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Review Article

Effect of Altered Environmental Conditions on Nutritional Quality of Bee Pollen: A Contemporary Overview

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Abstract: Pollen collected by honey-bee having valuable food and also used in apitherapy and commercially produced for many purposes. Bee Pollen is frequently called the "only perfectly complete food" thus pollen is essential for normal growth and development of individual as well as reproduction of colonies. Pollen is rich source of protein, carbohydrates, lipids, fats, vitamins; minerals etc. pollen has great medicinal value like honey since old days. In developed countries like Japan, China, bee pollen produced on large scale, however, India is lacking in its production. The meager literature was available on nutrition status of bee pollen. Researchers from western countries pinpointed the effect of degraded environment on nutritional quality of bee-pollen. Especially, global warming, water pollution and most important parameter which directly affect the production as well as quality of bee pollen is atmospheric air pollution. Here, attempt was made to overview the contemporary research in India and abroad. This will definitely help to future workers take as compared significance of change in environmental quality and its effect on nutritional status of bee pollen.

Keywords: Bee, Environment, Pollen, Nutrition, etc.

INTRODUCTION

Honeybees visit blossoms of entomophilous plants in search of their food i.e. nectar and pollen, nectar as a source of energy is required for the performance of variety of jobs such as foraging, flights, brood rearing, comb building etc. pollen is a rich source of protein, carbohydrates, fats, minerals, vitamins for bees and bee colony especially during brood rearing period. Bee pollen is a mixture of bee saliva, plant nectar and true pollen. At present bee pollen production annually in China is 1000 tons. In Indian market honey and beeswax are the only two products from beekeeping. There is no commercial production of other products in the country. No figures are available for the world's commercial production of bee-collected pollen. The production of bee pollen is mostly from apiary. There is no record of production of bee pollen by forest comb. In India market of Bee Pollen is not established but collection of bee pollen for feeding colonies during dearth's period, is becoming a need of beekeeping management.

Bees fly intensively in a radius of up to 3 km for this reason bees and their product can serve as a bio indicator for the contamination of this area the contamination can reach the beehive through air, water and soil. Since the 1980's, experiments have shown that pollen collected by honeybees reflects environmental pollution levels when examined for metals, heavy metals and radioactivity¹⁻³. Contaminants can be quantified and sampling may be cheaper than most standard methods currently in use. Attempts have also been made to use pollen-collecting honeybees for the identification of potential mining areas⁴. The same effect of accumulating aerial deposits and selective plant secretions of minerals beneficial when used to monitor pollution control becomes a hazard if pollen from heavily polluted areas is used for human or animal consumption. Air and water contain heavy metal from industrial and traffic area which can also contaminate the bee's colony and its product. The lead contamination has diminished due to increased world wide use of car engine catalyst; however heavy metal contamination has increased in industrial area. Due to pesticides-treated agricultural field pesticide residues remain in bee pollen.

India has potential to produce additional Bee pollen and can meet market demand if resources of Bee pollen are managed very well. Therefore it is necessary to study the effective environment. Bee pollen improvement is necessary for production of Bee pollen. This proposed study is an effort in that direction. An attempt has been made to survey the present scenario of bee pollen production in world while as compared to India where no much attention has been given.

Collection of Pollen: The pollen is collected by special device called pollen trap. Fresh bee collected pollen contains about 20-30% water per 100g pollen. The high humidity is an ideal culture medium for microorganism like bacteria and yeast. For prevention of spoilage and for preservation of a maximum quality the pollen has to be harvested daily and immediately placed in freezer. After two days of storage in the freezer, the pest will be killed. Extreme care should be taken that pollen is not contaminated by bees collecting from flowers treated with pesticides. During, and for several days or weeks after treatment of fields or forests in an area of several square kilometers (in a circle of at least 3- 4 km diameter) around the apiary, no pollen should be collected. This is independent of the method of pesticide application. Even systemic pesticides have been shown to concentrate in pollen of, for example coconut⁵.

Since a pollen pellet is collected from many flowers, even small quantities of pesticides per flower can be accumulated rapidly to reach significant concentrations. Though pollen pellets are collected before they enter the hive, treatment of colonies for bee diseases, can contaminate the pollen pellets. Though, cleaning of debris from the hive and bees regurgitating syrup, nectar or honey during

collection of the pellets. Pollen pellets are removed from the bees before they enter the hive. There are many designs of pollen traps some easier to clean and harvest, others more efficient or easier to install. The efficiency rarely exceeds 50%, i.e. less than 50% of the returning foragers lose their pollen pellets. Bees are ingenious in finding ways to avoid losing their pellets, like small holes or uneven screens and may even rob pollen from the collecting trays, if access is possible. Under some circumstances, pollen collection methods and regimes may interfere with normal colony growth or honey production. Therefore, standard beekeeping manuals should be consulted for the timing of collections^{6,7}. Pollen should be collected daily in humid climates but less frequently in drier climates to avoid deterioration of the pollen and growth of bacteria, moulds and insect larvae, pollen should be dried quickly. Ants can remove considerable amounts from pollen traps. Krell *et al.*⁸ reported that, losses are up to 30% in temperate climates. Pollen needs to be dried to less than 10% moisture content (preferably 5 % or 8% according to some laws) as soon as possible after harvesting. A simple method uses a regular light bulb (wE and 110V or 20W and 220V) suspended high enough above a pollen container or tray so that the pollen does not heat to more than 40 or 45 °C. For solar drying, the pollen itself should be covered to avoid direct sunlight and overheating. After drying the pollen needs to be cleaned of all foreign matter. A tubular tumbler made out of a wire mesh with a fan can clean considerable quantities of pollen pellets. Simpler winning methods can be used too. Benson *et al.*⁹ and Marcos *et al.*¹⁰ give very good accounts on trapping and subsequent processing of pollen. Most types of pollen traps are currently only fitted to standard frame hives are fitted to traditional log, clay or straw hives, small modifications are necessary. Beebread is usually found on brood combs or combs near the brood nest. Available quantities are normally very small and inadvertently the brood comb and sometimes the whole colony are destroyed during harvest. A team of Russian scientists described a nondestructive means of extracting beebread from combs, harvesting 300-600 kg per year from 1500 colonies¹¹.

Storage: Pollen loses its nutritional value rapidly when it stored improperly. The environmental factors such as humidity, temperature, moisture is very significant during storage. Pollen undergoes several chemical changes during storage i.e. reducing sugar, proteins and acids in bee bread were found to increases. Haydak *et al.* and Vivino *et al.*¹² suggested that microorganism is probably involved in the metabolism of stored pollen. Longer improper storage leads to the loss of a few particular amino acids, which cause deficiencies in brood rearing¹³. The pollen is dried in an electric oven, where humidity can continuously escape. The maximum temperature during drying up to 40°C and drying period should be less in order to avoid losses of volatile compounds until the humidity is 6 % or lower. Stored out of direct sunlight, pollen can be kept at room temperature for a several months. The same pollen may be refrigerated at 5°C for at least a year or frozen to -15°C for many years without quality loss as tested by feeding to honeybee colonies and recording brood rearing^{14,15}. Since sunlight, i.e. UV radiation, destroys the nutrient value of pollen, other more subtle characteristics probably suffer worse damage. Storage of dry pollen in dark glass containers or plastic recipients, casks, pails etc, that is perfectly airtight to avoid moisture and keep in cool, dry places where the temp is approximately 14°C.

Pollen composition: Lunden *et al.*¹⁶ reviewed in short the literature on pollen-chemistry. The nutritive value of pollen depends on the various chemical constituents present in it. All pollen species do not have the same nutritive value^{17,18}, two major groups of pollen have been analysed chemically. One type is airborne or anemophilous pollen occurring in abundance, e.g. pine and palm. The second type–insect transmitted pollen, can be collected in traps at the hive, but such pollen-load contain solidifying chemicals added by the bees¹⁹⁻¹⁶⁻¹⁷ since the composition of pollen changes from species to species, variation in absolute amounts of the different compounds can be very high. Protein

contents of above 40% have been reported, but the typical range is 7.5 to 35%: typical sugar content ranges from 15 to 50% and starch content is very high (up to 18%) in some wind-pollinated grasses²⁰. Composition of pollen and bee-collected pollen however, has to be distinguished. Some average values for bee-collected pollen are shown in Table 1.

Table 1: The average composition of dried pollen

Nutritional constituents	Bee collected %	Crane, 1990	Hand collected %
	Tabio, 1988		Crane, 1990
Water (air-dried-pollen)	7	11	10
Crude protein	20	21	20
Ash	3	3	4
Ether extracts (crude fat)	5	5	5
Carbohydrate	-	-	-
Reducing sugars	36	26	3
Non-reducing sugars	1	3	8
Starch	-	3	8
Undetermined	28	29	43

*Source: Schmidt and Buchmann *et al.*²⁰.

The major components are proteins and amino acid, lipids (fats, oils or their derivatives) and sugars. The minor components are more diverse all amino acids essential to humans (phenylalanine, leucine, valine, isoleucine, arginine, histidine, lysine, methionine, threonine and tryptophan) can be found in pollen and most others as well, with proline being the most abundant. Many enzymes (proteins) are also present but some like glucose oxidase which is very important in honey, have been added by the bees. This enzyme is therefore more abundant in "beebread" than in fresh pollen pellets. Only 16 of the 31 fatty acids found in pollen had been identified by 1989^{21,22}. Palmitic acid is the most important one, followed by myristic, linoleic, oleic, linolenic, stearic acids etc. Simal *et al.*²³ lists 7 sterols, including cholesterol. Mono-, di- and triglycerides are fairly abundant, too. Mainly simple sugars in pollen pellets such as fructose, glucose and sucrose come from the nectar or honey of the field forager. The polysaccharides like callose, pectin, cellulose, lignin sporopollenin and others are predominantly pollen components. After storage in the comb the further addition of sugars and enzymes creates beebread, through lactic acid fermentation.

Table 2: Gross chemical analysis of pollen

Constituents	Hand collected pollen %			Bee collected pollen %	
	Pisa	Sunflower	Maize	Average	Range
Protein	17.21	8.29	9.35	16.78	7.59- 25.03
Ether extract	5.62	3.87	2.2	5.14	2.50- 8.23
Carbohydrates	5.23	2.4	2.7	26.2	9.15- 36.87
Ash	1.72	2.4	2.7	2.12	1- 3.92

The gross chemical analysis of different pollens reported by Phadke *et al.*²⁴. Table 2 shows that there is little variation in ash (minerals) and fat (lipids) content. Proteins vary greatly with species usually accounting for 8.29 to 17.21%. The amount of ether-extractable material in pollen varies widely. Pollen of pisa, sunflower and maize contained 2.50 to 8.23 %. The Carbohydrate content in bee collected pollen 9.15 to 36.87 was higher was higher due to the fact that bees add honey while packing pollen into the pollen basket. An ash content range was 1.0 to 3.92 %.

Table 3: Pollen quality criteria (after the Swiss food manual, 2003)

Component	Content Min - Max (g)
Major component	gm/100gm
Carbohydrates	13 to 55
Protein	10 to 40
Fat	1 to 10
Dietary fibres	0.3 to 20
Minor components	mg/100gm
Minerals	500 to 3000
Vitamins	20 to 100
Flavonoid glycosides	40 to 3000

Stefan Bogdanov *et al.*²⁵, reported in 2003, carbohydrates are the principal components. Pollen contains proteins, amino acids, and minor component are vitamins and minerals and flavonoid are shown in table 2, this data was published in Swiss food manual 2003.

Significance of bee pollen: Nowadays pollen has been produced for various commercial purposes.

Human Diet: All over the world honeybee pollen is recognized as an ideal food. There are many advocates in England and Sweden²⁶ who recommended pollen for human diet. Pollen has been added to diets for domestic animals and laboratory insects resulting in improvements of health, growth and food conversion rates^{20, 27}. In our modern times, scientists, gerontologists and nutritionists have rediscovered these bee-prepared foods and confirmed that they are able to promote benefits in the form of healing and rejuvenation. Science shows that bee pollen, that wondrous yet mysterious nectar, has natural rejuvenating powers, aids beauty, boosts energy, and extends life span, fights allergies. Pollen is used in candy, pollen mixed with honey, Chocolate candy bars, sweets, desserts, breakfast cereals; tablets etc. Pollen will rarely cause allergy symptoms, when consumed orally.

Medicinal Application: Pollen has great medicinal value like honey since good old days. Many researchers reported that the collection of pollen from selected species is necessary for the study of hay fever and other pollen allergies. Pollen is wide-acting medicinal properties, including alleviate depression and fatigue, normalize digestive problems, relieve various prostate problems. Commercially pharmaceutical firms prepare pollen extract for diagnostic tests and allergy treatment. Bee pollen is recommended in the case of digestion difficulties arteriosclerosis, and liver dysfunction. It also improves the hemoglobin level in the blood of anemic patient and particularly in children and reduction of cholesterol level in body. Several decades of observations in Western European countries and a few clinical tests have shown pollen to be effective in treating prostate problems ranging from infections and swelling to cancer^{28, 29}. Naum Petrovich Ioyrish, chief of the former Soviet Academy of Vladivostok, "Long lives are attained by bee pollen users. It is one of the original treasure-houses of nutrition and medicine. Each grain contains every important substance necessary to life."

Apicultural Application: During dearth period when bees lack of natural pollen sources artificial supplement containing pollen, can be supplied as bee diet³⁰. When colony inspections reveal or no pollen in the combs, or the anticipated weather is going to prohibit pollen foraging for more than couple days, it is time to feed some pollen substitute. The substitute is composed of a mixture of lactic yeasts, vegetable proteins, egg proteins, and may receive an addition of acid, sugar and aromatic product. About 145 mg of pollen are required to raise one bee larva to maturity

Agricultural Application: Pollen from known parental sources is used in hybrid production. Generally limited quantities of pollen are needed for plant breeding. In many fruits orchards like

apple, almond and pear, pollen is artificially applied to assure an abundant crop³¹. In the United States and France pollen is supplied commercially for this purpose.

Environmental pollutants and bee pollen (quality, quantity and nutritional value): After industrialization, the various honeybee clusters plunged in danger because of degradation of environmental quality. Within that, global warming, water pollution and air pollution are the major environmental parameters. So, here attempt was made to linkage of these parameters with nutritional quality of bee pollen and can be used as pollution indicator. Very few investigations have been published concerning the use of bee or bee products as bioindicators, providing information about the diffusion of pesticides within agricultural environments, as a side effect of crop protection practices³². Many investigators have employed honeybees or honeybee products (honey, wax, pollen) as tools for assessing environmental pollution in industrial areas. A number of reports refer to their utility in monitoring environmental radionuclides contamination or heavy metal contamination³³.

Water pollution: There is plenty material available on the adverse effect of pollution on living community. Excess ionic species in water due to pollution interrupts the some processes of physiology of honeybee and put adverse effect on the pollen collection it's processing. The flowering plants growing on the polluted water can produce defected pollens with low nutritive quality. The sulfur and nitrates oxides inputs from acid rain may degrades the quality of bee-pollen. Heavy metal inputs of industrial pollution may adversely affects the nutritional quality of bee-pollen. Toxic metal water pollution may induce the chronic toxicity amongst the economically useful insects like honeybee. The organo-chlorine pesticides like DDT, BHC have more serious effect on the honeybee to decrease the number of honey combs from Maharashtra point of view.

Air pollution: The major air pollutants like SO_x and NO_x are may put their adverse effect on the respiratory system of honeybee enforces respiratory tract like diseases. The ill effect of honeybee may impacts the working capacity. The pollen also get deteriorated due to rainwater acidify with the air pollutants. Some sites near highly polluted air show the blackish appearance to pollen grains collected by honeybee.

Global warming: The worldwide problem of increasing average temperature may affect the efficiency of honey to collect pollen. The pollen production rate may be decreased due to increased temperature. So, global warming may adversely affects the nutritional quality of bee collected pollen.

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