

Apiculture and Apitherapy: A Boon to Mankind-A Review

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ABSTRACT: Microorganisms have developed resistance to many antibiotics and this has created serious clinical problems in the treatment of infectious diseases. Plethora of studies has emerged towards using natural products as an alternative therapy. One natural food product that has gained great momentum is honey. Researchers round the globe have worked both *in vitro* and *in vivo* to spark the unknown benefits of the inestimable values of honey as well as its application. The use of traditional medicine to treat infections has been practiced since the origin of mankind. Honey produced by *Apis mellifera* is one of the oldest traditional medicine considered to be important in the treatment of several human ailments. The belief that honey is just a nutrient is false but now it has proved to be a drug and an ointment, and thus, an alternative medicine branch, called Apitherapy arose. It has been developed in recent years, offering treatments based on honey and other bee products against many diseases including bacterial infections.

I. INTRODUCTION

The honeybee is a social insect that lives in a colony that includes thousands of associates that work together with various duties: e.g., queens, workers, and drones [1]. A typical honeybee colony includes between 10,000 and 60,000 worker bees depending on the season of the year and a unique queen [2]. Workers generally live for 5–6 weeks during efficient times (spring and summer) and for about 4–5 months during inefficient times (fall and winter). Workers usually begin foraging behavior when they are older than 2–3 weeks. The age at which workers begin looking for food is a powerful and decisive period in their lifetime. Tasks of workers may be classified into two broad subgroups: foraging bees that gather food outside, and non foraging bees that directly nurture the offspring [3]. This behavioral classification is regulated by the age of the worker honeybees, as well as hormones [4]. Low titers of juvenile hormone were reported in nursing workers, while the titers were high in 3-week-old workers just prior to foraging. Therefore, comparing the total protein values of worker bees at different ages helps in understanding their structural, metabolic, and physiological distinctions, and the social structure and environmental interactions of honeybees.

Natural honey is one of the most widely sought products due to its unique nutritional and medicinal properties, which are attributed to the influence of the different groups of substances it contains. Codex Alimentarius Commission defined honey as the natural sweet substance produced by honey bees [5, 6]. The bees are said to produce honey in order to serve as their source of food in times of scarcity or during harsh weather conditions.

Essentially, natural honey is sticky and viscous with a content of 80-85 % carbohydrate (mainly glucose and fructose), 15-17 % water, 0.1-0.4 % protein, 0.2 % ash and minor quantities of amino acids, enzymes and vitamins as well as other substances like phenolic antioxidants. Each of these minor constituents is known to have distinctive nutritional or medicinal properties and the unique blend accounts for the varied and different applications of natural honeys. Although the major constituents of honey are nearly the same in all honey samples, the precise chemical composition and physical properties of natural honeys differ according to the plant species on which the bees forage. Furthermore, differences in climatic conditions and vegetations are important factors that can affect the various properties of honey.

Honey is a thick, sweet liquid made by bees from the nectar of flowers. It contains water, glucose, fructose, proteins, vitamins and minerals [7]. It is also defined as the natural sweet substance produced by honeybees from the nectar of blossoms or from the secretions of living parts of plants or excretions of plants sucking insects on the living parts of plants, which honeybees collect, transform and combine with specific substances of their own, store and leave in the honeycomb to ripe and mature [8].

There are basically two types of honey, apiary and forest honeys. Honey produced by the honeybees, *Apis ceranaindica* and *Apis mellifera*, in apiaries and collected by modern extraction method are called apiary honey. They are transparent and free from foreign materials. In contrast, those produced by rock bee, *Apis dorsata*, or by wild nest of *Apis ceranaindica* in forests and collected by the crude method of squeezing the comb are known as forest honeys. They are

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turbid owing to the abundance of pollen, wax, brood (bee larvae), parts of bees and plant materials. It is therefore necessary to filter the honey to separate the suspended particles [9]. Honey primarily contains sugar and water. Sugar accounts for 95-99% of honey dry matter, majority of these are simple sugars, fructose (38.2 %) and glucose (31.3 %), which represents 85-95% of total sugars. These are “simple” sugars, 6-carbon sugars that are readily absorbed by the body [10]. Other sugars include disaccharide such as maltose, sucrose and isomaltose, few oligosaccharides are also present. Water is the second most important component of honey. Its content is critical, since it affects the storage of honey. The final water content depends on numerous environmental factors during production such as weather and humidity inside the hives, and also on nectar conditions and treatment of honey during extraction and storage. The color of honey can vary from nearly colorless to dark brown and its consistency can be fluid, viscous or partly to entirely crystallized. The nectar source visited by the honey bees leads to variation in colours, flavors and aroma [11]. Honey is characteristically acidic with pH between 3.2 and 4.5, which is low enough to be inhibitory to many animal pathogens [12]. The multi facet properties of honey anchored in the scientific world is regarded as a sweetener, functional food, antioxidant, antimicrobial, antiseptic, pre-biotic, probiotic, immunomodulatory, anti-inflammatory, anti-tumor and anti-cancer effect amongst others.

II. ECONOMIC IMPORTANCE OF APICULTURE INDUSTRY

Honey is used for nutritional, medicinal and industrial purposes and it is an important commodity in the international market; serving as foreign exchange earner for many countries. Beekeeping is an age-old tradition in Nigeria but it is not considered as a profit making venture in most parts of the country. Thus, while beekeeping has been a part of normal agricultural enterprise among some communities in the country [13], honey production has largely been at a subsistence level. However, honey is found in beehives in large quantities in Nigeria [14] and it has been recognized that honey production (beekeeping) has the potential to develop as a prime agro-horticultural and forest-based industry which can well become a major foreign exchange earner if international standards are met. For instance, it was shown that in Adamawa State, a beekeeper with an average number of 27 beehives made an average of \$1,119.29 per annum from the sales of honey and beeswax. Similarly, it was reported that in Ekiti State, a beekeeper with an average of 20 langstroth and top bar beehives made average revenue from sales of honey, bees wax and propolis amounting to about \$2,148.42 per annum and \$1,027.29 per annum respectively. Similar reports from Adamawa State indicate only a small percentage (5.62%) of the farming population who were already in the practice of beekeeping actually perceived apiculture as a profitable enterprise; while a majority (56.25%) of the rural farming community and about 36.25 % of the urban farming community considered apiculture only as a sideline economic activity.

III. BIOCHEMICAL AND ANTIBACTERIAL PROPERTIES OF HONEY

The biochemical components and antibacterial efficacy of pure honey produced by honeybee (*Apis mellifera*) revealed the presence of reducing sugar, saponins, glycosides, alkaloids and flavonoids and absence of phenols and tannins. Antibacterial activity of pure honey on some medically important bacteria including *Staphylococcus aureus*, *Salmonella typhi*, *Escherichia coli*, *Klebsiella pneumonia* and *Pseudomonas aeruginosa* was determined using the agar well diffusion method. The result shows that pure honey exhibit strong antibacterial activity producing zones of inhibition against the tested bacteria. Also, honey sample used in this study showed antibacterial activity than the commercially available antibiotics. Our findings shows that honey, apart from their roles as food and supplements, could be suitable for the treatment of various infection caused by bacteria hence should be used as a preventive and curative measure to common diseases related to the test organisms.

Above its therapeutic effect or medicinal attributes honey is also of potential use as bio indicators for environmental contamination. It is commonly used as a base for ointment and has successfully been applied in surgical dressing to avoid septic infections. Honey is gaining acceptance as an agent for the treatment of ulcers, bed sores and other skin infections resulting from burns and wounds. Moreover, it can be used on skin grafts and infected skin graft donor sites successfully. Honey may promote the repair of damaged intestinal mucosa, stimulate the growth of new tissues and work as an anti-inflammatory agent. The healing properties of honey can be attributed to the fact that it offers antimicrobial activity, maintain a moist wound environment that promotes healing and has a high viscosity which helps to provide a protective barrier to prevent infection [15]. Furthermore, honey has been employed to shorten the duration of diarrhea in patients with bactericidal gastro-enteritis due to bacterial infection.

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The antibacterial activity of honey was first recognized in 1892, by Van Ketel [16]. Numerous studies demonstrated that honey possesses antimicrobial activity. It destroys or inhibits the growth of some pathogenic vegetative microorganisms. An antifungal action has also been observed for some yeasts and species of *Aspergillus* and *Penicillium* [17], as well as the common dermatophytes [18]. Two millennia before bacteria were identified as the cause of disease, physicians at that time were aware that certain types of honey are the best therapy for particular ailment and infections. Honey was used to treat infected wounds as long ago as 2000 years before bacteria were discovered to be the cause of infection. When applied topically to wounds, it draws water from the wounds by the process of osmosis helping to dry the infected tissue and reduce bacterial growth. Laboratory studies and clinical trials have shown that honey is an effective broad-spectrum antimicrobial agent. Honey has been reported to have inhibitory effect on several bacteria including aerobes and anaerobes, Gram-positive and Gram-negative and is effective against methicillin resistant *Staphylococcus aureus* (MRSA), β -hemolytic *Streptococci* and vancomycin-resistant enterococci (VRE) [19, 20].

Pure honey has been shown to be bactericidal to many pathogenic microorganisms including *Salmonella spp*, *Shigella spp*, Other enteropathogenic organisms like *Escherichia coli*, *Vibrio cholerae* and other gram-negative and gram-positive organisms. This phenomenon was also observed in *S. aureus* and *P. aeruginosa* while *K. pneumonia* and *S. typhi* exhibited very less bactericidal activity. The ability of honey to kill microorganisms has been attributed to its high osmotic effect, high acidic nature, hydrogen peroxide concentration and its chemical nature, which include its content of tetracycline derivatives, peroxides, amylose, fatty acids, phenols, ascorbic acid, terpenes, benzyl alcohol and benzoic acid. Most types of honey generate hydrogen peroxide when diluted because of the activation of the enzyme glucose oxidase, which oxidize glucose to gluconic acid and hydrogen peroxide. Hydrogen peroxide is the major contributor to the antimicrobial activity of honey, and the different concentrations of this compound in different honeys result in their varying antimicrobial effects. It has further been reported that physical property along with geographical distribution and floral sources may play an important role in the antimicrobial activity of honey. The screening antibacterial activity and phytochemical analysis of essential plants has been of great interest in the discovery of drugs effective in the treatment of several diseases.

The biochemical screening conducted on pure honey revealed the presence of some bioactive components such as reducing sugar, Saponins, glycosides, alkaloids and flavonoids while phenols and tannins are absent. These compounds are known to have some therapeutic properties against several pathogens which support its traditional use for curing disease [21]. Flavonoids have been documented to possess potent antioxidant and free radical scavenging effect and have strong anticancer activity. They are also known to have anti-inflammatory, anti-allergic and anti-viral properties and help in the healing of wounds and treatment of skin diseases due to their ability to neutralize the acidity of wounds, and inflammation. The honey samples were also revealed to contain saponins. Saponins have the property of precipitating and coagulating red blood cells. Some of the characteristics of saponins include formation of foams in aqueous solutions, hemolytic activity, cholesterol binding properties and bitterness. More so, saponins have been found to be an antibacterial substance on the cell wall of many organisms. Saponins cause a reduction of blood cholesterol by preventing its re-absorption. The presence of alkaloid indicates that honey can be used as basic medicinal agents for their analgesic, antispasmodic and bactericidal effects. Glycosides are known to lower blood pressure according to many reports [22]. Plants containing reducing sugar are of great value to living organisms since they are primary metabolites and are directly involved in their growth, development and reproduction. Absence of other phytoconstituents (Phenols and tannins) may be due to certain factors such as climatic conditions, temperature and soil fertility.

IV. ANTIOXIDANT PROPERTIES OF HONEY

Although various studies have been carried out on honeybees and other insects, there are only a limited number of studies on the catalase (CAT) activities of worker bees at different ages. The effects of age on the antioxidant defense systems and pro oxidant generation were analyzed by comparing the activity of catalase and rates of H_2O_2 generation in the bees. [23]. There were evidence of the presence of SOD, CAT, and GST in the venom glands of bees; [24] in post mitochondrial fractions of tissue homogenates (spermathecae, muscle, and ventriculi), in haemolymph plasma, and in semen of honey bees; and [25] in the haemolymph of workers. The antioxidant capacities of workers differ according to age and feeding/diet type of bees. Over expression of CAT appears to have no or only slightly negative effects on the lifespan of organisms and to elevate resistance to H_2O_2 [26]. It seems that CAT over expression has no effect on normal living conditions, but it may have a role in aging. CAT activities increases slightly with increasing age in the workers.

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These increases in the CAT activities were not statistically important. The CAT activities slightly increased in parallel to the age of the workers. This could be the result of high CAT activity associated with increased cell viability and resistance to H₂O₂ in macrophages in the increasing age groups of workers [27]. Honeybee is a model organism for surveys of aging and senescence because it has a caste order in which a similar genome reproduces both a long-lived queen and a short-lived worker. They elevated mRNA grades for genes by scrambling 8 most important antioxidants and 5 mitochondrial proteins included in respiration. The expression of antioxidant genes usually diminished with age in queens, but not with worker bees. CAT activities among workers in different age groups slightly increased, but these increases were not statistically significant. (27). A significant change in total protein levels among different age groups were noted. The total RNA levels also decreased depending on the age of the workers. Synthesis of all proteins depends on translation of RNA. Changes in the levels of total protein may be parallel with changes in the levels of total RNA recorded. The total RNA levels may act as an indicator of the total protein amount. Increasing the amount of RNA involved in these structures suggests interaction at the transcriptional level. As a result, the metabolic processes of enzymes in different age groups cause interactions at the transcriptional and translational levels in bees. It was found that bees of different ages and labor divisions (depending on diet) may possess different transcriptional and translational expressions that could influence total RNA and total protein levels in bees. This would be the first step for new research in the future and contribute to the scientific literature.

V. REASONS FOR DECLINE OF APICULTURE INDUSTRY

Causes of long-term declines of honey bees in the U.S. and Europe are most likely due to the loss of beekeepers to the industry and intense competition for bee products. More research is needed on honey bee annual losses, but the global spread of pathogens and pests through the trade in bees and bee products likely plays a key role. These losses compound two critical environmental problems: the role of anthropogenic movement and manipulation of wildlife and their habitat and the role of agricultural intensification on managed species. In many ways, the state of research on honey bee losses mirrors the situation of livestock production in the early twentieth century, with poor coordination of best management practices (including lack of adequate knowledge of health threats and treatments) and a low appreciation of the impact of rapid demographic change on a managed population. For this issue, some lessons can be learned from amphibian population declines, which were first brought to global attention in the late 1980s and considered enigmatic by their occurrence in presumed pristine locations [28]. Despite several initial hypotheses of driver interactions [29, 30, 31], the identification of an emerging disease, chytridiomycosis [32] led to a marked shift in emphasis. The emergence of this disease, driven by the global trade in amphibians is now widely accepted as the major driver of enigmatic global amphibian population declines [33, 34, 35] and has led to the adoption of global policies to reduce its spread [34, 36]. Applying these lessons to the current state of honey bee health suggests that filling research gaps, particularly in management impacts and techniques, will complement additional studies on environmental factors such as nutrition, pesticides, pests, and pathogens to formulate comprehensive solutions to what may become an economically and environmentally costly phenomenon.

VI. CONCLUSION

Pure honey revealed the presence of bioactive components that has both bactericidal and bacteriostatic activity. This therefore justifies its usefulness in clinical and folklore practices against diseases caused by bacteria. But the dosage remains a challenge. The honey samples are found to be rich in phenolic and vitamin C contents which confer good antioxidant properties in honey. The quality parameters for the honey produced by apiary and forest honey coincide with those specified by the international honey regulations. Finally the protein levels such as enzymes in honeybee workers are related to age and labor division. The total RNA and protein levels in bees are also directly related to diet.

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