**Mwafaq Ibdah**  **September 2022**

**Part I: CURRICULUM VITAE**

1. **Personal**

Department of Plant Sciences

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| **Dates** | **Description** | |
| 1969 | | Born in Haifa, Israel | |

1. **University Education and Additional Training**

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| **Dates** | **Description** |
| 1992 -1994 | B.Sc., Biology, Humboldt University (Berlin, Germany). |
| 1994 -1997 | M.Sc., Biology, Humboldt University (Berlin, Germany).  Title of thesis: “Activity and cell compartment of *β*-amylases in primary leaves of monocot plants.”  Supervision by: Dr. W. Dreier and Prof. W. Lockau. |
| 1998 -2002 | Ph.D., Life Sciences, Department of Secondary Metabolites, Leibniz Institute of Plant Biochemistry, Martin Luther University (Halle-Saale, Germany).  Title of thesis: “Light-induced flavonoid and betacyanin accumulation in *Mesembryanthemum crystallinum.*”  Supervision by: Dr. T. Vogt and Prof. D. Strack. |
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| 2004-2005 | Post-doctoral position, Institute of Vegetable and Field Crops, Newe Ya′ar Research Center, Israel, with Dr. Efraim Lewinsohn.  Research subject: “Functional genomics to identify genes affecting the aroma of melons and watermelons.” |
| 2005-2008 | Post-doctoral position at the University of Michigan, Department of Molecular, Cellular, and Developmental Biology (MCDB), with Professor Eran Pichersky.  Research subject: “Identification and biochemical characterization of novel enzymes which catalyze the formation of benzoic acid in *Arabidopsis thaliana”*. |

1. **Positions Held and Academic Status**

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| **Dates** | **Description** | |
| 2002-2004 | Research Scientist, “Frutavit Ltd.”, Teradion Industrial Park (Misgav, Israel). | |
| 2008-2010 | Research Scientist, “Frutarom Ltd.”, Haifa, Israel. | |
| 2010-2011 | Associate Researcher, Institute of Biological Chemistry, Washington State University, Pullman, WA, U.S.A. | |
| 2011- to date | Principal Investigator, Institute of Plant Sciences, Agricultural Research Organization, Newe Ya′ar Research Center, Israel |
| 2015 | Promoted to Rank B (equivalent to “Senior Lecturer”) |
| 2020 | Promoted to Rank A (equivalent to “Associate Professor”) |

1. **Teaching Experience / Guiding Students**
2. Academic Contribution:

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| **Dates** | **Description** |
| 2000-2001 | Lecturer, Plant Biochemistry, Leibniz Institute for Plant Biochemistry, Martin Luther University (Halle-Saale, Germany). |

1. Guidance of M.Sc. Students (or B.Sc. internship)

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| **Graduation date** | **Name** | **Title of thesis** | **Guidance with** |
| 2012-2012 | \*\*Mr. Mosaab Yahyaa | Formation of norisoprenoid flavor compounds in carrot (*Daucus* *carota* L.) roots: characterization of a cyclic-specific carotenoid  cleavage dioxygenase 1 gene | Dr. Michal Maaoz |
| 2014-2017 | \*Mr. Dor Rachmany | Use of resistant pear trees to cope with pear psylla - understanding the resistance mechanism in resistant interstock to pear psylla | Dr. Liora Shaltiel-Harpaz |
| 2015-2016 | \*\*Ms. Majdoleen Khalili | How temperature stress changes carrot flavor: Elucidating the genetic determinants of undesirable taste in carrots. | Prof. Masha Grozovski |
| 2016-2017 | \*\*Ms. Hadil Khatteb | Identification and characterization of terpene synthase involved in the production of volatile terpenes in almond fruit | Prof. Masha Grozovski |
| 2016-2017 | \*\*Ms. Samah Ali | Characterization of three chalcone synthase-like genes from apple (*Malus* × *domestica* Borkh.) | Prof. Masha Grozovski |
| 2016-2017 | \*\*Ms. Reema Jacob | Profiling of volatile organic compounds in almond (*Prunus dulcis*) of different accessions and characterization of serval TPS genes | Prof. Masha Grozovski |
| 2016-2019 | \*Ms. Sewar Emran | Metabolic and biochemical aspects of the interaction between species of carrots to root parasite *Orobanche*. | Dr. Martin Goldway |
| 2017-2017 | \*\*Ms. Sally Libbes-Mahil | Profiling of volatile metabolome in carrot (*Daucus carota* L.) leaves infected with carrot psylla: characterization of Eugenol synthase and *O*-methyltransferase genes | Dr. Elana Kapten |
| 2018-2019 | \*\*Ms. Afeefe Nijem | Impact of insects on the volatile accumulation in lettuce: Characterization of a cyclic-specific carotenoid cleavage dioxygenase 1 gene | Prof. Masha Grozovski |
| 2019-2020 | \*\*Mr. Anas Kabha | Identification and characterization of terpene synthases potentially involved in the formation of volatile terpenes in Fig (*Ficus carica* L.) fruits | Prof. Masha Grozovski |
| 2019-2022 | \*\*Hadeel Mostafa | Biodegradation of hydrothermally treatment plastic waste | Dr. Roy Posmanik  Prof. Esam Sabbah |
| 2019-2022 | \*Mr. Mosaab Yahyaa | Characterization of the sensitivity of different carrot varieties to *Psylla Bactericera* trigonica | Dr. Liora Shaltiel-Herpaz |
| 2021-2021 | \*\*Sahda Hino | Identification and characterization of terpene synthases potentially involved in the formation of volatile terpenes in *Acorus calamus* | Dr. Lilach Iasur Kruh |
| 2021-2022 | \*\* Alya Bouz | Identification and characterization of volatile compounds in carrot and examined their biological activity against the soil-borne phytopathogenic fungus *Sclerotium rolfsii* | Dr. Mery  Dafny Yelin  Dr. Marcela Karpuj |
| 2022-2022 | \*\* Ranin Bisharat | Examine Sclerotium rolfsii resistance phenotypic variation and volatile chemical profiles among diverse carrot accessions | Dr. Mery  Dafny Yelin |

\*under my direct supervision

\*\* B. Sci. internship, as part of studies in ORT Braude College

1. Guidance of Ph.D. Students
2. Post-Docs and Visiting Scientists

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| **Dates** | **Name** | **Research subject** |
| 2018-2020 | Dr. Bhagwat Nawade PD | Developing of trilobatin/naringin dihydrochalcone as a new class of phytochemical agent |
| 2019-2020 | Dr. Kun Meng PD | Comparing herbivory and plant chemical response to insects of distinct feeding guilds |

XPD: Post-Doc working in my research team

1. **Activity in Scientific and Agricultural Committees**
2. International:

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| **Dates** | **Description** |
| 2015-present | Member of “American Society of Plant Biologists” |
| 2018-present | Member of “International Society of Chemical Ecology” |

1. National:

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| **Dates** | **Description** |
| 2019-present | Member of “Israel Society of Crop and Vegetable Sciences” |

1. Institutional:
2. **Contribution to the Scientific Community**
3. International:

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| **Dates** | **Description** |
| 2018 | Session Chair of the International Conference on Agricultural and Food Science. Istanbul. |

1. National:

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| **Dates** | **Description** |
| 2014 | Co-Chair of the Scientific Committee, BERC 3rd Conference on Bio-Exploration of Valuable Natural Products Derived from Palestinian Flora: From Biodiversity to Bioindustry. Til-Nablus. |
| 2021-present | Member of Scientific Steering Committee of “The Center for Quality Safety and Natural/Specialized Metabolites in Agricultural Products” ARO |

1. Institutional:

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| 2020 | Organizer of Workshop on “Chemical compounds potentially involved in black fig fly interactions with *Ficus carica*”, Newe Ya′ar Research Center. |

1. Outreach:

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| 2019 | Reviewer of BARD proposal |

1. Editorial responsibilities:

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| **Dates** | **Description** |
| 2011-present | Review Editor: Plant Metabolism and Chemodiversity, Frontiers in Plant Science. |
| 2016 | Reviewer, Ph.D. thesis of Snir Azaria: Biodegradation of the off-flavor compounds, geosmin, and 2-methylisoboreneol (MIB), in recirculating aquaculture systems. The Hebrew University of Jerusalem, Israel. |
| 2016-2022 | Reviewer of manuscript for: Frontiers Plant Science, International Journal of Molecular Sciences, Journal of Agriculture and Food Chemistry. Journal of Engineering and Technological Sciences |

1. Active Participation in Meetings
2. International:

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| --- | --- | --- | --- |
| **Date** | **Title of the Meeting** | **Place** | **Role** |
| 2001 | Phytochemical Society of North America | Oklahoma City, USA | Poster presenter |
| 2007 | Gordon Research Conference, Floral & Vegetative Volatiles | Les Diablerets, Switzerland | Attendee |
| 2010 | 2nd International Conference on Industrial Biotechnology | Padova, Italy | Speaker |
| 2012 | 26th International Conference on Polyphenols | Florence, Italy | Poster presenter |
| 2012 | 3rd Banff Conference on Plant Metabolism | The Banff Center, Banff, Alberta, Canada | Speaker |
| 2013 | 11th International Meeting on Biosynthesis, Function, and Biotechnology of Isoprenoids in Terrestrial and Marine Organisms | Crete, Greece | Poster presenter |
| 2014 | BERC 3rd Conference, Bio-Exploration of Valuable Natural Products Derived from Palestinian Flora: From Biodiversity to Bioindustry | Til-Nablus, Palestine Authority | Invited lecture |
| 2014 | Gordon Research Conferences: Plant Volatiles | Ventura CA,  USA | Poster presenter |
| 2014 | ISAHN Polyphenols | Lisbon, Portugal | Speaker |
| 2015 | Agriculture and Climate Change Conference | Amsterdam, Netherlands | Poster presenter |
| 2015 | 18th International Plant Protection Congress | Germany,  Berlin | Speaker |
| 2015 | Pheromones and Other Semio-Chemicals in Integrated Production | Israel  Jerusalem | Invited lecture |
| 2016 | 11th Wartburg Symposium on Flavor Chemistry & Biology | Germany,  Eisenach | Invited lecture |
| 2017 | HPIS 2017  Hemipteran-Plant Interaction Symposium | Spain,  Madrid | Poster presenter |
| 2017 | ICSS 2017  International Conference on Science and Society: Biopiracy and Phytomedicine | Mainz  Germany | Invited lecture |
| 2018 | Gordon Research Conferences: Plant Volatiles | Renaissance Tuscany Il Ciocco in Lucca (Barga) Italy | Poster presenter |
| 2018 | International Conference on Agricultural and Food Science 2018. | Istanbul, Turkey | Invited lecture |
| 2019 | World Congress on Biochemistry and Enzymology | Amsterdam, Netherlands | Keynote speaker |
| 2019 | International Plant Science Conference | Rostock,  Germany | Invited lecture |
| 2019 | 13th World Congress on Polyphenols Applications | Valetta,  Malta | Invited lecture |
| 2022 | Trends in Natural Products Research: A PSE Young Scientists’ Meeting (PSE-YSM2022) | Crete,  Greece | Speaker |
| 2022 | 6th International Symposium on Phytochemicals in Medicine and Food (6-ISPMF) | Hangzhou, China  (Zoom-meeting) | Invited speaker |

1. National:

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| --- | --- | --- |
| **Date** | **Title of the Meeting** | **Role** |
| 1999 | Day of German Science Research Leibniz Institute for Plant  Biochemistry, Halle-Saale,  Germany | Poster presenter |
| 1999 | Meeting of German Botanical Society Bonn-Röttgen, Germany | Poster presenter |
| 2000 | Meeting of German Botanical Society Jena, Germany | Poster presenter |
| 2015 | Annual Meeting of the Israel Society of Plant Sciences ARO, Israel | Poster presenter |
| 2021 | Agricultural Science Conference, Tel-Aviv, Israel | Speaker |

1. Institutional:

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| 2016 | Annual Meeting of the Production and Marketing Board of Almond Mattityahu Research Station, Israel | Speaker |
| 2017 | Annual Meeting of the Production and Marketing Board of Almond Newe Ya′ar, ARO, Israel | Speaker |
| 2020 | Annual Meeting of the Production and Marketing Board of Fig Newe Ya′ar, ARO, Israel | Speaker |
| 2020 | Annual Meeting of the Production and Marketing Board of Carrot ARO, Israel | Speaker |
| 2021 | Annual Meeting of the Production and Marketing Board of Carrot Shallit Carrots, Moshav Gan HaShomron, Israel | Speaker |

1. **Research Grants**
2. Internationally Peer-Reviewed Grants

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| --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Granting Source** | **Duration (years)** | **Role** | **Title (short)** | **Budget** | |
| **Total**  **(US $ / year)** | **Researcher**  **(US $ / year)** |
| 2014 | US-Israel Binational Agricultural Research and Development Fund (BARD) | 3 | LPI | How Temperature Stress Changes Carrot Flavor: Elucidating the Genetic Determinants of Undesired Taste in Carrots. | 108,000 | 40,000 |
| 2014 | Ministry of Agriculture Chief Sci.  (Biotechnology) | 3 | PI | Developing Sweet Tasting Grapefruits Based on Dihydrochalcones | 47,000 | 47,000 |
| 2018 | US-Israel Binational Science Foundation (BSF) | 3 | LPI | Elucidation of the Biochemical Pathway Leading to the Biosynthesis of Asarone and its Derivatives in *Daucus carota* | 78,000 | 39,000 |
| 2022 | US-Israel Binational Science Foundation (BSF) | 3 | LPI | Biosynthesis of Styrene and its Analogs in *Styrax officinalis* L. | 71,000 | 35,000 |

\*PI = Principal Investigator; LPI =Local Principal Investigator; CI = Cooperating Investigator

1. Nationally Peer-Reviewed Grants

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| --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Granting Source** | **Duration (years)** | **Role** | **Title (short)** | **Budget** | |
| **Total**  **(US $ / year)** | **Researcher**  **(US $ / year)** |
| 2013 | Chief Sci. | 3 | CI | The use of resistant pear trees to cope with psylla | 30,000 | 5,000 |
| 2015 | Chief Sci. | 3 | CI | Natural phytoecdesteroids from local wild plants for friendly management of insect pests | 40,000 | 5,000 |
| 2015 | Israel Plant Gene Bank | 1 | PI | Metabolomic profiling of roots and seeds of a wild population of carrot (*Daucus* spp. L.) in Israel. | 12,000 | 12,000 |
| 2016 | Chief Sci. | 3 | PI | Detecting the causes for differences in the susceptibility of almond species to *Eurytoma amygdali*, as a means of improving the integrated pest management interface | 28,000 | 15,000 |
| 2016 | Chief Sci. | 2 | CI | Integration of a resistant root-stock for the aphid *Eriosoma lanigerum* in IPM apple orchards | 40,000 | 20,000 |
| 2017 | Chief Sci. | 3 | CI | Characterization of genetic mechanisms for *Sclerotium rolfsii* resistance in peanut | 30,000 | 5,000 |
| 2017 | Chief Sci./ (Nitzan) | 1 | PI | Developing of trilobatin/naringin dihydrochalcone as a new-style sweeting agent | 85,000 | 60,000 |
| 2018 | Chief Sci. | 3 | CI | The contribution of biodiversity in the field to health-promoting phytochemicals in produce: a test of concept in leafy vegetables | 43,000 | 12,000 |
| 2019 | Chief Sci. | 3 | PI | Characterization of the sensitivity of various carrot cultivars to carrot psylla and yellow disease to improve the production of carrots | 72,000 | 43,000 |
| 2019 | Chief Sci. | 3 | CI | Developing methods to detect Mediterranean fruit fly subplot hot spots in apple orchards and using them for precision pest control | 58,000 | 10,000 |
| 2020 | Ministry of Science and Technology | 3 | CI | Crop phytochemical diversity and biological control services  in biodiversity-promoting agroecosystems | 76,000 | 18,900 |

\*PI = Principal Investigator; CI = Cooperating Investigator

1. National Non-Peer Reviewed Grants:

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| **Year** | **Granting Source** | **Duration (years)** | **Role\*** | **Title (short)** | |  |  | | --- | --- | | **Budget** | | | **Total (US $ / year)** | **Researcher (US $ / year)** | | |
| 2015 | Production and Marketing Board of Figs (Israel) | 1 | CI | Reducing the damage caused by the black fig fly *Silba adipata* MacAlphine figs with an emphasis on understanding the relationship between volatiles secreted by the fertilized fruit fly and black fig | 14,000 | 2,000 |
| 2016 | Israel dairy board Steering committee of Research in Ruminant Sciences | 3 | CI | Development of a mammalian milk substitute intended to improve calf health | 23,000 | 5,000 |
| 2019 | Production and Marketing Board of Carrot (Israel) | 1 | CI | Examining the presence of natural enemies of carrot and their impact on the reduction of the pest population and yellow disease | 25,000 | 6,000 |
| 2020 | Production and Marketing Board of Carrot (Israel) | 1 | PI | Examining the attraction/  repellency of wild carrot under field conditions in the western negev as a means to improve | 17,000 | 10,000 |
| 2022 | Production and Marketing Board of Carrot (Israel) | 1 | PI | Examining the effects of spraying of sabinene on carrot psylla under filed conditions | 12,000 | 12,000 |

\*PI = Principal Investigator; CI = Cooperating Investigator

D. Other Funds:

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| **Year** | **Granting Source** | **Duration (years)** | **Role\*** | **Title (short)** | |  |  | | --- | --- | | **Budget** | | | **Total (US $ / year)** | **Researcher (US $ / year)** | | |
| 2017 | MIGAL Translational Research Pilot study grants | 1 | CI | Development of a Carrot psyllid attractant to reduce yellows disease | 12,000 | 6,000 |
| 2020 | Jewish Charitable Association  (ICA) | 2 | PI | Development of fig fly atractant and /or repellent to reduce fig fruit damages | 17,500 | 8,700 |

\*PI = Principal Investigator; CI = Cooperating Investigator

1. **Awards**

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| **Dates** | **Description** |
| 2003 | Recipient of the “MA′OF” scholarship for new faculty and for outstanding Arab lectures. |
| 2004 | Recipient of an Israel Ministry of Science and Technology Scholarship for Arab-Israeli Scientists. |

# Mwafaq Ibdah September 2022

##### Part II: LIST OF PUBLICATIONS

Marks:

X \*                    Equal contribution as the first author

X \*\* Corresponding Author *(in cases where the researcher is the Corresponding Author)*

Marks (only for the first author):

XS                     Student under my supervision

XT                    Technician or research engineer working in my research team

XPD, XVS           Post-Doc or Visiting Scientist working in my research team

1. **Articles in Reviewed Journals**

1. Vogt, T., **Ibdah, M.,** Schmidt, J., Wray, V., Nimtz, M., and Strack, D. (1999).

Light-induced betacyanin and flavonol accumulation in bladder cells of *Mesembryanthemum crystallinum*.

*Phytochemistry* 52: 583-592.

IF: 4.004;Category: Plant Sciences;

Rank 3/238 (Q1)

2. **Ibdah, M.**, Krins, A., Seidlitz, H.K., Heller, W., Strack, D., and Vogt, V. (2002).

Spectral dependence and dose-response of flavonol and betacyanin accumulation in *Mesembryanthemum crystallinum* under enhanced UV radiation.

*Plant Cell Environ*. 25: 1145-1154.

IF: 7.947;Category: Plant Sciences;

Rank 13/228 (Q1)

3. **Ibdah, M.**, Zhang, X.H., Schmidt, J., and Vogt, T. (2003).

**A novel Mg++ dependent *O*-methyltransferase in the phenylpropanoid metabolism of *Mesembryanthemum crystallinum.***

*J. Biol. Chem*. 278: 43961-43972.

IF: 5.486;Category: Biochemistry and Molecular biology;

Rank 94/296 (Q2)

4. Lewinsohn, E., Sitrit, Y., Bar, E., Azulay, Y., **Ibdah, M.**, Meir, A., Yosef, E., Zamir, D., and Tadmor, Y. (2005).

Not just colors - carotenoid degradation as a link between pigmentation and aroma in tomato and watermelon fruit.

*Trends Food Sci. Tech*. 16: 407-415.

IF:8.519;Category: Food Science and Technology; Rank 2/135 (Q1)

5. **Ibdah, M.**, Azulay, Y., Portnoy, V., Wasserman, B., Bar, E., Meir, A., Burger, Y.,

Hirschberg, J., Schaffer, A.A., Katzir, N., Tadmor, Y., and Lewinsohn, E. (2006).

Functional characterization of *CmCCD1*, a carotenoid cleavage dioxygenase from melon.

*Phytochemistry* 67: 1579-89.

IF: 4.004;Category: Plant Sciences;

Rank 53/238 (Q1)

6. Koeduka, T., Louie, G.V., Orlova, I., Kish, C.M., **Ibdah, M.**, Wilkerson, C.G., Baiga T.J.,

Noel, J.P., Dudareva, N., and Pichersky, E. (2008).

The multiple phenylpropene synthases in both *Clarkia breweri* and *Petunia hybrida* represent two distinct protein lineages.

*Plant J*. 54: 362-374.

IF: 7.091; Category: Plant Sciences;

Rank 8/258 (Q1)

7. **Ibdah,** **M.**, Chen, Y.T., Wilkerson, C.G., and Pichersky, E. (2009).

An aldehyde oxidase in developing seeds of *Arabidopsis* *thaliana* converts benzaldehyde to benzoic acid.

*Plant Physiol*. 150: 416-423.

IF: 8.005; Category: Plant Sciences;

Rank 5/258 (Q1)

8. **Ibdah, M.,** and Pichersky, E. (2009).

Arabidopsis Chy1 null mutants are deficient in benzoic acid-containing glucosinolates in the seeds.

*Plant Biol*. 11: 574-481.

IF: 3.877;Category: Plant Sciences;

Rank 58/238 (Q1)

9. Gang, R. D., Davin, L. B., **Ibdah, M.**, Lange, B. M., Norman G. Lewis, G. N., Turner, G.

W., Shion, H., Witkop, G., Harris, D., and Alan Millar, A. (2012).

Probing medicinal plant phytochemical factories through in situ MALDI tissue imaging using Quadrupole Ion Mobility Time-of-Flight Mass Spectrometry.

*Pharmaceutical Biol.,* 50: 567-568.

IF: 3.889; Category: Medical Laboratory Technology;

Rank 10/29 (Q2)

10. Botnick, I., Xue, W., Bar, E., **Ibdah, M.**, Schwartz, A., Joel, D.M., Lev, E., Fait, A., and Lewinsohn, E. (2012).

Distribution of primary and specialized metabolites in *Nigella sativa* seeds, a spice with vast traditional and historical uses.

*Molecules* 17: 10159-10177.

IF: 4.927;Category: Biochemistry and Molecular Biology; Rank 114/296 (Q2)

11. Serfaty, M., **Ibdah, M.**, Fischer, R., Chaimovitsh, D., Saranga, Y., and Dudai, N. (2013).

Dynamics of yield components and stevioside production in *Stevia rebaudiana* grown under different planting times, plant stands and harvest regimes.

*Ind. Crop Prod.* 50: 731-736.

IF: 6.449;Category: Agronomy; Rank 8/124 (Q1)

12. Shalata, A., Ramirez, M.C., Desnick, R.J., Priedigkeit, N., Buettner, C., Lindtner, C.,

Mahroum, M., Abdul-Ghani, M., Dong, F., Arar, N., Camacho-Vanegas, O., Zhang, R., Camacho, S.C., Chen, Y., **Ibdah, M.,** Defronzo, R., Gillespie, V., Kelley, K., Dynlacht, B.D., Kim, S., Glucksman, M.J., Borochowitz, Z.U., and Martignetti, J.A. (2013).

Morbid obesity resulting from inactivation of the ciliary protein cep19 in humans and mice.

*Am. J. Hum. Genet*. 6: 1061-1071.

IF: 11.043;Category: Genetics and Heredity; Rank 10/175 (Q1)

13. Yahyaa, Ms., Bar, E., Dubey, NK., Meir, A., Davidovich-Rikanati, R., Hirschberg, J., Aly, R.,

Tholl, D., Simon, PW., Tadmor, Y., Lewinsohn, E., and **Ibdah, M**. (2013).

Formation of norisoprenoid flavor compounds in carrot (*Daucus carota* L.) roots: characterization of a cyclic-specific carotenoid cleavage dioxygenase 1 gene.

*J. Agric. Food Chem.* 61: 12244-12252.

IF: 5.89;Category: Agriculture, multidisciplinary; Rank 8/84 (Q1)

14. **Ibdah, M**.,and Gang, DR. (2014).

Use of coupled ion mobility spectrometry-time of flight mass spectrometry to analyze saturated and unsaturated phenylpropanoic acids and chalcones.

*Chem. Cent. J*. 8: 38. doi: 10.1186/1752-153X-8-38.

IF: 4.215; Category: Chemistry, multidisciplinary; Rank 65/178 (Q2)

15. Aly, R\*., Dubey, NK\*., Yahyaa, M\*., Abu-Nassar, J.,and **Ibdah, M\*\***. (2014).

Gene silencing of CCD7 and CCD8 in *Phelipanche aegyptiaca* by tobacco rattle virus system retarded the parasite development on the host.

*Plant Signal. Behav.* 9, e29376

IF: 2.734; Category: Plant Sciences;

Rank 95/238 (Q2)

16. **Ibdah**, **M\*\*.,** Dubey, N.K., Eizenberg, H., Dabour, Z.,Abu-Nassar, J., Gal-On, A., and Aly, R. (2014).

*Cucumber Mosaic Virus* as a carotenoid inhibitor reducing *Phelipanche aegyptiaca* infection in tobacco plants.

*Plant Signal. Behav.* 9:10, e97216

IF: 2.734; Category: Plant Sciences;

Rank 95/238 (Q2)

17. **Ibdah, M**., Berim, B., Martens, S., Valderrama, A.L.H., Palmieri, L., Lewinsohn, E., and Gang DR. (2014).

Identification and cloning of an NADPH-dependent hydroxycinnamoyl-CoA double bond reductase involved in dihydrochalcone formation in *Malus* x *domestica* Borkh.

*Phytochemistry* 107:24-31.

IF: 4.004;Category: Plant Sciences;

Rank 53/238 (Q1)

18. Yahyaa, MT., Tholl, D., Cormier, G., Jensen, R., Simon, P.W., and **Ibdah, M\*\***. (2015).

Identification and characterization of terpene synthases potentially involved in the formation of volatile terpenes in carrot (*Daucus carota* L.) Roots.

*J. Agric. Food Chem.*63:4870-4878.

IF: 5.89;Category: Agriculture, multidisciplinary; Rank 8/84 (Q1)

19. Yahyaa, MT., Matsuba, Y., Brandt, W., Doron-Faigenboim, A., Bar, E., McClain, A.,

Davidovich-Rikanati, R., Lewinsohn, E., Pichersky, E., and **Ibdah, M\*\***. (2015).

Identification, functional characterization and evolution of terpene synthases from a basal dicot.

*Plant Physiol.* (Special Issues*)* 169:1683-1697.

IF: 8.005;Category: Plant Sciences;

Rank 5/258 (Q1)

20. Yahyaa, MT, A Berim, A., Isaacson, T., Marzouk, S., Bar, E., Davidovich-Rikanati, R.,

Lewinsohn, E., and **Ibdah, M\*\***. (2015).

Isolation and functional characterization of carotenoid cleavage dioxygenase1 from *Laurus nobilis* L. (Bay Laurel) fruits.

*J. Agric. Food Chem.*63:8275-8282*.*

IF: 5.89;Category: Agriculture, multidisciplinary; Rank 8/84 (Q1)

21. Yahyaa, MT., Davidovich-Rikanati, R., Eyal, Y., Shachter, A., Marzouk, S., Lewinsohn, E.,

and **Ibdah, M\*\***. (2016).

Identification and characterization of UDP-glucose: Phloretin 4’-*O*-glycosyltransferase from *Malus* x *domestica* Borkh.

*Phytochemistry* 130:47-55

IF: 4.004;Category: Plant Sciences;

Rank 53/238 (Q1)

22. Yahyaa, MT., Davidovich-Rikanati, R., Eyal, Y., Shachter, A., Marzouk, S., Lewinsohn, E.,

and **Ibdah, M\*\***. (2017).

Characterization of three chalcone synthase-like genes from apple (*Malus* x *domestica* Borkh.).

*Phytochemistry* 140:125-133

IF: 4.004;Category: Plant Sciences;

Rank 53/238 (Q1)

23. Yahyaa, MT., Ibdah, M., Marzouk, S., and **Ibdah M\*\***. (2018).

Profiling of the terpene metabolome in carrot fruits of wild (*Daucus carota* L. ssp. *carota*) accessions and characterization of a geraniol synthase.

*J. Agric. Food Chem.* 66:2378-2386.

IF: 5.89;Category: Agriculture, multidisciplinary; Rank 8/84 (Q1)

24. Shaltiel‐Harpaz, L., Gerchman, Y., **Ibdah, M**., Kedoshim, R., Rachmany, D., Hatib, K., Bar‐

Ya’akov, I., Soroker, V., and Holland, D. (2018).

Grafting on resistant interstocks reduces scion susceptibility to pear psylla, *Cacopsylla bidens*.

*Pest Management Sci*. 70: 234-239.

IF: 4.462; Category:; Entomology;

Rank 8/100 (Q1)

25. Yahyaa, MT., Berim, B., Nawade, B., Ibdah, M., Dudareva, N., and **Ibdah, M\*\***. (2019).

Biosynthesis of methyleugenol and methylisoeugenol in *Daucus carota* leaves: Characterization of eugenol/isoeugenol synthase and *O*-methyltransferase.

*Phytochemistry* 159: 197-189

IF: 4.004;Category: Plant Sciences;

Rank 53/238 (Q1)

26. Taha-Salaime, L., Davidovich-Rikanati, R., Sadeh, A., Abo-Nassar, J., Marzouk, S., Yahyaa,

M., **Ibdah, M**., Ghanim, M., Inbar, M., and Aly, R (2019).

Phytoecdysteroid and clerodane content in three wild *Ajuga* species in Israel.

*ASC Omega* 4: 2369-2376

IF: 2.584; Categorie: Chemistry, Multidisciplinary Sci; Rank 76/172 (Q2)

27. Yahyaa, MT., Rachmany, D., Shaltiel-Harpaz, L., Nawade B., Sadeh, A., Ibdah, M., Gerchman,

Y., Holland, D., and **Ibdah, M\*\***. (2019).

A *Pyrus communis* gene for *p*-hydroxystyrene biosynthesis: has a role in defense against the pear psylla *Cacopsylla biden.*

*Phytochemistry* 161: 107-116

IF: 4.004;Category: Plant Sciences;

Rank 53/238 (Q1)

28. Nawade, B PD., Yahyaa, M., Reuveny H., Shaltiel-Harpaz, L., Eisenberg, O., Faigenboim, A., Bar-Yakkov, I., Holland, D., and **Ibdah, M\*\***. (2019).

Profiling of volatile terpenes from almond (*Prunus dulcis*) young fruits and characterization of seven terpene synthase genes

[*Plant Sci.*](https://www.sciencedirect.com/science/journal/01689452)287: 110187

IF: 5.363;Category: Plant Sciences; Rank 29/238 (Q1)

29. Nawade, B.PD, Shaltiel-Harpaz, L., Yahyaa, M., Bosamia, C. T., Kabaha, A., Kedoshim, R.,

Zohar, M., Isaacson, T., and **Ibdah, M\*\*.** (2020).

Analysis of apocarotenoid volatiles during the development of *Ficus carica* fruits and characterization of carotenoid cleavage dioxygenase genes

[*Plant Sci.*](https://www.sciencedirect.com/science/journal/01689452)290: 110292

IF: 5.363;Category: Plant Sciences; Rank 29/238 (Q1)

30. Emran, SS., Nawade, B., Yahyaa, M., Abu Nassar, J., Tholl. D., Eizenberg, H., and **Ibdah,**

**M\*\*.** (2020).

Broomrape infestation in carrot (*Daucus carota*): Changes in carotenoid gene expression and carotenoid accumulation in the parasitic weed *Phelipanche aegyptiaca* and its host

*Sci. Rep.* 10: 1-10

IF: 4.996;Category: Multidisciplinary

Sciences; Rank 19/73 (Q2)

31. Muchlinski, A., **Ibdah, M**., Ellison, S., Yahyaa, M., Nawade, B., Laliberte, S., Senalik, D.,

Simon, P., Whitehead, S., and Tholl, D. (2020).

Diversity and function of terpene synthases in the production of carrot aroma and flavor compounds.

*Sci. Rep.* 10: doi.org/10.1038/s41598-020-66866-1

IF: 4.996;Category: Multidisciplinary

Sciences; Rank 19/73 (Q2)

32. Nawade, B.PD, Yahyaa, M., Kabaha, A., Kedoshim, R., Bosamia, C. T., and **Ibdah, M\*\*.**

(2020).

Characterization of terpene synthase genes potentially involved in black fig fly (*Silba adipata*) interactions with *Ficus carica.*

[*Plant Sci.*](https://www.sciencedirect.com/science/journal/01689452) 298:110549

IF: 5.363;Category: Plant Sciences; Rank 29/238 (Q1)

**Since previous promotion**

33. Nawade, B.PD, Yahyaa, M., Davidovich-Rikanati, R., Lewinsohn, E., and **Ibdah, M\*\*.** (2020).

Optimization of culture conditions for the efficient biosynthesis of trilobatin from phloretin by engineered *Escherichia coli* harboring the apple phloretin-4′-O-glycosyltransferase

*J. Agric. Food Chem*. 68:14212-14220

IF: 5.89;Category: Agriculture, multidisciplinary; Rank 8/84 (Q1)

34. Schlesinger, D., Salama, F., Davidovich Rikanati, R., Tal, O., Yahyaa, M., Faigenboim, A.,

**Ibdah, M**., Inbar, M., Efraim Lewinsohn, E. (2021).

Further insights on the *Datura innoxia* hyoscyamine 6*β*-hydroxylase (DiH6H) based

on biochemical characterization and molecular modeling

*Am. J. Plant Sci.,* 12:53

IF: 1.34;Category: Plant Science;

Rank 3/57 (Q1)

35. Warburg, S., Yahyaa, M., Lahav, T., Medina, S., Freilich, S., Gal, S., Palevsky, E., Inbar, M.

and **Ibdah, M\*\***. (2021).

UV-induced citrus resistance to spider mites (*Tetranychus urticae*).

*Crop Protection*, 144, p.105580.

IF: 3.03;Category: Agronomy;

Rank 18/124 (Q1)

36. Shaltiel-Harpaz, L., Yahyaa, M., Nawade, B., Dudareva, N., and **Ibdah, M\*\*.** (2021).

Identification of a wild carrot as carrot psylla (*Bactericera trigonica*) attractant and host plant chemistry.

*Plant Sci*.: 111011.

IF: 5.363;Category: Plant Sciences; Rank 29/238 (Q1)

37. Agmon, S., Kunta, S., Dafny-Yelin, M., Moy, J., **Ibdah, M**., Harel, A., Levy, Y., and Hovav,

R. (2022).

Mapping of stem rot resistance in peanut indicates significant effect for plant architecture locus

*Crop Science*: https://doi.org/10.1002/csc2.20803

IF: 2.856;Category: Agronomy;

Rank 25/90 (Q2)

38. **Ibdah, M\*\***., Hino, S., Nawade, B., Yahyaa, M., Bosamia, TC., and Shaltiel-Harpaz, L.

(2022).

Identification and characterization of three nearly identical linalool/nerolidol synthase from *Acorus calamus*

*Phytochemistry:* 202: 113318

IF: 4.004;Category: Plant Sciences;

Rank 53/238 (Q1)

**Five selected publications**

Publication 21: <https://pubmed.ncbi.nlm.nih.gov/27316677/>

Publication 27: <https://pubmed.ncbi.nlm.nih.gov/30825705/>

Publication 33: <https://pubmed.ncbi.nlm.nih.gov/33089679/>

Publication 36*:* <https://pubmed.ncbi.nlm.nih.gov/34482913/>

Invited Reviews: <https://www.ncbi.nlm.nih.gov/pubmed/29171271>

1. **Books and Invited Reviews** **and Opinion Articles**

**Invited Reviews**

**Ibdah, M\*\*.,** Martens, S., and Gang, R.G. (2018).

Biosynthetic pathway and metabolic engineering of plant dihydrochalcones.

*J. Agric. Food Chem.* 66: 2273-2280. **Invited review**.

IF: 5.89; Category: Agriculture, multidisciplinary; Rank 8/84 (Q1)

**Since previous promotion**

Paparella, A., Shaltiel-Harpaza, L., and **Ibdah, M**\*\* (2021).

*β*-Ionone: Its occurrence and biological function and metabolic engineering.

Plants 10: 754. <https://doi.org/10.3390/plants10040754>.

Paparella, A., Nawade, B., Shaltiel-Harpaz, L. and **Ibdah, M\*\*** (2022).

A review of the botany, volatile composition, biochemical and molecular aspects, and traditional uses of *Laurus nobilis*.

Plants, 11(9), p.1209.

1. **Book Chapters**

Gonda, I., Burger, J., Schaffer, A.A., **Ibdah, M**., Tadmor, Y., Katzir, K., Fait,

A., and Lewinsohn, E. (2016).

Biosynthesis and perception of melon (*Cucumis melo* L.) aroma.

In “Biotechnology in Flavor Production” 2nd edition.

Edited by Nativ Dudai and Daphna Havkin-Frenkel.

Chapter 11, 281-305.

Oxford: Wiley-Blackwell Publishing Ltd.

**Ibdah, M\*\*.,** Yahyaa, M., Muchlinski, A., Nawade, B., and Tholl, D. (2019).

Carrot volatile terpene metabolism: Terpene diversity and biosynthetic genes

In “The Carrot Genome” 1st edition.

Edited by Philip Simon

Chapter 16, 279-294

Springer Nature Switzerland AG

**Since previous promotion**

Nawade, BPD., Yahyaa, M., Lewinsohn, E., and **Ibdah, M\*\*.** (2020)

Vegetative and fruit volatiles for human consumption

In “ Biology of Plant Volatiles” 1st edition.

Edited by Eran Pichersky and Natalia Dudareva

Chapter 5, 79-95

CRC Press, Taylor & Francis group, Boca Raton.

1. **Articles in Reviewed Journals in Hebrew**

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1. **Articles in Non-Reviewed Journals in Hebrew and English**

Shalata, A., **Ibdah, M**., Abushqara, E., and Safadi, M. (2003).

The efficacy of ascorbic acid derivatives (frutavit preparations) for quality preservation in shredded lettuce.

*Daruna (Education and literary articles produced in the Arab college for education in Israel-Haifa)* 36, 221-237.

**Ibdah, M**., Lavid, N., Lewinsohn, E., Amit, A., and Dror, N. (2010).

Green Routes to Green Notes.

*Chem. Engineer. Transac*. 20: 241-246.

**Since previous promotion**

Shaltiel‐Harpaz, L., Gerchman, Y., Holland, D., **Ibdah, M**., BarYa'akov, I., Rachmany, D. Hatib, K., and Soroker, V. (September 2016).

Dealing with pear psylla using resistant pear trees

*Alon Hanotea* 70:16-22.

Shaltiel-Harpaz, L., Kedoshim, R., Rachmany, D., Yahyaa, M.,and **Ibdah, M**. (September 2017).

The secret of communication between the fig fruit that has not ripened to the fertilizing wasp and its exploitation to control the fly.

*Alon Hanotea* 71:44-47.

Eisenberg, O., Bar-Yakkov, I., Hatib, K., Holland, D., Dag, A., Reuveny H., Shaltiel-

Harpaz, L., **Ibdah, M.** (2020).

Sensitivity of almond fruit to almond seeds wasps (*Eurytoma amygdali* Enderlein (Hymenoptera: Eurytomidae)

*Alon Hanotea* 74:18-54

1. **Articles in Symposia Proceedings (including Acta Horticulturae) (since previous promotion)**

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1. **Granted Patents and Registered Cultivars**

**Since previous promotion**

**Ibdah, M.** (2019).

Identification and characterization of UDP-glucose: phloretin 4’-o-glucosyltransferase

from *Malus* x *domestica* Borkh.

US Patent No: US2019/0062768A1

**Mwafaq Ibdah September 2022**

Part III: DESCRIPTION OF MAJOR ACHIEVEMENTS

1. **Contribution to Agricultural and/or Environmental Sciences**

**1-** My scientific contributions started with my work at the Leibniz Institute of Biochemistry in Germany, 1998-2002 (Halle/Salle, Germany), in collaboration with the Helmholtz Institute in Munich. We investigated the UV-stress response of the halophyte *Mesembryanthemum crystallinum* (ice plant, Livingstone daisy). This led to the characterization and quantification (by HPLC and LC-MS) of the light-induced betacyanin and flavonol compounds in bladder cells of the ice plant following light irradiation. Preparative HPLC and NMR methodologies were used to identify a series of new compounds that protect plants from enhanced UV-stress. During this investigation, a set of genes was identified which were upregulated upon light stress. One of these genes was a novel *S*-adenosyl-*L*-methionine and cation-dependent methyltransferase, which surprisingly was not involved in lignin monomer formation but in the methylation of both flavonols and betacyanin conjugates. Classical purification of the enzyme and sequencing of the peptide fragments led to the cloning and functional expression of the corresponding cDNA. A broad spectrum of methods ranging from analytical chemistry to protein biochemistry to molecular techniques led to the identification of a new subtype of methylating enzymes, present in many species that are involved in various biosynthetic pathways of secondary metabolism (Reviewed publication nos. 1-3).

**2-** During my work with the company “Frutavit Ltd.” (2002-2004), I applied my knowledge, gained in research at the Leibniz Institute of Plant Biochemistry, toward developing natural-based formulations based on plant extracts with antioxidant and antimicrobial action, with the goal of preserving and extending the shelf life of freshly harvested fruits and vegetables (Non-reviewed publication no. 1).

**3-** During my first post-doctoral experience (2004-2005), I used a functional genomics approach to identify genes producing the aroma of melons and watermelons at the Newe Ya′ar Research Center of the Agricultural Research Organization, with Dr. Efraim Lewinsohn (Reviewed publication nos. 4 and 5).

**4-** Applying a additional sets of molecular and biochemical tools at Prof. Eran Pichersky’s lab at the University of Michigan, U.S.A. from 2005-2008, I identified reactions and enzymes leading to the biosynthesis of benzoic acid. This compound is a key precursor metabolite in several plant biosynthetic routes involved in the formation of pharmaceutical compounds such as taxol and cocaine, as well as methylbenzoate and benzylbenzoate, which are common volatile esters that attract pollinators and are found in the scent of many flowers, including snapdragon and petunia. The levels of benzoylated glucosinolates and benzoic acid in several knock-out lines were analyzed and I identified a gene, designated CHY1, involved in the synthesis of benzoic acid (directly or via benzaldehyde) in *Arabidopsis*. Moreover, using classical biochemical techniques, I isolated and biochemically characterized an enzymatic activity derived from *Arabidopsis* seeds that converts benzaldehyde to benzoic acid, showing that benzoic acid can be made directly from benzaldehyde in plants (Reviewed publication nos. 6-8).

**5-** My work in the company “Frutarom LTD” 2008-2010 (Haifa, Israel) involved production of food aroma compounds, such as “green notes”, from natural sources. I developed an efficient and elegant system for the industrial-scale production of natural green notes (Non-reviewed publication no. 2).

**6-** Using metabolomic tools, I evaluated the utility of coupling ion mobility spectrometry to UPLC-TOFMS (UPLC-Q-IMS-TOFMS) at Washington State University 2010-2011 (Pullman, U.S.A.), with Prof. David R. Gang, as a means of separating and identifying functionally important saturated and unsaturated phenylpropanoic acids and the related compounds known as chalcones, commonly found in plant extracts (Reviewed publication no. 9 and 14).

**7-** During my current work (2011-present) at the Institute of Vegetable and Field Crops, Newe Ya′ar Research Center, (A.R.O., Israel), I have studied the molecular mechanisms producing specific plant natural sweet compounds, particularly dihydrochalcones. I have applied a set of molecular tools to identify reactions and enzymes leading to the biosynthesis of *p*-dihydrocoumaroyl-CoA. This compound is a key precursor metabolite in biosynthetic routes leading to important compounds such as dihydrochalcones. The accumulations of dihydrochalcone compounds in several *Malus* species were analyzed and I identified a gene termed *p*-coumaroyl-CoA double-bond reductase involved in the synthesis of *p*-dihydrocoumaroyl-CoA in apple. Furthermore, I am utilizing a novel approach, based on the recently cloned NADPH-dependent hydroxycinnamoyl-CoA double-bond reductase, to develop low-calorie/low-sugar fruit sweetness via production of natural dihydrochalcones, for a growing market segment of people suffering from “modern” diseases (Reviewed publication no. 17, 21, 22, invited reviews, and patent; Recipient of two grants from: Chief Sci. 2014; and 2017).

**8-** I have undertaken a study of the molecular mechanisms of producing specific flavor attributes in carrots. This work was initiated because of recent consumer complaints concerning undesirable stress-related off-flavors. Metabolic profiles for the accumulation of terpenoid and norisoprenoid compounds in several carrot varieties were analyzed. By using bioinformatics tools, I have identified genes and enzymes leading to the biosynthesis of these volatile compounds. These included several terpene synthase genes involved in the production of monoterpene and sesquiterpene volatile compounds in carrots. In addition, we identified a novel carotenoid cleavage dioxygenase involved in the synthesis of *α*-, and *β*-ionone (Reviewed publications no. 13, 18, 23, 31 and book chapter no. 2; Recipient of two grants from: BARD 2014; Israel Plant Gene Bank 2015).

**9**- The common figs (*Ficus carica* L.) is an agriculturally and economically important fruits due to the nutritional value of minerals, vitamins, dietary ﬁber, polyphenols, proteins, and sugars. The Fig fruits commercial production is subject to lose due to the attack of black fig fly (*Silba adipata*), which is one of the major pests of figs worldwide. I have observed that the black fig fly gave a strong preference to unpollinated figs, which also showed higher emissions of volatile organic compounds. I also showed that these compounds have potent attractants to black fig fly. Therefore, this study could be the basis for further research to develop a kairomonal trap to minimize pest damage in the figs field. Additionally, by using bioinformatics tools, I have identified several genes and enzymes leading to the biosynthesis of terpenes in *F. carica*. The terpene synthase genes identified could be used to modulate the pest defenses in *F. carica* or other *Ficus* species through metabolic engineering of terpene biosynthesis and insect bioassays, thus provide the basis for future sustainable pest management strategies (Reviewed publications no. 29, 32, and Articles in Non-Reviewed Journals in Hebrew nos. 4; Recipient of grant from “Production and Marketing Board of Figs”, and from ICA).

1. **Achievements in Applied Research**(Specifying major contribution to agriculture and/or the environment in Israel and abroad)

**1-** Carrots are an important crop worldwide and in Israel, where they occupy 3,217 hectares yielding of 220,402 tons/year. However, the commercial carrot production is subject to significant losses due to carrot psylla, the host-vector of yellows disease. We discovered that wild carrot of the Newe Ya′ar carrot germplasm collection constitutively attracts carrot psylla. We also demonstrated that specialized volatile organic compounds accumulated in the leaves of this wild carrot possess potent insecticidal activity on psylla nymphs and affect oviposition. The identification of this wild carrot and its natural insecticides makes this plant as a potential trap plant. The developed protocol has the potential to be transformed into an effective application procedure to be adopted by carrot growers, and may lead to a reduction of the damage caused by carrot psylla by ca. 70-90% (Innovation level: Improvement and adaptation of existing technology; Implementation level: Validation of new technology by the developers) (Reviewed publications no 25; Recipient of several grants from: ICA, and MIGAL 2016 and 2017; BSF 2018; Chief Sci. 2019).

**2**- Several diseases, such as diabetes, obesity, Alzheimer’s, and cancer, are associated with craving and excessive consumption of sugar-rich foods. Dihydrochalcones are plant-derived, zero-calorie sweeteners that satisfy the craving and reduce the sugar consumption, and are thus beneficial for preventing those diseases and supporting human health. We have developed a novel concept to produce trilobatin dihydrochalcone in a microbial cell factory on a commercial-scale replacing the chemical synthesis of this compound (Reviewed publication nos. 17, 21, 22, and 33, Invited Reviews, and allowed patent). (Innovation level: Improvement and adaptation of existing technology; Implementation level: Validation of new technology by the developers and others and implementation of the new technology under commercial conditions within a small scale (relative to the potential scope of application) in Israel and/or elsewhere).

**3-** Pears are an important crop in Israel, occupying 3,500 hectares. Pear psylla, *Cacopsylla bidens*, is a sap-sucking insect that is a highly destructive pest of pears. Resistance has been observed in two pear accessions screened at Newe Ya′ar. Methodologies towards discovering the genetic, biochemical, and molecular factors that confer resistance were developed and improved during the last ten years (Reviewed publications nos. 24, 27; and Articles in Non-Reviewed Journals in Hebrew nos. 3; Recipient of a grant from Chief Sci. 2013). Specifically, we developed a grafting strategy and evaluated a control protocol to reduce the pest damages to pear trees. We also demonstrated that specialized volatile organic compound accumulating in the leaves of the resistant accessions is effective against psylla eggs, nymphs, and adults. The developed protocol which combines grafting and the use of natural insecticides may translate into an effective application procedure for use by pear growers, and may reduce the pear psylla damage by ca. 90% (Innovation level: Improvement and adaptation of existing technology; Implementation level: Validation of new technology by the developers).