Review Article

Review of the Medicinal Effects of Tualang Honey and a Comparison with Manuka Honey

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Abstract

Tualang honey (TH) is a Malaysian multifloral jungle honey. In recent years, there has been a marked increase in the number of studies published in medical databases regarding its potential health benefits. The honey is produced by the rock bee (*Apis dorsata*), which builds hives on branches of tall Tualang trees located mainly in the north-western region of Peninsular Malaysia. This review collates the results of the various studies of TH that range from research on tissue culture to randomised control clinical trials. Findings thus far show that, TH has antimicrobial, anti-inflammatory, antioxidant, antimutagenic, antitumor, and antidiabetic properties, in addition to wound-healing attributes. Some of its properties are similar to the well-researched Manuka honey (New Zealand and/or Australian monofloral honey). Distinct differences include higher phenolics, flavonoids, and 5-(hydroxymethyl) furfural (HMF). Compared with Manuka honey, TH is also more effective against some gram-negative bacterial strains in burn wounds.

Keywords: *ailments, antitumor, properties of Tualang honey, Tualang honey, wound healing*

Introduction

Honey has been used to cure a multitude of ailments since ancient times. Researchers are re-appraising its medicinal and nutritional values (1). The published literature indicates that honey has antimicrobial (2), anti-inflammatory (3), antioxidant, (4–7) and antimutagenic (8) properties, that it expedites wound healing (9–11) and that it has antitumor (3,12,13) and antidiabetic effects (6,14,15). The composition and physicochemical properties of honey are variable depending on its floral source (16). Honey is often named according to the geographical location where the honey is produced, the floral source of the honey or the trees on which the hives are found (11). Well-researched honey includes Manuka honey, pasture honey, jelly bush honey and African jungle honey. Although the benefits of Manuka honey are internationally recognised, the potential medicinal benefits of Tualang honey (TH), a multifloral jungle honey found in Malaysia, are only recently attracting attention. Some Malaysian researchers are investigating its effects on tissue culture medium (13,17) and in clinical trials (18).

TH is produced by the rock bee (*Apis dorsata*), which builds hives high up in the branches of Tualang tree (*Kompassia excelsa*). This tree (common name *Mengaris*) is found mainly in tropical rain forests (6,15,19–22) and can reach up to 250 feet in height. In Malaysia, the trees are plentiful in the north-eastern region in the state of Kedah. The honeycombs can be up to 6 feet across, and the hive can contain as many as 30 000 bees. More than 100 nests may be found on one Tualang tree. Such a tree can yield some 450 kg (about 1000 pounds) of honey (22). In Malaysia, the honey is used traditionally as a health and anti-ageing supplement.

Unlike TH honey, Manuka honey is a monofloral honey. It is produced by honeybees from the nectar of the Manuka honey bush (*Leptospermum scoparium*) throughout New Zealand and Australia. Published data on Manuka honey indicate that it has numerous therapeutic properties against several ailments (23–25). Manuka honey is already extensively studied and characterised. This review collates research findings on TH, some of which use Manuka honey as the 'gold standard'.

Composition and Physicochemical Properties of TH

Honey is primarily composed of fructose (38%), glucose (31%), and other sugars. It contains more than 180 substances, including amino acids, vitamins, minerals, and enzymes (26–28). The composition varies according to its floral source

and origin (11). TH has a dark brown appearance. It has a pH of 3.55–4.00 and a specific gravity of 1.335 (29). The low pH is similar to Manuka honey (pH 3.2–4.21) (21,25). TH is more acidic than other local Malaysian honeys, such as Kelulut Hitam, Kelulut Putih, and Gelam (29). This characteristic makes TH effective against several pathogenic microorganisms (21,29). The concentration of 5-(hydroxymethyl) furfural (HMF) in TH is greater than in other Malaysian honeys (30). A comparison of the physicochemical characteristics of TH (29) and Manuka (31) honey is presented in Table 1.

TH contains more phenolic acids and flavonoids than Manuka honey and other local Malaysian honeys (32). A total of six phenolic acids (gallic, syringic, benzoic, trans-cinnamic, p-coumaric, and caffeic acids) and five flavonoids (catechin, kaempferol, naringenin, luteolin and apigenin) are found in TH (32–34). Hydrocarbons constitute more than half (58.5%) of its composition. These include alcohols, ketones, aldehydes, furans, terpenes, flavonoids, and phenols (33). Some compounds found in TH previously not reported in other honeys are stearic acids, 2-cyclopentene-1,4,-dione, 2[3H]-furanone or dihydro-butyrolactone, gamma-crotonolactone or 2[5H]-furanone, 2-hydroxy-2-cyclopenten-1-one, hyacinthin, 2,4-dihydroxy-2,5-dimethyl-3[2H]-furan-3-one, and phenylethanol (33–35). The details of the various compounds present in TH (33,35) and Manuka (24,31) honey are summarised in Table 2.

The vitamins, enzymes, amino acids, trace elements, and other compounds in TH have yet to be quantified.

Antibacterial Activity of TH

Honey has antimicrobial effects, which are attributed to the osmotic effect of the substance's sugars, its pH, and particularly its peroxidase activity (21,28,29,36). The antimicrobial effects are also due to the presence of non peroxidase substances such as phenolic acids, flavonoids, and lysozymes (21,28,36). TH has both bactericidal and bacteriostatic properties against a range of bacteria, including common bacteria on the skin (21,36). At concentrations of 6.25–25%, TH inhibits the growth of several bacterial strains, such as *Streptococcus pyogenes, Salmonella typhi, Staphylococcus aureus,* coagulase-negative *Streptococcus* spp., and *Escherichia coli* (36–39). In general, it is as effective as Manuka honey against several bacterial strains (21). Table 3 describes the microorganisms that are sensitive to TH and Manuka honey.

The health benefits of TH are better compared to other Malaysian honeys. TH is more effective than Manuka honey against some gram-negative bacterial strains in burn wounds management (36,39), probably due to its higher content of

Table 1: The physicochemical characteristics of Tualang versus Manuka honey

Physiochemical properties	Tualang Honey	Manuka Honey
Appearance	Dark brown	Light to Dark brown
Specific gravity	1.335	1.39
pH	3.55–4.00	3.2–4.21
Moisture content	23.30%	18.7%
Total Reducing sugars	67.50%	76.0%
Fructose	29.60%	40.0%
Glucose	30.00%	36.2%
Sucrose	0.60%	2.8%
Maltose	7.90%	1.2%
Potassium	0.51%	1.0%
Calcium	0.18%	1.0%
Magnesium	0.11%	1.0%
Sodium	0.26%	0.0008%
Carbon	41.58%	–
Oxygen	57.67%	–

Table 2: List of active chemical compounds found in Manuka and Tualang honeys

Phenolic acids/Flavonoids		Bio-chemical compounds	
Tualang honey	**Manuka honey**	**Tualang honey**	**Manuka honey**
Benzoic Acid	Benzoic Acid	5-(hydroxymethyl)-furfural(HMF)	5-(hydroxymethyl)-furfural(HMF)
Gallic acid	Gallic acid	Furfural	4-Methylacetophenone
Syringic acid	Syringic acid	2-furylmethylketone	Ortho-Methoxyacetophenone
p-coumaric acid	Apigenin	5-methyl furfural	1-Methoxy-4-propyl-benzene
Hyacinthin	Salicylic Acid	Acetic acid	1-(2-Hydroxy-6-methoxyphenyl)-ethanone
Trans-cinnamic acid	3-Phenyllactic acid	Phenylethanal	4-Hydroxy-3-methoxybenzoic acid methyl ester
Caffeic acid	3,5-Dimethoxybenzoic acid	2-hydroxy-2-cyclopenten-1-one	2,3-Dimethoxynaphthalene
Catechin	Methyl syringate	2 furancarboxaldehyde	3,5-Dimethoxybenzoic acid methyl ester
Kaempferol	Desoxyanisoin	Furfural alcohol	4-(x-Methoxyphenyl)-1-phenyl-1-butanone
Naringenin	Pinostrobin chalcone	2-cyclopentene-1,4,-dione	2,6-Dimethoxybenzoic acid benzyl ester
Luteolin	Pinocembrin	2[3H]-furanone	4,4'-Dimethoxystilbene
–	Tectochrysin	Gamma-crotonolactone	3,3,4,5,5,8-Hexamethyl-2,3,5,6-tetrahydro-sindacene-1,7-dione
–	Chrysin	Palmitic acid	1,4-Bis(x-methoxyphenyl)-but-2-en-1-one
–	2-Methoxybenzoic acid	Ethyl linoleate	1,5-Bis(4-methoxyphenyl)-pentane-1,5-dione
–	(4-Methoxyphenyl)-acetic acid	Ethyl oleate	1,5-Bis(x-methoxyphenyl)-pent-3-en-1-one
–	2-Methoxybenzoic acid	2,4-dihydroxy-2,5-dimethyl-3[2H]-furan-3 one	1,4-Bis(x-methoxyphenyl)-1-pentanone
–	Phenyllactic acid	Oleic acid	1,6-Bis(x-methoxyphenyl)-3-heptene
–	Methyl syringate	Linoleic acid	1,6-Bis(x-methoxyphenyl)-hex-2(3 or 4)-en-1-one
	Abscisic acid	Octadecanoic acid	2(3, 4 or 5)-Hydroxy-1,6-bis(x-methoxyphenyl)
–	4-Methoxybenzoic acid	2-hydroxy-1-[hydroxymethyl] ethyl ester	
–	–	Dihydro-butyrolactone	–
–	–	2[5H]-furanone	–

phenolics, flavanoids, and HMF. The bactericidal effect of the acidic fraction of TH is greater against some bacterial strains than the non-extracted or non-fractionated fraction (40). TH reduces the growth of wounds infected with *Pseudomonas aeruginosa*, *Acinetobacter baumanii* or *Klebsiella pneumonia* (36), with one study reporting superior healing with a honey dressing than with conventional silver and aquacel dressings (41). These bacteria are a common cause of hospital infections.

Wound Healing Properties of TH

The healing properties of honey are well known (3). In general, honey improves wound healing by abating the oedema, inflammation, and exudation that commonly occur in all types of wounds. Honey stimulates the growth of epithelial cells and fibroblasts (25,42). Manuka honey heals moist burns and several other types of wounds (25,43). Studies of TH report similar outcomes (36,41,44). In full-thickness burn wounds treated with TH and conventional hydrofibre silver-treated wounds, the wounds treated with the TH show a reduction in wound size of 32.26% (45). The healing efficacy is also superior in TH-treated burn wounds compared with hydrofibre silver and aquacel plain dressings (41). Wound healing in TH-impregnated dressings are comparable to those obtained with modern hydrofibre and silver dressings (46). Patients prefer TH hydrogel dressings than conventional dressings because the treatment is soothing, they experience minimal pain and the dressings have a pleasant odour (47). TH is as effective as Manuka honey in the treatment of diabetic foot (47).

Table 3: List of micro-organisms that have been found to be sensitive to Tualang and Manuka honeys

Gram +ive strains		Gram –ive strains	
Tualang honey	**Manuka honey**	**Tualang honey**	**Manuka honey**
Streptococcus pyogenes	*Streptococcus pyogenes*	*Stenotrophomonas maltophilia*	*Stenotrophomonas maltophilia*
Coagulase negative Staphylococci	*Coagulase negative Staphylococci*	*Acinetobacter baumannii*	*Acinetobacter baumannii*
Methicillin-resistant -Staphylococcus aureus(MRSA)	*Methicillin-resistant -Staphylococcus aureus(MRSA)*	*Salmonella enterica Serovar typhi*	*Salmonella enterica Serovar typhi*
Streptococcus agalactiae	*Streptococcus agalactiae*	*Pseudomonas aeruginosa*	*Pseudomonas aeruginosa*
Staphylococcus aureus	*Staphylococcus aureus*	*Proteus mirabilis*	*Proteus mirabilis*
Coagulase-negative-Staphylococcus aureus (CONS)	*Coagulase-negative-Staphylococcus aureus (CONS)*	*Shigella flexneri*	*Shigella flexneri*
–	haemolytic streptococci	*Escherichia coli*	*Escherichia coli*
–	*Enterococcus*	*Enterobacter cloacae*	*Enterobacter cloacae*
–	*Streptococcus mutans*	*Shigella sonnei*	*Shigella sonnei*
–	*Streptococcus sobrinus*	*Salmonella typhi*	*Salmonella typhi*
–	*Actinomyces viscosus*	*Klebsiella pneumonia*	*Klebsiella pneumonia*
		Stenotrophomonas maltophilia	*Stenotrophomonas maltophilia*
			Burkholderia cepacia
			Helicobacter pylori
			Campylobacter spp.
			Porphyromonas gingivalis

Antioxidant Activity of TH

Chronic or degenerative diseases are more susceptible to oxidative stress. Honey has antioxidant activities that can suppress oxidative stress (22). The antioxidants in honey are flavonoids, phenolic acids, amino acids, proteins, and some enzymes (32,33). TH has similar antioxidant activity (7,15,22) to Manuka honey (23), Slovenian honey (5) and other honeys (5,22). TH alone or in combination with glibenclamide and metformin protects against oxidative stress in streptozotocin-induced diabetic rats (14,15,48,49). TH has a higher level of antioxidant activity than other local Malaysian honeys, such as Gelam, Indian forest, and pineapple honeys (32). Based on a study of nine different Malaysian honeys from different origins (using Manuka honey as gold standard), TH has more free-radical scavenging and antioxidant activity than other local and commercially available honeys (22,32). This was attributed to its high content of phenolics and flavonoids (22,32).

Antitumor and Antiproliferative Activity of TH

Honey may have potential as a natural cancer 'vaccine' because it reduces chronic inflammation, which is a risk factor for cancer pathogenesis, improves the healing of chronic ulcers and wounds, and improves the immune status (3). The antitumor properties of honey seem to involve multifactorial processes: (i) the apoptosis of cancer cells via depolarisation of the mitochondrial membrane (20), (ii) the inhibition of cyclooxygenase-2 by various constituents, such as flavonoids (50), (iii) the release of cytotoxic H_2O_2 and (iv) the scavenging of reactive oxygen species (28,51). TH shows antiproliferative or antitumor activity against various types of cancer cells (3), exhibiting antiproliferative and early apoptotic effects against oral squamous cell carcinoma (13), human osteosarcoma cell lines (13), human breast cancer MCF-7 cells (20) and cervical cancer cell lines at concentrations of 1–20% (20,51). Thus, in common with other honeys, TH seems to have promising antitumor activity related to its high content of phenolic and flavanoid antioxidants.

Antidiabetic Activity of TH

As honey is high in sugar, it can be considered detrimental to diabetics. However, some honeys have a positive role in regulating the blood glucose level (7,15,19,52,53). As honey is high in fructose, it has a low glycaemic index and is therefore, recommended for patients with diabetes. However, chronically high consumption of honey may lead to hepatic and extrahepatic insulin resistance (54). TH honey has an intermediate glycaemic index based on tests in healthy individuals (53). TH modulates the glucose level according to studies comparing the effect of TH and the oral hypoglycaemic agents glibenclamide and metformin on streptozotocin-induced diabetic rats (19,52).The diabetic rats were randomised into six groups and administered distilled water, honey, glibenclamide alone, glibenclamide and TH, metformin alone or metformin and TH. TH significantly increased insulin levels (0.41 +/– 0.06 ng/ml) and decreased hyperglycaemia (12.3 +/– 3.1 mmol/L) and fructosamine (304.5 +/– 10.1 mmol/L). Although glibenclamide or metformin alone significantly ($P < 0.05$) reduced hyperglycaemia, glibenclamide or metformin combined with TH resulted in a significantly lower blood glucose level (8.8 +/– 2.9 or 9.9 +/– 3.3 mmol/L, respectively) compared to glibenclamide or metformin alone (13.9 +/– 3.4 or 13.2 +/– 2.9 mmol/L, respectively. These results indicate that a combination of oral hypoglycaemic agents with TH improves glycaemic control in diabetic rats (19).

Other Potential Health Benefits of TH

TH has been studied in animal models and in humans, with one study showing it has the potential to reduce cardiovascular risk factors in healthy individuals (55). It also decreases systolic blood pressure and reduces levels of triglycerides and very low density lipoprotein (VLDL) in diabetic spontaneously hypertensive rats (48). Furthermore, Hajj pilgrims in Mecca who took TH daily had a lower incidence of acute respiratory symptoms compared to those who did not consume TH in a randomised controlled trial (56).

TH improves the sperm count, increases sperm motility (57), and increases some female hormones (58). It ameliorates the toxic effects of cigarette smoke on spermatogenesis and the testosterone level in male Sprague-Dawley rats (59). Post-menopausal women who take TH exhibit an improvement in their immediate memory but not after interference and delayed recall that is comparable to that seen in women receiving oestrogen plus progestin therapy (60).

Conclusion

TH is a Malaysian multifloral jungle honey. In recent years, there has been a surge of interest in the potential health benefits of this honey. Studies range from pure laboratory tests to animal experiments and controlled clinical trials. They show that the ability of TH to heal various types and depths of wounds is better than that of conventional wound treatments. TH shows bactericidal and bacteriostatic activity against a number of gram-positive and gram-negative bacteria. It is rich in antioxidants and has great potential as an anticancer agent. It improves hypertension, lipid profiles and diabetes in rats. It shares some similar properties and biochemical characteristics with the much-researched Manuka honey (New Zealand and/or Australian monofloral honey). Distinct differences include higher phenolics, flavonoids, and HMF. TH is more effective than Manuka honey against some gram-negative bacterial strains in burn wounds. Although the health benefits of Manuka honey are internationally recognised, those of TH are only recently attracting attention. More laboratory research and clinical trials are needed to develop a better understanding of its potential health benefits and to abate scepticism.

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Conflict of interest

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Authors' contributions

Conception and design, analysis and interpretation of the data, critical revision of the article for the important intellectual content and final approval of the article: NHO
Drafting of the article, statistical expertise, collection and assembly of data: SA

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