramnath and Venkataramegowda, 2012, Rane and Doke, 2012, Balkanska and Ignatova, 2013; Ligia et al., 2013; Kumar et al., 2013; Manzoor et al., 2013; Rahman, et al., 2013; Shahnawaz et al., 2013, Ahmed et al., 2014; Akhtar et al., 2014; Rebiai and Lanez 2014; Draiaia et al., 2015; Krishna et al., 2015; Linkon et al., 2015; Oshomah et al., 2015; Prica et al., 2015). Madhya Pradesh has a lot of diversity among bee flora and varied agro-climatic conditions due to which this state has enormous potentialities for profitable beekeeping.

The special status of honey among consumers is due to its natural image and its purported
health benefits. After some previous food scandals involving honey, consumer’s expectation are now also associated with the quality of honey linked to its origin. For example, honey produced in non-EU countries was discovered within European Community, adulterated with high fructose corn syrup and cane sugar there were identified other incidents where excessive antibiotics residues have been found in honey derived from third-world countries (Cabanero et al., 2006). Therefore, the quality standards stress the importance of the quality of honey that is linked to the origin and which is used to promote sales through specific labeling. Unifloral or multifloral, organic, protected designation of origin are a few of designations used for honey, that provide scientist with a challenge in terms of confirming labeling that will satisfy consumers, honey industry and control bodies. Moreover, scientists are requested to provide methods and markers that establish the compliance of honey with regulatory requirements.

However, in our country quality of honey produced has not been worked out so far on the basis of the physico-chemical characters of persistent pesticides. The review of literature does not reveal any reference on this aspect of Madhya Pradesh honey and only a few isolated studies on this aspect are reported. Therefore, honey samples from four districts (Gwalior, Morena, Guna & Shivpuri) of Madhya Pradesh were collected, analyzed and compared with the samples commercially available in the market, for gradation of their quality. The purpose of the proposed study is to carry out in-depth study on analysis and assessment of commercial honey samples with regards to purity, quality standards, benefits, uses and possible risks of consumption. As standard sample, pure honey extracted from bee hive will be used and suspected adulterants will be mixed in pure honey to make it impure.

Indian beekeepers (village farmers) are illiterate, have poor scientific knowledge of beekeeping & harvesting of honey, its extraction, handling, processing, storage, packaging & marketing. Extraction, handling & storing conditions are poor & pure honey get spoiled & contaminated. Usually honey is stored in tin canisters, not properly cleaned & dried, they are rusted. Sometimes honey is not even filtered & contains dead brood and bees, their body parts, fragments of the comb, foreign bodies, thus, quality (flavour, taste, colour, biochemical parameters) of honey is deteriorated. Such honey samples fail during purity testing. Indian scientists have covered several aspects of beekeeping & bee botany.
Much focus has not been given on research on bee products including honey in India.

Adulterants may also be accidentally or unknowingly introduced into substances. In India normally the contamination/adulteration in food is done either for financial gain or due to carelessness and lack in proper hygienic condition of processing, storing, transportation and marketing. This ultimately results that the consumer is either cheated or often become victim of diseases. Such types of adulteration are quite common in developing countries or backward countries. Nevertheless, there is no sufficient work on quality determination as well as effect and extent of adulteration for locally produced natural honey. Nowadays, adulteration of different natural food items becomes a common problem in many parts of the world regardless of economic status of the nation. One of the susceptible food materials for intentional or unintentional adulteration or contamination is honey. The most common adulteration practiced with honey is the addition of sucrose, corn syrup, molasses, banana or other harmless or harmful materials. The act of honey adulteration is causing severe impact on the domestic and international market opportunities of the product and may result nutritional and health problems on consumers (Gary and Nichols, 2000 & Ayansola and Banjo, 2011). Honey is declared adulterated if cheaper or inferior substances are substituted wholly or in part. It may also contain some added substances injurious to health and for whatever reasons its quality is below the standard. In this work, honey samples from apiary sites and selected household beekeepers as well as from local markets were collected and assessed for their quality parameters. Moreover, susceptible adulterants were checked for their effect on the test parameters and simple methods were suggested to screen adulterated honey samples from the pure ones. Food can be contaminated by different adulterants. Adulterants are chemical substances which should not be contained within other substances (e.g. food, beverages and fuels for legal or other reasons). The addition of adulterants is called adulteration. It is also a substance which also reduces the vital importance of food and causes some toxic effect to the human body.

The main objectives of present study were:

- Sample collection and storage from different districts of Madhya Pradesh, India.
- To analyse physico-chemical characteristics of honey samples.
• To check the high titres of toxic residues of pesticides, antibiotics and heavy metals.

• To study *in-vitro* antioxidant activity and total phenolic content in as markers for free radical scavenging activity.

• To conduct tests for purity of honey so as to find out suitable tests & techniques for testing of honey quality.

• To conduct literature survey on benefits of honey as food, tonic, medicine & cosmetic and possible risks of consumption.