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REVIEW ARTICLE

The Enzymatic Role in Honey from Honey Bees and Stingless Bees

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Abstract: A variety of biomolecules known as enzymes are found in honey and originated from bees and plant nectars. The plant yields nectar that aids bees in producing honey. Diastases, invertases, glucosidases, glucose oxidases and proteases are the common enzymes present in honey and highly sensitive toward UV-vis light, heat, and microwave energy. Among all enzymes, invertase and diastase have been used for assessing the freshness of honey. The enzyme's capacity to transform amylose into glucose enhances the sweetness and flavor of honey. The role of enzymatic reactions in two types of honey, based upon bee sting morphology, namely honey from honey bees (HB) and stingless bees (SB) are discussed in this review. Enzymes that act as the main ingredient in honey production are comprehensively discussed for their significance in producing good quality and therapeutic properties of honey.

Keywords: Diastase, nectar, preservative, amylase, monosaccharides, honey.

1. INTRODUCTION

Honey is a sweet supersaturated material produced by bees [1] with high therapeutic and nutraceutical properties [2]. The health benefits of honey have been widely reported, such as wound healing [3, 4], antioxidant [5, 6], antimicrobial [7, 8], antibacterial [9], antityrosinase [10], anti-inflammatory [11, 12], antifungal [13], anticancer [14] and antiviral [15, 16]. Generally, honey has a high viscosity [17] as compared to the nectar collected by the bees. The solubility of honey in water is affected by supersaturation, enzymes, heat, or other chemical agents. The supersaturation of the honey indicates the consistency in thickness and solidity [18]. The water content in stingless bee honey (SBH) and honey bee honey (HBH) is varied [19] due to differences in climate, regional origin, plant & bee species, and harvesting style of wild bees or cultivated bees [20]. More than 600 different species of stingless bees (SB) exist worldwide, with *Heterotrigona itama* being one of the typical native species of SB in Southeast Asia. The *H. Itama* species can endure harsh conditions and are less susceptible to seasonal fluctuations. *H. itama* produces honey and nutrients of a higher quality than those produced by other SB species.

Commonly, SBH has a higher content of water compared to bee honey [21], which reduces self-life, quality, and appearance and alters the taste of honey [22]. Physiochemical parameters such as taste, color, and pH also assist in determining honey's purity and quality [23, 24]. For example, white honey is obtained from alfalfa, reddish-brown is produced from heather, and straw-colored honey is produced from citrus and acacia. The flavor of honey is also influenced by color; for instance, light-colored honey produces a mellow flavor, whereas darker-colored honey produces a harsher flavor [25]. Dark-colored honey has a sharp taste due to low pH and more phenolic acid and flavonoid derivatives as compared to light-colored honey [26]. Color varies due to the phenolic content and mineral content variation in honey [27].

Most of the earlier studies and reviews focused on honey adulteration [28, 29], analytical characterization [30, 31], honey products, therapeutic profiling and applications [32-34]. Enzymes play an important role in the production, sweetness , preservance , and mainatenance the quality of honey. However, the substantial involvement of enzymes in the formation of honey is scarcely reported. The enzymatic involvement in honey production is comprehensively discussed in this paper using two varieties of honey (*i.e.,* HBH & SBH). The enzymatic action of honey has been supported by a wide range of data that has been gathered from the literature, which therefore provides significant information to mankind.

2. HONEY FORMATION, PROCESSING AND BEE ROLE

A naturally sweet material called honey is produced by bees from nectar [35] collected from flowers and plants [36]. The honeybees convert nectar into honey by enzymatic action and store in the honey sac or honeycombs [37]. Honeybees follow the natural process along with other honeybees' coordination to make honey (Fig. **1**). The internal environment, *i.e.,* colony strength, brood unsealed and sealed, honey and pollen area, regulates the management of the colony throughout the production of honey and crop pollination [38]. The nectar is changed into honey from the inversion of sucrose sugar into fructose (sugars levulose) and glucose (dextrose). An excessive amount of moisture is also removed from the honey [39, 40].

The physiochemical properties, such as color, flavor and chemical composition of the honey are determined by the types of flowers from which nectar is collected and the nature of plants and soil [41]. The processing duration and temperature have also affected the yield and phenology [32, 42] of the honey. Honey processing such as preheating, filtration, moisture reduction, pasteurization and

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IEF	=	Isoelectric Focusing
LTVD	=	Low-temperature Vacuum Drying
LTVD-NB	=	Low-temperature Vacuum Drying with induced Nucleation Boiling
MRJP	=	Major Royal Jelly Proteins
NMR	=	Nuclear Magnetic Resonance Spectroscopy
pnf	=	*p*-nitrophenol
pnf G	=	*p*-nitrophenyl-d-glucopyranoside
SB	=	Stingless Bees
SBH	=	Stingless Bee Honey
SDS-PAGE	=	Sodium Dodecyl Sulfate-polyacrylamide Gel Electrophoresis
SS	=	Sucrose Syrup
UHPLC/Q-TOF-MS	=	Ultrahigh-performance Liquid Chromatography/Quadrupole Time-of-flight Mass Spectrometry

CONSENT FOR PUBLICATION

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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