SUPPLEMENTARY MATERIAL

A review on biological sources, chemistry and pharmacological activities of pinostrobin

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Abstract

Pinostrobin, a dietary bioflavanoid discovered more than 6 decades ago in the heart-wood of pine (Pinus strobus) and has depicted many pharmacological activities including anti-viral, anti-oxidant, anti-leukemic, anti-inflammatory and anti-aromatase activities. It is an inhibitor of sodium channel and Ca^{2+} signaling pathways and also inhibits intestinal smooth muscle contractions. Inspite of the fact that pinostrobin has an application as functional foods, till-to-date no comprehensive review on pinostrobin has been carried out. Hence, the present review deals with the biological sources, chemistry and pharmacological activities of pinostrobin.

Keywords: Pinostrobin; Flavanones; Anti-inflammatory; Anti-cancer; Anti-viral; Functional foods
### Supplementary table 1: Biological sources of Pinostrobin

| S. No. | Biological Source                          | Extraction methodology                          | Parts used (yield on dry basis) | References |
|--------|-------------------------------------------|-------------------------------------------------|---------------------------------|------------|
| 1.     | *Cajanus cajan* (L.) Millsp (Fabaceae)    | Ethanol (80%) (Closed microwave assisted extraction) | Leaves (0.35% w/w)             | Chan et al., 2011 |
|        |                                           | Ethanol (95%) (Maceration)                       | Leaves (0.003% w/w)            | Kong et al., 2010a |
|        |                                           | CO\textsubscript{2} and aqueous ethanol (Supercritical fluid extraction) | Leaves (0.273% w/w) | Kong et al., 2009; de Melo et al., 2014 |
|        |                                           | Ethanol (80%) (Negative-pressure cavitation extraction) | Leaves (0.054% w/w)          | Kong et al., 2011 |
|        |                                           | Aqueous ethanol (Microwave assisted extraction) | Leaves (0.37% w/w)            | Kong et al., 2010b |
|        |                                           | Boiling ethanol (Maceration)                     | Leaves (0.005% w/w)           | Nicholson et al., 2010 |
|        |                                           | Ethanol and water (80:20) (Maceration)           | Leaves (0.008% w/w)           | Duker-Eshun et al., 2004 |
|        |                                           | Ethanol (70%) (Ultrasonication)                  | Leaves (0.05-0.3% w/w)        | Wei et al., 2013 |
|        |                                           | Ethanol (80%) (Percolation)                      | Leaves (0.36% w/w)            | Wu et al., 2009 |
| 2.     | *Boesenbergia pandurata* (Roxb.) (Zingiberaceae) | Dichloromethane (Maceration)                    | Rhizome/Root (NA)              | Fahey & Stephenson 2002 |
|        |                                           | Methanol (Maceration)                            | Rhizomes (0.071% w/w)         | Atun et al., 2013 |
|        |                                           | n-hexane (Maceration)                            | Rhizomes (0.099% w/w)         | Charoensin et al., 2010 |
|        |                                           | Methanol (Maceration)                            | Rhizomes (0.081% w/w)         | Trakoontivakorn et al., 2001 |
|        |                                           | Chloroform (Maceration)                          | Fresh yellow rhizome (NA)     | Panthong et al., 1994 |
|        |                                           | Hexanes (Maceration)                             | Dried rhizomes (NA)           | Tanjung et al., 2013 |
|        |                                           | Chloroform (Percolation)                         | Red rhizomes (1.302% w/w)     | Tuchinda et al., 2002 |
|        |                                           | Chloroform (Maceration)                          | Rhizomes (0.007% w/w)         | Jaipetch et al., 1982 |
|        |                                           | Methanol (Maceration)                            | Rhizomes (NA)                 | Abdewahab et al., 2011 |
| 3.     | *Kaempferia parviflora* (Wall. ex Baker) (Zingiberaceae) | Methanol (Maceration)                            | Rhizomes (0.02% w/w)          | Feroz et al., 2013 |
| 4.     | *Boesenbergia longiflora* (Wall.) (Zingiberaceae) | Ethanol (Maceration)                             | Rhizomes (NA)                 | Pripdeevech et al., 2012 |
|        |                                           | Ethanol (Maceration)                             | Rhizomes (0.00008% w/w)       | Sudsai et al., 2014 |
| No. | Species                          | Preparation Method      | Extracted Part        | Concentration (w/w) | References                      |
|-----|---------------------------------|-------------------------|-----------------------|---------------------|---------------------------------|
| 5.  | *Isodon oresbius* (W. W. Smith) | Boiling Ethanol (95%) (Infusion) | Whole plant          | 0.090%              | Hao et al., 1996               |
| 6.  | *Muntingia calabura* (L.)       | Methanol (Maceration)    | Leaves (NA)           |                     | Zakaria et al., 2014           |
|     |                                 | Methanol (Maceration)    | Leaves (0.002% w/w)   |                     | Su et al., 2003                |
| 7.  | *Lychnophora markgravi?* (G.M. Barroso) | Dichloromethane (Maceration) | Aerial parts          | 0.087%              | Sartori et al., 2002           |
| 8.  | *Lychnophora reticulata* (Gardn.) | Acetonitrile and water (9:1) (Maceration) | Glandular trichomes of leaves (NA) |                     | Alves et al., 2008             |
| 9.  | *Lychnophora staavioides* (Mart.) | Methanol (Maceration)    | Leaves (NA)           |                     | Takeara et al., 2003           |
| 10. | *Lychnophora ericoides* (Mart.) | Methanol (Maceration)    | Leaves (0.009% w/w)   |                     | Gobbo-Neto, dos Santos et al., 2008 |
|     |                                 | Methanol and water (80:20) (Maceration) | Glandular trichomes (NA) |                     | Gobbo-Neto, Gates et al., 2008 |
| 11. | *Dysphania graveolens* (Willd.) | Water (Infusion)         | Aerial parts          | 0.016% w/w          | Álvarez-Ospina et al., 2013     |
|     |                                 | Methanol (Maceration)    | Aerial parts (0.0006% w/w) |                     | Calzada et al., 2003           |
|     |                                 | Chloroform (Maceration)  | Aerial parts (0.100% w/w) |                     | Mata et al., 1987              |
| 12. | From hive of *Apis mellifera* (L.) (Apidae) | Methanol (Sonication)   | Thai propolis         | 0.035% w/w          | Athikomkulchai et al., 2013     |
| 13. | *Sarcandra hainanensis* (Pei)   | Ethanol (Percolation)    | Whole plant           | 0.00004% w/w        | Cao et al., 2009               |
| 14. | *Onychium auratum* (Kaulf.)     | Light petroleum (Percolation) | Whole plant (NA)      |                     | Ramakrishnan et al., 1974      |
|   | Plant Name                  | Extracting Solvent               | Extracted Part               | Reference                          |
|---|----------------------------|----------------------------------|-------------------------------|------------------------------------|
|15.| *Onychium siliculosum*      | Acetone (Maceration)             | Fronds exudate (NA)           | Wollenweber 1982                   |
|   | (Desv.) (Cryptogrammataceae)| Ethanol (Maceration)             | Whole herb (0.092% w/w)        | Wu et al., 1981                    |
|16.| *Pyracantha coccinea*       | Chloroform and Methanol (9:1)    | Dried roots (0.003% w/w)      | Billia et al., 1993                |
|   | (M.Roem.) (Rosaceae)        | (Percolation)                     |                               |                                    |
|17.| *Ribes viscossimimum*       | Dichloromethane (Maceration)     | Viscid leaves (NA)            | Bohm 1993                          |
|   | (Pursh) (Grossulariaceae)   |                                  |                               |                                    |
|18.| *Piper aduncum*             | Methanol (Maceration)            | Dried milled fruits           | Burke & Nair 1986                  |
|   | (L.) (Piperaceae)            |                                  | (1.54% w/w)                   |                                    |
|19.| *Piper hispidum*            | Methanol (Maceration)            | Dried milled fruits           | Burke & Nair 1986                  |
|   | (Sw.) (Piperaceae)           |                                  | (1.54% w/w)                   |                                    |
|20.| *Piper hostmannianum*       | Ethyl acetate (Maceration)       | Leaves (NA)                   | Portet et al., 2008                |
|   | (Miq.) (Piperaceae)          |                                  |                               |                                    |
|21.| *Piper methysticum*         | Water (Maceration)               | Roots (0.007% w/w)            | Wu et al., 2002                    |
|   | (G. Frost.) (Piperaceae)     |                                  |                               |                                    |
|22.| *Piper ecuadorense*         | Methanol (Dynamic maceration)    | Dried leaves (0.013% w/w)     | Ramirez et al., 2013               |
|   | (Sodiro) (Piperaceae)        |                                  |                               |                                    |
|23.| *Populus trichocarpa*       | Diethylether (Maceration)        | Bud exudates (NA)             | English et al., 1991               |
|   | (Torr. & Gray) (Salicaceae)  |                                  |                               |                                    |
|24.| *Populus deltoides*         | Ethylacetate (Maceration)        | Bud exudates (NA)             | English et al., 1992               |
|   | (Marsh.) (Salicaceae)        |                                  |                               |                                    |
|25.| *Populus nigra*             | Dimethylether (Maceration)       | Buds (NA)                     | Isidorov et al., 2014              |
|   | (L.) (Salicaceae)            |                                  |                               |                                    |
|26.| *Populus szechuanica*       | Dimethylether (Maceration)       | Buds (NA)                     | Isidorov et al., 2014              |
|   | (S.)                        |                                  |                               |                                    |
| No. | Species                        | Solvent/Extraction Method | Extract (w/w%) | Source                                      |
|-----|-------------------------------|---------------------------|----------------|---------------------------------------------|
| 27  | Populus balsamifera (L.)      | Ethyl acetate (Maceration)| Bud exudate (NA)| Greenaway & Whatley 1990                    |
|     | (Salicaceae)                  |                           |                |                                             |
| 28  | Populus angustifolia (J.)     | Diethylether (Maceration) | Bud exudate (NA)| Greenaway et al., 1991                      |
|     | (Salicaceae)                  |                           |                |                                             |
| 29  | Pinus kremppii (Lecomte)      | Ether (Maceration)        | Heartwood (NA) | Erdtman et al., 1966                        |
|     | (Pinaceae)                    |                           |                |                                             |
| 30  | Pinus morrisonicola (Hay.)    | Acetone (Maceration)      | Heartwood (0.002% w/w) | Fang et al., 1987                           |
|     | (Pinaceae)                    |                           |                |                                             |
| 31  | Pinus armandii (Fr.)          | Acetone (Maceration)      | Heartwood (0.0003% w/w) | Fang et al., 1988                           |
|     | (Pinaceae)                    |                           |                |                                             |
| 32  | Pinus clausa (Vasey)          | Ether (Maceration)        | Heartwood (0.023% w/w) | Lindstedt 1950                              |
|     | (Pinaceae)                    |                           |                |                                             |
| 33  | Carya tonkinensis (Lecomte)   | Chloroform (Maceration)   | Leaves (0.1% w/w) | Cuong et al., 1996                          |
|     | (Juglandaceae)                |                           |                |                                             |
| 34  | Alnus viridis (Chaix)         | Acetone (Maceration)      | Winter buds and catkins (male flowers) (NA) | Favre-Bonvin et al., 1978                    |
|     | (Betulaceae)                  |                           |                |                                             |
| 35  | Pyracantha coccinea (M.J. Roemer) | Ethanol (Percolation)  | Roots (NA)    | Fico et al., 2000                           |
|     | (Rosaceae)                    |                           |                |                                             |
| 36  | Prunus cerasus (L.)           | Acetone and water (4:1)   | Bark (NA)      | Geibel & Feucht 1991                        |
|     | (Rosaceae)                    | (Maceration)              |                |                                             |
| 37  | Prunus avium (L.)             | Acetone and water (7:3)   | Heartwood (0.400% w/w) | Vinciguerra et al., 2003                   |
|     | (Rosaceae)                    | (Maceration)              |                |                                             |
| 38  | Renealmia alpinia (Mass.)     | Dichloromethane (Maceration) | Dried leaves (0.321% w/w) | Gómez-Betancur et al., 2014               |
| No. | Species                              | Extraction Method | Part Used                  | Concentration | Reference               |
|-----|--------------------------------------|-------------------|----------------------------|---------------|-------------------------|
| 39. | *Renealmnia nicolaioides* (Loes.)    | Methanol (Maceration) | Roots (0.374% w/w)        |               | Gu et al., 2002         |
|     | (Zingiberaceae)                      |                   |                            |               |                         |
| 40. | *Salvia texana* (Torr.)              | Cold Methanol (Maceration) | Roots (0.0008% w/w)      |               | González et al., 1989   |
|     | (Labiatae)                           |                   |                            |               |                         |
| 41. | *Pityrogramma tartarea* (Cav.)       | Acetone (Maceration) | Frond exudates (NA)        |               | Iinuma et al., 1994     |
|     | (Polypodiaceae)                      |                   |                            |               |                         |
| 42. | *Miliusa balansae* (Fin. & Gagn.)    | Methanol and water (95:5) (Maceration) | Dried leaves and branches (0.010% w/w) | Kamperdick et al., 2002 |
|     | (Annonaceae)                         |                   |                            |               |                         |
| 43. | *Miliusa sinensis* (Fin. & Gagn.)    | Methanol (95%) (Maceration) | Dried leaves and branches (0.0066% w/w) | Thuy et al., 2011 |
|     | (Annonaceae)                         |                   |                            |               |                         |
| 44. | *Polygonum limbatum* (Meisn.)        | Methanol (Maceration) | Aerial parts of plant (NA) |               | Kuete et al., 2013      |
|     | (Polygonoceae)                       |                   |                            |               |                         |
| 45. | *Polygonum ferrugineum* (Wedd.)      | Methanol (Maceration) | Dried leaves (0.010% w/w)  |               | López et al., 2006      |
|     | (Polygonoceae)                       |                   |                            |               |                         |
| 46. | *Dalbergia odorifera* (T. Chen)      | Methanol (Maceration) | Heartwood (NA)             |               | Lee et al., 2013        |
|     | (Leguminosae)                        |                   |                            |               |                         |
| 47. | *Litsea fruticosa* (Hemsl.)          | Ethanol (Maceration) | Dried leaves (0.0017% w/w) |               | Liu et al., 2013        |
|     | (Lauraceae)                          |                   |                            |               |                         |
| 48. | *Corymbia torelliana* (F.Muell.)     | Methanol (Maceration) | Fruit resins of capsules (NA) |               | Massaro et al., 2014    |
|     | (Myrtaceae)                          |                   |                            |               |                         |
| 49. | *Gymnema montanum* (H.)              | Ethanol (95%) (Percolation) | Fresh leaves (NA)          |               | Ramkumar et al., 2009   |
|     | (Asclepiadaceae)                     |                   |                            |               |                         |
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| 50. | *Uvaria chamae* (P. Beauv.) (Annonaceae) | Ethanol (95%) (Percolation) | Root bark (0.0019% w/w) | Lasswell et al., 1977 |
| 51. | *Lindera umbellate* (Thunb.) (Lauraceae) | Hot Methanol (Maceration) | Fresh bark (0.170% w/w) | Shimomura et al., 1988 |
| 51. | | Methanol (Maceration) | Fresh leaves (0.009% w/w) | Ichino et al., 1988 |
| 52. | *Myrica pensylvanica* (Loisel) (Myricaceae) | Acetone (Maceration) | Leaves and young twigs (NA) | Wollenweber et al., 1985 |
| 53. | *Pinus strobus* (L.) (Pinaceae) | Hexane (Maceration) | Wood (0.0116% w/w) | Carvalho et al., 1996 |

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