

# Environmental Contaminants and Medicinal Plants Action on Female Reproduction

Alexander V. Sirotkin and Adriana Kolesarova



# **Environmental Contaminants and Medicinal Plants Action on Female Reproduction**

This page intentionally left blank

# Environmental Contaminants and Medicinal Plants Action on Female Reproduction

---

**Alexander V. Sirotkin**

Professor,

Constantine the Philosopher University in Nitra, Slovakia

**Adriana Kolesarova**

Professor,

Slovak University of Agriculture in Nitra, Slovakia



**ACADEMIC PRESS**

An imprint of Elsevier

Academic Press is an imprint of Elsevier  
125 London Wall, London EC2Y 5AS, United Kingdom  
525 B Street, Suite 1650, San Diego, CA 92101, United States  
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States  
The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, United Kingdom

Copyright © 2022 Elsevier Inc. All rights reserved.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Details on how to seek permission, further information about the Publisher's permissions policies and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency, can be found at our website: [www.elsevier.com/permissions](http://www.elsevier.com/permissions).

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

### Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

### Library of Congress Cataloging-in-Publication Data

A catalog record for this book is available from the Library of Congress

### British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library

ISBN: 978-0-12-824292-6

For information on all Academic Press publications visit our website at  
<https://www.elsevier.com/books-and-journals>

*Publisher:* Andre G. Wolff  
*Acquisitions Editor:* Kattie Washington  
*Editorial Project Manager:* Sam W. Young  
*Production Project Manager:* Kiruthika Govindaraju  
*Cover Designer:* Christian Bilbow



Typeset by TNQ Technologies

# Contents

Preface

xv

## 1. Female reproductive system and its regulation

<b>1.1 Introduction</b>	1
<b>1.2 The ovary</b>	1
1.2.1 Folliculogenesis	2
1.2.2 Preovulatory changes and ovulation	4
1.2.3 Luteogenesis and luteolysis	5
1.2.4 Oocytes	6
<b>1.3 Fallopian tubes</b>	6
<b>1.4 Uterus</b>	7
<b>1.5 Extra- and intracellular regulators of female reproductive processes</b>	7
<b>1.6 Some female reproductive disorders</b>	14
<b>1.7 Conclusions and possible direction of future studies</b>	15
<b>References</b>	15

## 2. Environmental contaminants and their influence on health and female reproduction

<b>2.1 Heavy metals</b>	21
2.1.1 Introduction	21
2.1.2 Provenance and properties	22
2.1.3 Physiological actions	23
2.1.4 Mechanisms of action	26
2.1.5 Effects on female reproductive processes	27
2.1.5.1 Effect on ovaries	27
2.1.5.2 Effect on uterus and pregnancy	29
2.1.6 Mechanism of action on female reproductive processes	30
2.1.7 Application in reproductive biology and medicine	31
2.1.8 Conclusions and possible direction of future studies	32
References	32
<b>2.2 Mycotoxins</b>	38
2.2.1 Introduction	38
2.2.2 Provenance and properties	38

2.2.3	Physiological actions	43
2.2.4	Mechanism of action	43
2.2.5	Effects on female reproductive processes	44
2.2.5.1	Effect on ovarian cell functions	44
2.2.5.2	Effects on oocytes and embryos	45
2.2.6	Mechanisms of action on female reproductive processes	46
2.2.7	Application in reproductive biology and medicine	48
2.2.8	Conclusion	49
	References	49
<b>2.3.</b>	<b>The oil-related environmental contaminants</b>	<b>54</b>
2.3.1	Introduction	54
2.3.2	Provenance and properties	54
2.3.3	Physiological actions	55
2.3.4	Mechanisms of action	56
2.3.5	Effects on female reproductive processes	57
2.3.5.1	Effects on the CNS	57
2.3.5.2	Effects on the ovarian and reproductive state	57
2.3.5.3	Effect on ovarian cell functions	58
2.3.5.4	Effects on oocytes and embryos	59
2.3.5.5	Effects on oviducts	60
2.3.5.6	Effects on cytogenetics of somatic and generative cells	60
2.3.5.7	Effects on reproductive hormones	60
2.3.6	Mechanisms of action on female reproductive processes	61
2.3.7	Application in reproductive biology and medicine	62
2.3.8	Conclusions and possible direction of future studies	64
	References	66
<b>2.4.</b>	<b>Tobacco smoking</b>	<b>70</b>
2.4.1	Introduction	70
2.4.2	Provenance and properties	70
2.4.3	Physiological actions	71
2.4.4	Mechanism of action	73
2.4.5	Effects on female reproductive processes	73
2.4.5.1	The effect on ovarian and reproductive state	73
2.4.5.2	Effect on reproductive hormones	74
2.4.5.3	Effect on embryos	74
2.4.6	Mechanisms of action on female reproductive processes	75
2.4.7	Application in reproductive biology and medicine	75
2.4.8	Conclusions and possible direction of future studies	76
	References	77
<b>3.</b>	<b>Food/medicinal herbs and their influence on health and female reproduction</b>	
3.1	<b>Apricot (<i>Prunus armeniaca</i> L.)</b>	<b>81</b>
3.1.1	Introduction	81
3.1.2	Provenance and properties	82
3.1.3	Physiological and therapeutic actions	83

3.1.4	Mechanisms of action	86
3.1.5	Effects on female reproductive processes	87
	3.1.5.1 Effect on reproductive hormones	87
	3.1.5.2 Effect on ovarian follicular cell functions	88
3.1.6	Mechanisms of action on female reproductive processes	88
3.1.7	Application in reproductive biology and medicine	89
3.1.8	Conclusions and possible direction of future studies	90
	References	90
<b>3.2</b>	<b>Black elder (<i>Sambucus nigra</i> L.)</b>	96
3.2.1	Introduction	96
3.2.2	Provenance and properties	96
3.2.3	Physiological and therapeutic actions	98
3.2.4	Mechanisms of action	99
3.2.5	Effects on female reproductive processes	100
	3.2.5.1 Effect on ovarian cell functions	100
	3.2.5.2 Effect on embryo	101
3.2.6	Mechanisms of action on female reproductive processes	101
3.2.7	Application in reproductive biology and medicine	102
3.2.8	Conclusions and possible direction of future studies	102
	References	103
<b>3.3</b>	<b>Buckthorn (<i>Hippophae rhamnoides</i> L.)</b>	108
3.3.1	Introduction	108
3.3.2	Provenance and properties	109
3.3.3	Physiological and therapeutic actions	110
3.3.4	Mechanisms of action	111
3.3.5	Effects on female reproductive processes	113
	3.3.5.1 Effect on ovarian follicular cell functions	113
	3.3.5.2 Effect on vagina and uterus	114
3.3.6	Mechanisms of action on female reproductive processes	114
3.3.7	Potential for application in reproductive biology and medicine	115
3.3.8	Conclusions and possible direction of future studies	116
	References	116
<b>3.4</b>	<b>Buckwheat (<i>Fagopyrum tataricum</i>, L., <i>Fagopyrum esculentum</i> Moench)</b>	121
3.4.1	Introduction	121
3.4.2	Provenance and properties	121
3.4.3	Physiological and therapeutical actions	122
3.4.4	Mechanisms of action	123
3.4.5	Effects on female reproductive processes	125
	3.4.5.1 Effect of on ovarian and reproductive state	125
	3.4.5.2 Effect on ovarian cell functions	125
	3.4.5.3 Effect on reproductive hormones	125
	3.4.5.4 Effect on ovarian cell response to environmental contaminants	126



3.4.6	Mechanisms of action on female reproductive processes	126
3.4.7	Application in reproductive biology and medicine	127
3.4.8	Conclusions and possible direction of future studies	127
	References	128
<b>3.5</b>	<b>Curcuma/turmeric (<i>Curcuma longa</i> L., <i>Curcuma zedoaria</i> (Christm.) Roscoe)</b>	<b>130</b>
3.5.1	Introduction	130
3.5.2	Provenance and properties	130
3.5.3	Physiological and therapeutic actions	131
3.5.4	Mechanisms of action	132
3.5.5	Effect on female reproductive processes	132
3.5.5.1	Effect on ovarian and reproductive state	132
3.5.5.2	Effect on ovarian cell functions	133
3.5.5.3	Effect on reproductive hormones	133
3.5.5.4	Mechanisms of action on female reproductive processes	134
3.5.6	Application in reproductive biology and medicine	135
3.5.7	Conclusion and possible directions of further studies	136
	References	137
<b>3.6</b>	<b>Flaxseed (<i>Linum usitatissimum</i> L.)</b>	<b>141</b>
3.6.1	Introduction	141
3.6.2	Provenance and properties	141
3.6.3	Physiological action	142
3.6.4	Mechanisms of action	143
3.6.4.1	Flaxseed constituents responsible for its physiological effects	143
3.6.4.2	Mediators of flaxseed effects	144
3.6.5	Effects on female reproductive processes	145
3.6.5.1	Effect on ovarian and reproductive state	145
3.6.5.2	Effect on oocytes and embryos	146
3.6.5.3	Effect on reproductive hormones	147
3.6.6	Mechanisms of action on female reproductive processes	148
3.6.6.1	Flaxseed constituents responsible for its effects on female reproductive processes	148
3.6.6.2	Mediators of flaxseed effects on female reproductive processes	149
3.6.7	Application in reproductive biology and medicine	150
3.6.8	Conclusions and possible direction of future studies	151
	References	152
<b>3.7</b>	<b>Ginkgo (<i>Ginkgo biloba</i>, L.)</b>	<b>156</b>
3.7.1	Introduction	156
3.7.2	Provenance and properties	156
3.7.3	Physiological and therapeutic actions	157
3.7.4	Mechanisms of action	159
3.7.4.1	Ginkgo constituents responsible for particular effects	159

3.7.4.2	Mediators of ginkgo and its constituents' effects	160
3.7.5	Effects on female reproductive processes	162
3.7.5.1	Effect on ovarian and reproductive state	162
3.7.5.2	Effect on ovarian cell functions	163
3.7.5.3	Effect on oocytes and embryos	163
3.7.5.4	Effect on reproductive hormones	163
3.7.6	Mechanisms of action on female reproductive processes	164
3.7.7	Application in reproductive biology and medicine	165
3.7.8	Conclusions and possible direction of future studies	165
	References	166
<b>3.8</b>	<b>Grape (<i>Vitis vinifera</i> L.)</b>	170
3.8.1	Introduction	170
3.8.2	Provenance and properties	171
3.8.3	Physiological and therapeutic actions	171
3.8.4	Mechanisms of action	172
3.8.5	Effects on female reproductive processes	172
3.8.5.1	Effect on ovaries	173
3.8.5.2	Effect on uterus	174
3.8.6	Mechanisms of action on female reproductive processes	174
3.8.7	Application in reproductive biology and medicine	177
3.8.8	Conclusions and possible direction of future studies	178
	References	178
<b>3.9</b>	<b>Pomegranate (<i>Punica granatum</i> L.)</b>	183
3.9.1	Introduction	183
3.9.2	Provenance and properties	183
3.9.2.1	Bioavailability, metabolism and pharmacokinetics	184
3.9.3	Physiological and therapeutic actions	185
3.9.4	Mechanisms of action	186
3.9.5	Effects on female reproductive processes	189
3.9.6	Mechanisms of action on female reproductive processes	191
3.9.7	Application in reproductive biology and medicine	191
3.9.8	Conclusions and possible direction of future studies	192
	References	192
<b>3.10</b>	<b>Puncture vine (<i>Tribulus terrestris</i> L.)</b>	199
3.10.1	Introduction	199
3.10.2	Provenance and properties	199
3.10.3	Physiological and therapeutical actions	200
3.10.4	Mechanisms of action	201
3.10.5	Effect on male reproductive processes	203
3.10.6	Mechanisms of effects on male reproductive processes	204
3.10.7	Effects on female reproductive processes	205

3.10.8	Mechanisms of effects on female reproductive processes	207
3.10.9	Application in reproductive biology and medicine	208
3.10.10	Conclusions and possible direction of future studies	208
	References	209
<b>3.11</b>	<b>Rooibos (<i>Aspalathus linearis</i> (Burm.f.) R.Dahlgren)</b>	<b>213</b>
3.11.1	Introduction	213
3.11.2	Provenance and properties	213
3.11.3	Physiological actions	214
3.11.4	Mechanisms of action	215
3.11.5	Effects on female reproductive processes	216
3.11.6	Mechanisms of action on female reproductive processes	217
3.11.7	Application in reproductive biology and medicine	217
3.11.8	Conclusions and possible direction of future studies	218
	References	218
<b>3.12</b>	<b>Tea (<i>Camelia sinensis</i> L.)</b>	<b>220</b>
3.12.1	Introduction	220
3.12.2	Provenance and properties	220
3.12.3	Physiological actions	221
3.12.4	Mechanisms of action	222
3.12.5	Effects on female reproductive processes	223
3.12.5.1	Effect on ovarian and reproductive state	223
3.12.5.2	Effect on ovarian cell functions	224
3.12.5.3	Effect on oocytes and embryos	224
3.12.5.4	Effect on reproductive hormones	225
3.12.6	Mechanisms of action on female reproductive processes	226
3.12.7	Application in reproductive biology and medicine	227
3.12.8	Conclusions and possible direction of future studies	228
	References	229
<b>3.13</b>	<b>Vitex (<i>Vitex agnus-castus</i> L.)</b>	<b>232</b>
3.13.1	Introduction	232
3.13.2	Provenance and properties	232
3.13.3	Physiological actions	233
3.13.4	Mechanisms of action	234
3.13.5	Effects on female reproductive processes	236
3.13.5.1	Effect on ovarian and reproductive state	236
3.13.5.2	Effect on ovarian cell functions	236
3.13.5.3	Effect on reproductive hormones	237
3.13.6	Mechanisms of action on female reproductive processes	237
3.13.7	Application in reproductive biology and medicine	238
3.13.8	Conclusions and possible direction of future studies	240
	References	240

<b>4. Plant molecules and their influence on health and female reproduction</b>	
<b>4.1 Amygdalin</b>	245
4.1.1 Introduction	245
4.1.2 Provenance and properties	246
4.1.3 Physiological and therapeutic actions	248
4.1.4 Mechanisms of action	249
4.1.5 Effects on female reproductive processes	251
4.1.5.1 Effect on ovarian follicular cell functions	251
4.1.5.2 Effect on reproductive hormones	251
4.1.5.3 Effect on reproductive state	252
4.1.6 Mechanisms of action on female reproductive processes	252
4.1.7 Application in reproductive biology and medicine	253
4.1.8 Conclusions and possible direction of future studies	253
References	254
<b>4.2 Apigenin</b>	259
4.2.1 Introduction	259
4.2.2 Provenance and properties	259
4.2.3 Physiological and therapeutical actions	260
4.2.4 Mechanisms of action	262
4.2.5 Effects on female reproductive processes	263
4.2.5.1 Effect on ovarian and reproductive state	263
4.2.6 Effect on ovarian and uterine cell functions	264
4.2.7 Effect on oocytes and embryos	265
4.2.8 Effect on reproductive hormones	265
4.2.9 Effect on response to adverse external factors	266
4.2.10 Mechanisms of action on female reproductive processes	267
4.2.11 Application in reproductive biology and medicine	270
4.2.12 Conclusions and possible direction of future studies	271
References	272
<b>4.3 Berberine</b>	276
4.3.1 Introduction	276
4.3.2 Provenance and properties	276
4.3.3 Physiological and therapeutic actions	277
4.3.4 Mechanisms of action	278
4.3.5 Effects on female reproductive processes	280
4.3.5.1 Effect on ovaries	280
4.3.5.2 Effect of vagina and uterus	281
4.3.6 Mechanisms of action on female reproductive processes	281
4.3.6.1 Proliferation and apoptosis	281
4.3.6.2 Oxidative stress	282
4.3.6.3 Prostaglandins	282
4.3.6.4 Hormones and growth factors	282
4.3.7 Application in reproductive biology and medicine	283
4.3.8 Conclusions and possible direction of future studies	283
References	284

<b>4.4 Capsaicin</b>	287
4.4.1 Introduction	287
4.4.2 Provenance and properties	287
4.4.3 Physiological and therapeutic actions	288
4.4.4 Mechanisms of action	290
4.4.5 Effects on female reproductive processes	293
4.4.5.1 Effect on ovarian and reproductive state	293
4.4.5.2 Effect on ovarian cell functions	294
4.4.5.3 Effect on reproductive hormones	294
4.4.6 Mechanisms of action on female reproductive processes	294
4.4.7 Application in reproductive biology and medicine	295
4.4.8 Conclusions and possible direction of future studies	296
References	296
<b>4.5 Daidzein</b>	303
4.5.1 Introduction	303
4.5.2 Provenance and properties	303
4.5.3 Physiological and therapeutical actions	305
4.5.4 Mechanisms of action	306
4.5.5 Effect on female reproductive processes	307
4.5.5.1 Effect on ovarian and reproductive state	307
4.5.5.2 Effect on ovarian cell functions	308
4.5.5.3 Effect on reproductive hormones	308
4.5.5.4 Mechanisms of action on female reproductive processes	309
4.5.5.5 Application in reproductive biology and medicine	311
4.5.6 Conclusion and possible direction of further studies	312
References	313
<b>4.6 Diosgenin</b>	317
4.6.1 Introduction	317
4.6.2 Provenance and properties	317
4.6.3 Physiological action	318
4.6.4 Mechanisms of action	320
4.6.5 Effects on female reproductive processes	320
4.6.5.1 Effect on ovarian and reproductive state	320
4.6.6 Effect on ovarian cell functions	321
4.6.7 Effect on oocytes and embryos	321
4.6.8 Effect on reproductive hormones	321
4.6.9 Mechanisms of action on female reproductive processes	322
4.6.10 Application in reproductive biology and medicine	323
4.6.11 Conclusions and possible direction of future studies	324
References	325
<b>4.7 Isoquercitrin</b>	328
4.7.1 Introduction	328
4.7.2 Provenance and properties	328

4.7.3	Physiological and therapeutic actions	330
4.7.4	Mechanisms of action	331
4.7.5	Effects on female reproductive processes	332
4.7.6	Mechanisms of action on female reproductive processes	333
4.7.7	Application in reproductive biology and medicine	334
4.7.8	Conclusions and possible direction of future studies	334
	References	334
<b>4.8</b>	<b>Punicalagin</b>	338
4.8.1	Introduction	338
4.8.2	Provenance and properties	338
4.8.3	Physiological and therapeutic actions	340
4.8.4	Mechanisms of action	340
4.8.5	Effects on female reproductive processes	342
4.8.5.1	Effect on reproductive health and fertility	342
4.8.5.2	Effect on ovarian follicular cell functions	343
4.8.5.3	Effect on uterus and pregnancy	343
4.8.6	Mechanisms of action on female reproductive processes	343
4.8.7	Application in reproductive biology and medicine	344
4.8.8	Conclusions and possible direction of future studies	345
	References	345
<b>4.9</b>	<b>Quercetin</b>	349
4.9.1	Introduction	349
4.9.2	Provenance and properties	349
4.9.3	Physiological actions	351
4.9.4	Mechanisms of action	352
4.9.5	Effects on female reproductive processes	355
4.9.5.1	Effect on ovarian and reproductive state	355
4.9.5.2	Effect on ovarian cell functions	355
4.9.5.3	Effect on oocytes and embryos	356
4.9.5.4	Effect on reproductive hormones	357
4.9.5.5	Effect on ovarian disfunctions	358
4.9.5.6	Effect on response to hazardous factors	359
4.9.6	Mechanisms of action on female reproductive processes	360
4.9.7	Application in reproductive biology and medicine	362
4.9.8	Conclusions and possible direction of future studies	363
	References	364
<b>4.10</b>	<b>Resveratrol</b>	371
4.10.1	Introduction	371
4.10.2	Provenance and properties	371
4.10.3	Physiological and therapeutic actions	372
4.10.4	Mechanisms of action	374
4.10.5	Effects on female reproductive processes	374
4.10.5.1	Effect on ovarian and reproductive state and on ovarian cell functions	374

4.10.5.2	Effect on reproductive hormones	375
4.10.5.3	Possible causes of variability in resveratrol effects	376
4.10.6	Mechanisms of action on female reproductive processes	377
4.10.7	Application in reproductive biology and medicine	378
4.10.8	Conclusion and possible directions of the further studies	380
	References	382
<b>4.11</b>	<b>Rutin</b>	387
4.11.1	Introduction	387
4.11.2	Provenance and properties	387
4.11.3	Physiological actions	389
4.11.4	Mechanisms of action	390
4.11.5	Effects on female reproductive processes	391
	4.11.5.1 Effect on ovarian and reproductive state	391
	4.11.5.2 Effect on ovarian cell functions	392
	4.11.5.3 Effect on oocytes and embryos	392
4.11.6	Effect on reproductive hormones	392
4.11.7	Mechanisms of action on female reproductive processes	393
4.11.8	Application in reproductive biology and medicine	394
4.11.9	Conclusions and possible direction of future studies	395
	References	396
	Conclusion	401
	Index	403