BY’s Apitherapy Niagara Wellness Center study on Beehive Air proves significant therapeutic advantages for Respiratory Conditions

R. Gagne, EET, CFE, NADEP

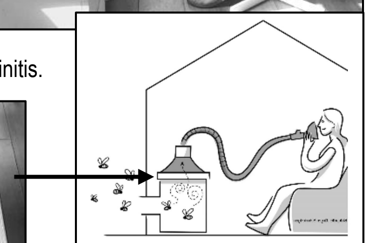
Apitherapy is a type of therapy that uses honeybee products, such as honey, pollen, propolis, royal jelly, beeswax and bee venom. In fact, these products are extraordinary not only because they contain biologically active components, but also because they are proven to be good for our health. This therapy has been used over the centuries to treat some illnesses and their symptoms, as well as pain from acute and chronic injuries. As research in the journal Environmental Science and Pollution Research showed, honey has anti-inflammatory and antioxidant properties, which means it can be used to treat wounds and scars and alleviate allergies. Moreover, within apitherapy there is bee venom treatment, which has proven to be helpful when it comes to treat immune and neurological diseases. Propolis has also been proven to reduce dental plaque and gingivitis. It has also been proven that inhaling the air from beehives has a beneficial effect on our well-being and the purpose of this study was to expand upon known research to determine the healing qualities of Bee Air in relation to the treatment of respiratory conditions. By inhaling that warm beehive air, the aerosol, through a special breathing mask, we directly input precious natural elements which are organically occurring within the hive (propolis, royal jelly, beeswax and pollen). The purpose of this new study was to enhance previous research regarding the collection of active air components from controlled beehives to evaluate the therapeutic advantage to treatments for respiratory and other conditions.

Background

Bees create a consistent environment in their hive. They use their bodies to heat the air to around 35 degrees. At the same time, there is humidity of 70 to 75 per cent. The bees continuously circulate this air. Components of honey, bee pollen, beeswax, and bee propolis are released into the air. This is how bees create unique beehive air. Beehive air contains natural substances such as propolis, cytochrome protein, the smell of honey, wax, and other 1000-plus known substances. Propolis boasts strong anti-inflammatory properties and is also a natural antioxidant. The cytochrome protein helps eliminate chemical residues and any hydrocarbons that are found in the body. It is believed that the other substances when combined with these two make therapeutic treatment the most effective.

Therapeutic Advantages of Bee Air

It is believed that beehive air treatment is an effective immune booster as a potential remedy for treating asthma, bronchitis, lung fibrosis, and respiratory tract infections. Other diseases that may be countered with beehive air treatment include immunodeficiency, chronic headaches, and chronic Rhinitis.



<u>Some of the benefits of beehive air treatment include:</u>

1. It is an immune booster.
2. Helps improve the respiratory organs.
3. Improves overall well-being.
4. Eliminates stress.

Treatment Session Details

Proponents claim that patients get the best results after undergoing 10 to 40 beehive air treatment sessions. The air is extracted for 15 minutes for every application and 2 honeybee colonies will be sufficient for a 30-min. session and then will be given a 45-min. break after an initial session.

Technology for Healthy Bee air:

The device used in beehive air treatment comprises a tube with a sieve that goes into the beehive and an airflow controller that helps regulate the quantity of air inhaled. It is built in such a manner that the patient does not come into direct contact with the honeybees but will sit beside or behind the hive. With beehive air treatment, patients inhale hive air directly from the beehive. Due to the relatively high temperature and humidity of the beehive air, condensation naturally occurs when it hits colder surrounding surfaces. If this happens inside the control unit, corrosion can occur. In the worst case, mold and bacteria can also develop inside the device. The complete encapsulation of the control unit of the inhaler prevents this. Another undesirable effect of condensation: With the moisture, the beehive air’s active substances are also deposited in the condensate. A heated hose prevents the formation of condensation so that all the bee air components reach the patient in full. A valve ensures that the patient only inhales fresh beehive air with each breath. It prevents exhaled air from flowing back into the tube. BY’s has invested in the technology to ensure Healthy Bee Air is always inhaled.

Previous Research
Understanding the chemical nature of the Bee Air is not new to research internationally, where in previous studies volatile compounds were collected from beehive air using solid phase micro-extraction (SPME) coupled to gas chromatography-mass spectrometry (GC–MS). Antimicrobial assay of the air released from 4 beehive products was further performed against Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, and multi drug-resistant Staphylococcus aureus (MRSA) using the in vitro agar-well diffusion and microtiter plate assays.

Previous study results and conclusions: A total of 56 volatile compounds were identified from beehive air, venom, bee insect and wax air including 6 fatty acids, 6 alcohols, 10 aldehydes, 5 esters, 1 ether, 9 hydrocarbons, 1 phenol, 7 ketones, 1 nitrogenous compound and 10 terpenes. The most abundant constituents were short-chain fatty acids (26.32%) while the lowest were the nitrogenous compounds (0.82%). The principal component analysis (PCA) scores plot of the UPLC/MS dataset showed the similarity of the beehive air to the insect bee's aroma profile. With regards to antimicrobial assay, beehive air and venom exerted the strongest antimicrobial activity.

Modern science has revealed that each bee product (raw material, crude extract, and purified active compounds) is economically important due to the several potent bioactivities, such as antimicrobial, antiviral, antitumor, and anti-inflammatory potential (Alvarez-Suarez, 2017). Equally interesting, the herbal preparations containing propolis have been utilized to prevent respiratory tract infections in children (Tilahun et al., 2015). Previous studies have concluded that the bee products exhibit antibacterial activity against Staphylococcus aureus (Silici and Kutluca, 2005), Klebsiella pneumoniae, Acinetobacter baumannii (Morroni et al., 2018), and multi drug-resistant Staphylococcus aureus (MRSA) (Alotibi et al., 2018, Chen et al., 2017). Further, clinical investigations proved the antimicrobial potential against both Gram-positive and Gram-negative bacteria (Basualdo et al., 2007) and suggested the involvement of the volatile components in these effects. The well recognized anti-inflammatory, anti-microbial and dietary applications of bee products and in particular the volatile constituent over time poses a possible promising treatment for microbial diseases.

Given this context, the characterization of the aroma profiles of bee products is warranted, and more efforts have increasingly focused on their identification utilizing techniques such as high-performance liquid chromatography (HPLC), mass spectrometry (MS), liquid chromatography–MS/MS (LC-MS/MS), gas chromatography-mass spectrometry (GC–MS), and nuclear magnetic resonance (NMR) (De-melo et al., 2018, Zhao et al., 2017). Headspace solid phase micro-extraction (HS-SPME) followed by GC–MS is one of the most advanced techniques for studying the volatile profiles of the biological samples. HS-SPME-GC–MS is the technique of choice for fingerprinting and quantifying of specific classes of volatile compounds and has been applied for the identification of volatile compounds in bee products (Isidorov et al., 2009, Farag et al., 2017a).

Objective of the new BYs Study

BY's Apitherapy has set up the first Canadian Apitherapy Center to complete research and therapeutic trials derived from the bee. This project encompasses capturing and analyzing air from bee hives to determine the chemical profile of the air. There are two outcomes based on the results. Firstly, the chemical makeup of the bee "air" will help to understand the chemical differences between healthy and unhealthy hives, assisting in the process of developing a healthy hive indicator process and technology. Secondly, bee "air" is considered a therapeutic process for certain respiratory conditions, known as Beehive Air Treatment.

The main objective of this study was to explore the efficiency of beehive air treatment based on its active components and to determine the major aroma contributors to beehive air. For the purpose of this study, we used Mass Spectrometry and all samples were measured according to the conditions in Table 3 and 4. Acquisition parameters included; Gas Temperature (C) 320, Gas Flow (L/min) 8, Nebulizer (psig) 35, Sheath Gas Temp (C) 350, Sheath Gas Flow (L/min) 11, Ionization Mode Positive, Capillary Voltage 3500, Nozzle Voltage 250, Fragmentor Voltage 140 and Skimmer Voltage. There were 248 unique compounds present in the ambient air samples collected with Orbo 32 tubes, and 201 compounds collected with Orbo 53 tubes. These compounds were excluded from the hive datasets, to isolate compounds which were a direct result of the hives.

HPLC (High-performance liquid chromatography (HPLC) is a broad analytical chemistry technique used to separate compounds in a chemical mixture. These separations utilize the pressure-driven flow of a mobile phase through a column packed with a stationary phase). separation conditions included; Solvent: 70%, Acetonitrile/30% Water, Flow Rate of 0.200 mL/min and Column, Zorbax UPLC C18.

Conclusion

As per the Loyalist Applied Research and Innovation Centre findings. "After comparing samples of the atmosphere versus the hives, several compounds were detected as being unique to the Bee Air and displayed a high score which is an indication of an active component. These include the following tentative identifications: Tetradecanamide, 2-(1-Pyrrolidinyl)-3-pentanone, 3-(1-Pyrrolidinyl)-2-pentanone, 2,2,6,6,-Tetramethyl-4-piperidione, N-Methylpelletierine, 1 Hexadecylamine, N-Methyldioctylamine and Hexadecyl Acetyl Glycerol."

<u>The following is a detailed description of the therapeutic advantages noted in the chemical compounds unique to the Bee Air:</u>

1. **Tetradecanamide** Synonyms: Tetradecanamide, Myristamide, Tetradecylamide
   Myristamide is a fatty amide of myristic acid. It has a role as a human metabolite. It is a primary carboxamide and a primary fatty amide. It is functionally related to a tetradecanoic acid. Tetradecanoic acid is a straight-chain, fourteen-carbon, long-chain saturated fatty acid mostly found in milk fat. It has a role as a human metabolite, an EC 3.1.1.1 (carboxylesterase) inhibitor, a Daphnia magna metabolite and an algal metabolite. It is a long-chain fatty acid and a straight-chain saturated fatty acid. It is a conjugate acid of a tetradecanoate. Myristic acid strengthens the skin barrier by keeping the skin's outermost layer robust and undamaged. As surfactant, myristic acid can mix with water and oil to remove dirt and impurities on the skin, hair, scalp, etc. while keeping the skin hydrated. Naturally occurring chemical substances and their semisynthetic derivatives have shown various biological activities. In this context,

Myristic acid, a naturally occurring saturated fatty acid found in nutmeg and has shown diverse biological actions against fungi, viruses, cancerous cells, and parasitic microbes.

2. **2,2,6,6,-Tetramethyl-4-piperidione**
   2,2,6,6-Tetramethyl-4-piperidone is used as a low energy source for chemical reactions due to its carbonyl group. This compound was found to have an inhibitory effect on the growth of bacteria through reactions with oxidative dna and triacetonamine.
3. **1 Hexadecylamine**
   Fatty acids and their derivatives, such as fatty amines, have been identified as antimicrobials (Kabara, 1977; Kitahara et al., 2004). The amylose-N-1-hexadecylammonium chloride (5 % ligand) inclusion complex (Hex-Am) may possess many of the necessary characteristics needed for an effective antimicrobial polymer. The antimicrobial action of the complex would be derived from the fatty ammonium chloride ligand, as the amylose alone does not have antimicrobial properties. The amylose portion of the complex would serve as a delivery vehicle of the antimicrobial ligand. The amylose complex is a polymer which is cationic and amphiphilic (Fanta, Felker, & Selling, 2016; Fanta, Felker, Selling, Hay, & Biswas, 2016).
4. **Hexadecyl Acetyl Glycerol**
   Higher concentrations of 1-O-hexadecyl-2-acetyl-sn-glycerol significantly inhibited the growth of HL-60 cells (HL-60 - The human promyelocytic leukemia cell line) and resulted in the virtual absence of cells resembling the original HL-60 line.
5. **N-Methyldioctylamine**
   N-Methyldioctylamine is a biodegradable, water soluble, and non-toxic chemical. It removes organic matter from industrial effluents by breaking down long chain hydrocarbons into smaller fragments and reacts with the hydroxyl group of proteins to form hydroxylamines. N-Methyldioctylamine has been shown to inhibit protease activity in wild-type strains of bacteria, such as Escherichia coli and Pseudomonas aeruginosa (E. coli is a facultative anaerobic bacterial species belonging to the genus Escherichia, Enterobacteriaceae family. On the other hand, P. aeruginosa is an aerobic bacterial species belonging to the Pseudomonadadaceae family under the Pseudomonas genus). It also inhibits hematopoietic cells from developing into mature cells by disrupting the biochemical composition of their membranes. N-Methyldioctylamine is reactive with fatty acids and amines found in mammalian tissue samples. This compound can be used as a sample preparation agent or analytical reagent for caproic acid, which is used in process optimization applications.
6. **N-Methylpelletierine:** pelletierine (Punica granatum) The Punica Granatum Tree
   N-methylpelletierine is a particularly interesting identification, postulated to be a bee metabolite of pelletierine from the Punica granatum (Pomegranate) tree unique to and located on the property of the BYs Apitherapy Center farm. Quinoline–piperidine hybrids: Piperidine ring is present in naturally occurring alkaloids such as piperine, sedum alkaloids (e.g., sedamine), pelletierine, the lobelia alkaloids (e.g., lobeline), the conium alkaloids (such as coniine), and the pinus alkaloids [26]. Piperidine nucleus has tremendous importance in medicinal chemistry. The extensive synthetic exploration of piperidine-containing compounds showed that the piperidine nucleus has interesting pharmacological activities such as anti-allergic, anti-inflammatory, analgesic, antioxidant, antipsychotic, antidepressant, antidiabetic, anticancer, antibacterial, antimalarial, antifungal, and other activities with a considerable number of compounds in clinical use [27].

What and where the bees harvest is integral to the quality of product they provide.

Profiling other beehive aroma from other localities or of bees reared on different crops, different climate could provide stronger information on variation in volatiles composition among beehives. Honey, for example, produced more than 600 volatile compounds, including hydrocarbons, aldehydes, alcohols, ketones, acids, esters, terpenes and cyclic compounds. The aroma contents and biological properties of honey are influenced qualitatively and quantitatively by botanical and geographical origin (Ramos et al., 2018). This is documented in this study through the results for the chemical compound N-Methylpelletierine: pelletierine (Punica granatum) which is directly related to the Punica Granatum Tree which is uniquely located on the BYs Honey Farm.

At BY's Apitherapy Center the bee management policy is to maintain healthy and productive honeybee colonies without the use of synthetic treatments or antibiotics. There are parasite and disease control options available for the management system. The treatments for pest and disease control are often based on natural chemicals or compounds. Cultural and physical controls are also management practices applied by our beekeepers that use specialized equipment or physical means to control pests and reduce the level of diseases in the hive. We also use genetic control of pests and diseases by selection and use of honeybees which have a genetic tendency to be resistant to infection or infestation.

The floral environment planted includes enough buckwheat, wildflowers, clover, etc. to ensure the food requirements are met for our bee population such that they do not have to travel far. Bees are known to fly as far as 12 km (8 miles), but usually foraging is limited to food sources within 3 km. Approximately 75% of foraging bees fly within one kilometer while young field bees only fly within the first few hundred meters. This is of particular importance as the farm on which BY's resides, has had no spraying of any harmful chemicals for at least the past 15 years.

In summary

In previous studies, 56 volatile compounds were identified from beehive air and its individual components and categorized into fatty acids, alcohols, aldehydes, esters, ether, hydrocarbons, phenol, ketones, nitrogenous compounds, and terpenes. The abundance of n-caprylic acid, cinnamaldehyde, geranic acid, decanal, limonene, eugenol, benzaldehyde, nonanoic acid, nonanal, b-linalool, caryophyllene, a-humulene, cinnamaldehyde, limonene, eugenol, and benzaldehyde were closely related to their anti-inflammatory, anti-asthmatic and antimicrobial actions. Taken together, this information could support the validity of beehive air aromatherapy for the treatment of respiratory tract disorders such as asthma, bronchitis, and lung fibrosis, although no direct evidence was found in this study based on employed antimicrobial assay.

Noted therapeutic compounds related directly to the BY's Honey Farm Bee Air Treatment displayed interesting pharmacological activities such as anti-allergic, anti-inflammatory, analgesic, antioxidant, antidepressant, antidiabetic, anticancer, antibacterial, antimalarial, antifungal, and other activities as is noted above. The importance of hive maintenance to ensure a quality and healthy hive is of utmost importance as is the collection medium and technology used to transfer the air to the patient. Lastly the air itself is a representation of the surroundings and could have a significant impact on positive outcomes as is documented in the new study.

Further work and investigation of samples could be collected as gas and analyzed by gas chromatography mass spectrometry which could improve the outcomes in terms of chemical profiling accuracy. Given the complexity of the beehive air, it may also prove more valuable to assay the air as a whole (for example, antimicrobial and antioxidant effects), rather than determine individual chemical components. BY's Honey Farm will continue to be a research and innovation centre for new studies in this field.

References

1. BY's Apitherapy – Tech IV (2024) LC-NPMC-RPT-71, Chemical Analysis of Hive Air, Declan DeJordy Date: 27-Jul-2024
2. Abdelmegid, F., Al-Agamy, M., Alwohaibi, A., Ka'abi, H., Salama, F., 2015. Effect of honey and green tea solutions on Streptococcus mutans. J. Clin. Pediatr. Dent. 39, 435–441. https://doi.org/10.17796/1053-4628-39.5.435.
3. Abd El-Wahed, A.A.A., Khalifa, S.A.M, Sheikh, B.Y., Farag, M.A., Saeed, A., Larik, F.A., Koca-Caliskan, U., AlAjmi, M.F., Hassan, M., Wahabi, H.A., Hegazy, M.E.F., 2019. Bee venom composition: From chemistry to biological activity. Studies in Natural Products Chemistry, 459–484. https://doi.org/10.1016/B978-0-444- 64181-6.00013-9. Fig 3. Antimicrobial activity of bee product against the Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, and multi drug resistant Staphylococcus aureus (MRSA) using agar-well diffusion method at the doses100 mg and using drugs control (100 mL; gentamicin (8 lg/mL) for Staphylococcus and Klebsiella, vancomycin (8 lg/mL) for MRSA and amikacin (32 lg/mL) for Acinetobacter. Tests were performed in triplicate. A.A. Abd El-Wahed, M.A. Farag, W.A. Eraqi et al. Journal of King Saud University – Science 33 (2021) 101449 7
4. Alissandrakis, E., Kibaris, A.C., Tarantilis, P.A., Harizanis, P.C., Polissiou, M., 2005. Flavour compounds of Greek cotton honey. J. Sci. Food Agric. 85, 1444–1452. https://doi.org/10.1002/jsfa.2124.
5. Alotibi, I.A., Harakeh, S.M., Al-Mamary, M., Mariod, A.A., Al-Jaouni, S.K., Al-Masaud, S., Alharbi, M.G., Al-Hindi, R.R., 2018. Floral markers and biological activity of Saudi honey. Saudi J. Biol. Sci. 25, 1369–1374. https://doi.org/10.1016/j. sjbs.2018.05.021.
6. Alvarez-Suarez, J.M., 2017. Bee products - chemical and biological properties. Springer. https://doi.org/10.1007/978-3-319-59689-1.
7. Basualdo, C., Sgroy, V., Finola, M.S., Marioli, J.M., 2007. Comparison of the antibacterial activity of honey from different provenance against bacteria usually isolated from skin wounds. Vet. Microbiol. 124, 375–381. https://doi. org/10.1016/j.vetmic.2007.04.039.
8. Bayraktar, D., Onoğur, T.A., 2011. Investigation of the aroma impact volatiles in Turkish pine honey samples produced in Marmaris, Datça and Fethiye regions by SPME/GC/MS technique. Int. J. Food Sci. Technol. 46, 1060–1065. https://doi. org/10.1111/j.1365-2621.2011.02588.x.
9. Broeckling, C.D., Reddy, I.R., Duran, A.L., Zhao, X., Sumner, L.W., 2006. MET-IDEA: Data extraction tool for mass spectrometry-based metabolomics. Anal. Chem. 78, 4334–4341.
10. Chen, Y., Ye, S., Ting, C., Yu, Y., 2017. Antibacterial activity of propolins from Taiwanese green propolis. J. Food Drug Anal. 26, 761–768. https://doi.org/ 10.1016/j.jfda.2017.10.002.
11. De-melo, A.A.M., Estevinho, L.M., Delerue-matos, C., De-melo, A.A.M., Moreira, M.M., Delerue-Matos, C., Freitas, A.D.S.D., Barth, O.M., Almeida-Muradian, L.B.D., 2018. Phenolic profile by HPLC-MS, biological potential, and nutritional value of a promising food: Monofloral bee pollen. J. Food Biochem. 42 (5), e12536. https:// doi.org/10.1111/jfbc.12536.
12. El-Halfawy, O.M., Valvano, M.A., 2015. Antimicrobial heteroresistance: An emerging field in need of clarity. Clin. Microbiol. Rev. 28, 191–207. https://doi.org/ 10.1128/CMR.00058-14.
13. El-Sound, N.H.A., 2012. Honey between traditional uses and recent medicine. Maced. J. Med. Sci. 5, 205–214. https://doi.org/10.3889/MJMS.1857-5773. 2012.0213.
14. Escriche, I., Kadar, M., Domenech, E., Gil-Sánchez, L., 2012. A potentiometric electronic tongue for the discrimination of honey according to the botanical origin. Comparison with traditional methodologies: Physicochemical parameters and volatile profile. J. Food Eng. 109, 449–456. https://doi.org/ 10.1016/j.jfoodeng.2011.10.036.
15. Falagas, M.E., Makris, G.C., Dimopoulos, G., Matthaiou, D.K., 2008. Heteroresistance: a concern of increasing clinical significance?. Clin. Microbiol. Infect. 14, 101– 104. https://doi.org/10.1111/j.1469-0691.2007.01912.x.
16. Falcão, S.I., Freire, C., Cristina Figueiredo, A., Vilas-Boas, M., 2015. The volatile composition of Portuguese propolis towards its origin discrimination. Rec. Nat. Prod. 10, 176–188.
17. Farag, Mohamed A., Ali, S.E., Hodaya, R.H., El-Seedi, H.R., Sultani, H.N., Laub, A., Eissa, T.F., Abou-Zaid, F.O.F., Wessjohann, L.A., 2017a. Phytochemical profiles and antimicrobial activities of Allium cepa red cv. and A. sativum subjected to different drying methods: A comparative MS-based metabolomics. Molecules 22, 761–779. doi: 10.3390/molecules22050761.
18. Farag, Mohamed A, Song, G.C., Park, Y., Audrain, B., Lee, S., Ghigo, J., Kloepper, J.W., Ryu, C., 2017b. Biological and chemical strategies for exploring inter- and intrakingdom communication mediated via bacterial volatile signals. Nat. Protoc. 12, 1359–1377. doi: 10.1038/nprot.2017.023.
19. Gill, A.O., Holley, R.A., 2004. Mechanisms of bactericidal action of cinnamaldehyde against Listeria monocytogenes and of eugenol against L. monocytogenes and Lactobacillus sakei. Appl. Environ. Microbiol. 70, 5750–5755. https://doi.org/ 10.1128/AEM.70.10.5750. Isidorov, V.A.,
20. Isidorova, A.G., Sczczepaniak, L., Czyzewska, U., 2009. Gas chromatographic-mass spectrometric investigation of the chemical composition of beebread. Food Chem. 115, 1056–1063. https://doi.org/ 10.1016/j.foodchem.2008.12.025.
21. Mizrahi, A., Yaacov, L., 2013. Bee products, properties, applications, and apitherapay. Springer Science & Business Media. https://doi.org/10.1016/ B978-0-12-374144-8.00020-5.

22. Morroni, G., Alvarez-suarez, J.M., Brenciani, A., Simoni, S., Fioriti, S., Pugnaloni, A., Giampieri, F., Mazzoni, L., Gasparrini, M., Marini, E., Mingoia, M., Battino, M., Giovanetti, E., 2018. Comparison of the antimicrobial activities of four honeys from three countries (New Zealand, Cuba, and Kenya). Front. Microbiol. 9, 1378–11346. https://doi.org/10.3389/fmicb.2018.01378.
23. Nair, M.K.M., Joy, J., Vasudevan, P., Hinckley, L., Hoagland, T.A., Venkitanarayanan, K. S., 2005. Antibacterial effect of caprylic acid and monocaprylin on major bacterial mastitis pathogens. J. Dairy Sci. 88, 3488–3495. https://doi.org/ 10.3168/jds.S0022-0302(05)73033-2.
24. Odeh, I., Abu-Lafi, S., Dewik, H., Al-Najjar, I., Imam, A., Dembitsky, V.M., Hanuš, L.O., 2007. A variety of volatile compounds as markers in Palestinian honey from Thymus capitatus, Thymelaea hirsuta, and Tolpis virgata. Food Chem. 101, 1393– 1397. https://doi.org/10.1016/j.foodchem.2006.03.046.
25. Pickett, J.A., Williams, I.H., Martin, A.P., Smith, M.C., 1980. Nasonov pheromone of the honey bee, Apis mellifera L. (Hymenoptera: Apidae). J. Chem. Ecol. 6, 425– 434. https://doi.org/10.1007/BF01402919.
26. Qamar, M.U., Saleem, S., Toleman, M.A., Saqalein, M., Waseem, M., Nisar, M.A., Khurshid, M., Taj, Z., Jahan, S., 2018. In vitro and in vivo activity of Manuka honey against NDM-1-producing Klebsiella pneumoniae ST11. Future Microbiol. 13, 13–26. https://doi.org/10.2217/fmb-2017-0119.
27. Qiu, J., Feng, H., Lu, J., Xiang, H., Wang, D., Dong, J., Wang, J., Wang, X., Liu, J., Deng, X., 2010. Eugenol reduces the expression of virulence-related exoproteins in Staphylococcus aureus. Appl. Environ. Microbiol. 76, 5846–5851. https://doi.org/ 10.1128/AEM.00704-10.
28. Ramos, O.Y., Salomón, V., Libonatti, C., Cepeda, R., Maldonado, L., Basualdo, M., 2018. Effect of botanical and physicochemical composition of Argentinean honeys on the inhibitory action against food pathogens. LWT – Food Sci. Technol. 87, 457– 463. https://doi.org/10.1016/j.lwt.2017.09.014.
29. Remirez, D., González, R., Rodriguez, S., Ancheta, O., Bracho, J.C., Rosado, A., Rojas, E., Ramos, M.E., 1997. Protective effects of propolis extract on allyl alcohol-induced liver injury in mice. Phytomedicine Int. J. Phyther. Phytopharm. 4, 309–314. https://doi.org/10.1016/S0944-7113(97)80038-4.
30. Santos, A., Moreira, R.F.A., De Maria, C.A.B., 2015. Study of the principal constituents of tropical angico (Anadenanthera sp.) honey from the atlantic forest. Food Chem. 171, 421–425. https://doi.org/10.1016/j.foodchem.2014.09.017.
31. Silici, S., Kutluca, S., 2005. Chemical composition and antibacterial activity of propolis collected by three different races of honeybees in the same region. J. Ethnopharmacol. 99, 69–73. https://doi.org/10.1016/j.jep.2005.01.046.
32. Silva, L.N., Zimmer, K.R., Macedo, A.J., Trentin, D.S., 2016. Plant natural products targeting bacterial virulence factors. Chem. Rev. 116, 9162–9236. https://doi. org/10.1021/acs.chemrev.6b00184.
33. Tenório, E.G., De Jesus, N.R., Nascimento, A.R., Teles, A.M., 2015. Antimicrobial activity of honey of stingless bees, tiúba (Melipona fasciculata) and jandaira (Melipona subnitida) compared to the strains of Staphylococcus aureus, Escherichia coli and Pseudomonas aeruginosa. AIP Conf. Proc. 1702, 10–14. https://doi.org/10.1063/1.4938905.
34. Tilahun, B., Faust, A.C., McCorstin, P., Ortegon, A., 2015. Nasal colonization and lower respiratory tract infections with methicillin-resistant Staphylococcus aureus. Am. J. Crit. Care 24, 8–13.
35. Verzera, A., Campisi, S., Zappalà, M., Bonaccorsi, I., 2001. SPME-GC-MS analysis of honey volatile components for the characterization of different floral origin. Am. Lab. 33, 18–21.
36. Wasihun, A.G., Kasa, B.G., 2016. Evaluation of antibacterial activity of honey against multidrug resistant bacteria in Ayder Referral and Teaching Hospital. Springer Plus 5, 842–849. https://doi.org/10.1186/s40064-016-2493-x.
37. Yadav, M.K., Chae, S.W., Im, G.J., Chung, J.W., Song, J.J., 2015. Eugenol: A phytocompound effective against methicillin-resistant and methicillin-sensitive Staphylococcus aureus clinical strain biofilms. PLoS One 10,. https://doi.org/ 10.1371/journal.pone.0119564 e0119564.
38. Zhang, J.H., Sun, H.L., Chen, S.Y., Zeng, L., Wang, T.T., 2017. Anti-fungal activity, mechanism studies on a-phellandrene and nonanal against Penicillium cyclopium. Bot. Stud. 58, 13–21. https://doi.org/10.1186/s40529-017-0168-8.
39. Zhao, L., Yu, M., Sun, M., Xue, X., Wang, T., Cao, W., Sun, L., 2017. Rapid determination of major compounds in the ethanol extract of geopropolis from Malaysian stingless bees, Heterotrigona itama, by UHPLC-Q-TOF/MS and NMR. Molecules 22, 1935–1949. https://doi.org/10.3390/molecules22111935.
40. Zhao, Y.Z., Li, Z.G., Tian, W.L., Fang, X.M., Su, S.K., Peng, W.J., 2016. Differential volatile organic compounds in royal jelly associated with different nectar plants. J. Integr. Agric. 15, 1157–1165. https://doi.org/10.1016/S2095-3119(15) 61274-6.

To receive additional information regarding research at
BY's Apitherapy Wellness Center, please contact us at:

info@apitherapywellnesscenter.com

Or visit us online at:

www.apitherapywellnesscenter.com