

# Contents

---

## List of contributors

xi 3.3 Nutritional and antinutritional composition of cabbage 37  
xi 3.4 Antioxidant phytochemicals of cabbage 40

## About the editor

xv 3.5 Factors influencing antioxidant and nutritional profile of cabbage 46

## Preface

xvii 3.6 Side effects associated with cabbage consumption 48

## Section I

### Vegetables

#### Part 1

##### Inflorescence/Flowers/Flower Buds

###### 1. Broccoli

5 4.1 Globe artichoke 55

GEETHA SHREE NAGRAJ, ANITA CHOUKSEY, SWARNA JAISWAL AND AMIT K. JAISWAL

4.2 Chemical composition 55

1.1 Background 5

4.3 Health effects associated to globe artichoke 60

1.2 Nutritional components of broccoli 6

4.4 Conclusions 66

1.3 Antinutritional factors in broccoli 8

Acknowledgment 66

1.4 Health benefits 9

References 66

1.5 Factors affecting bioactive components of broccoli 14

4. Artichoke 55

1.6 Possible health risk of consuming broccoli 15

4.1 Globe artichoke 55

1.7 Concluding remarks and future trends 15

4.2 Chemical composition 55

References 16

4.3 Health effects associated to globe artichoke 60

###### 2. Cauliflower

4.4 Conclusions 66

VALENTINA PICCHI, MARTA FIBIANI AND ROBERTO LO SCALZO

Acknowledgment 66

2.1 Background 19

References 66

2.2 Health benefits 19

5. Onion 73

2.3 Macronutrients, micronutrients, and antinutritional compounds 19

NADEZHDA GOLUBKINA AND GIANLUCA CARUSO 73

2.4 Antioxidant phytochemicals 20

5.1 Background 73

2.5 Antioxidant properties 23

5.2 Health benefits 74

2.6 Factors influencing antioxidants content 27

5.3 Nutritional and antinutritional composition 75

2.7 Cauliflower by-products (as dietary or food antioxidants) 27

5.4 Antioxidant phytochemicals and properties 80

2.8 Concluding remarks and future trends 27

5.5 Factors influencing nutritional and antioxidants content 84

References 27

5.6 Concluding remarks and future trends 85

###### 3. Cabbage

Acknowledgment 86

NORA MOREB, AMY MURPHY, SWARNA JAISWAL AND AMIT K. JAISWAL

References 86

3.1 Background 33

6. Onion 73

3.2 Health benefits of cabbage 34

5.1 Background 73

###### Part 2

5.2 Health benefits 74

### Bulb/Stem/Stalk

5.3 Nutritional and antinutritional composition 75

3.3 Nutritional and antinutritional composition 37

5.4 Antioxidant phytochemicals and properties 80

3.4 Antioxidant phytochemicals 40

5.5 Factors influencing nutritional and antioxidants content 84

3.5 Factors influencing antioxidant and nutritional profile of cabbage 46

5.6 Concluding remarks and future trends 85

3.6 Side effects associated with cabbage consumption 48

Acknowledgment 86

3.7 Breakthroughs in the utilization of cabbage waste 49

References 86

3.8 Concluding remarks and future trends 51

6. Garlic 89

###### Part 3

6.1 Garlic; origin and major types 89

6.2 Health benefits of garlic 91

6.3 Garlic composition and constituents 97

6.4 Concluding remarks and future trends 101

References 101

<b>7. Celery</b>	107	10.5 Factors influencing the antioxidant content and other parameters	170
PHETCHARAT BOONRUAMKAEW, WANIDA SUKKETSIRI AND PENNAPA CHONPATHOMPIKUNLERT		10.6 Concluding remarks and future trends	172
7.1 Background	107	Acknowledgments	173
7.2 Nutritional composition	108	References	173
7.3 Health benefits	111		
7.4 Anti-oxidant phytochemicals	114	<b>11. Spinach</b>	181
7.5 Factors influencing anti-oxidant content	114	M. ANTONIA MURCIA, ANTONIA M. JIMÉNEZ-MONREAL, JULIA GONZALEZ AND MAGDALENA MARTÍNEZ-TOMÉ	
7.6 Toxicological properties	116		
7.7 Concluding remarks and future trends	116	11.1 Background	181
Acknowledgments	116	11.2 Nutritional and antinutritional composition	181
References	116	11.3 Health benefits	183
Further reading	120	11.4 Antioxidant components in spinach	187
		11.5 Antioxidant activity test	189
<b>8. Asparagus</b>	121	11.6 Environmental variations and agronomic conditions	189
AMEL HAMDI, SARA JARAMILLO-CARMONA, ROCIO RODRÍGUEZ-ARCOS, ANA JIMÉNEZ-ARAUJO AND RAFAEL GUILLÉN-BEJARANO		11.7 Development of novel products with spinach as ingredient	191
8.1 Background	121	11.8 Conclusion	191
8.2 Health benefits	121	References	192
8.3 Nutritional composition	124		
8.4 Antioxidant phytochemicals	127	<b>12. Watercress</b>	197
8.5 Antioxidant properties	131	JOSÉ PINELA, ANA MARÍA CARVALHO AND ISABEL C.F.R. FERREIRA	
8.6 Factors influencing antioxidants content	132		
8.7 Asparagus by-products as a source of functional ingredients	134	12.1 Introduction	197
Acknowledgment	136	12.2 Nutritional composition	197
References	136	12.3 Antinutrients composition	207
		12.4 Nonnutrients composition	208
<b>Part 3</b>		12.5 Antioxidant properties	211
<b>Leafy vegetables</b>		12.6 Health benefits	214
		12.7 Safety precautions	216
<b>9. Lettuce</b>	143	12.8 Concluding remarks and future trends	216
RANJANA DAS AND CHIRANJIB BHATTACHARJEE		Acknowledgments	217
9.1 Background	143	References	217
9.2 General health benefits of lettuce	144		
9.3 Nutritional and antinutritional composition of lettuce	147	<b>Part 4</b>	
9.4 Polyphenols and antioxidant phytochemical in four lettuce varieties	150	<b>Fruit and Seed</b>	
9.5 Factors influencing the antioxidant content	152		
9.6 Other aspects	154	<b>13. Pepper</b>	223
9.7 Future trends of lettuce	155	NORA MOREB, CARON O'DWYER, SWARNA JAISWAL AND AMIT K. JAISWAL	
References	155		
<b>10. Kale</b>	159	13.1 Background	223
JOSÉ ANTONIO PELLICER, MARÍA ISABEL FORTEA, MARÍA ISABEL RODRÍGUEZ-LÓPEZ, PILAR HERNÁNDEZ-SÁNCHEZ, SANTIAGO LÓPEZ-MIRANDA, JOSÉ ANTONIO GABALDÓN AND ESTRELLA NÚÑEZ-DELICADO		13.2 Health benefits	223
10.1 Background	159	13.3 Nutritional and antinutritional composition	226
10.2 Nutritional composition and quality parameters	159	13.4 Antioxidant phytochemicals	228
10.3 Antioxidant phytochemicals	160	13.5 Other aspects	235
10.4 Health benefits	165	13.6 Concluding remarks and future trends	236
		References	236
		<b>14. Summer squash</b>	239
		MARÍA TERESA BLANCO DÍAZ, RAFAEL FONT, PEDRO GÓMEZ AND MERCEDES DEL RÍO CELESTINO	
		14.1 Introduction	239
		14.2 Health benefits	239

14.3 Nutritional and antinutritional composition	242	18. Cluster beans	301
14.4 Antioxidant properties	243	KRISHNAPURA SRINIVASAN	
14.5 Factors influencing the nutritional content	246		
14.6 Potential contribution	249	18.1 Introduction	301
14.7 Concluding remarks and future trends	249	18.2 Chemical and nutritional composition	301
Acknowledgments	252	18.3 Guar gum—the fiber component and its application	
References	252	in food industry	302
<b>15. Tomato</b>	<b>255</b>	18.4 Health benefits of cluster beans/guar gum	302
FRANCISCO-JAVIER GARCÍA-ALONSO, VERÓNICA GARCÍA-VALVERDE, INMACULADA NAVARRO-GONZÁLEZ, GALA MARTÍN-POZUELO, ROCÍO GONZÁLEZ-BARRIO AND MARÍA JESÚS PERIAGO		Conclusion	309
		References	310
15.1 Introduction	255		
15.2 Nutritional composition	255		
15.3 Antioxidant capacity and bioactive compounds profile	257		
15.4 Factors influencing the antioxidant properties of tomato	260		
15.5 Potential health effects	262		
Conclusions	267		
References	267		
Further Reading	271		
<b>16. Eggplant</b>	<b>273</b>		
CHARU LATA MAHANTA AND DIPANKAR KALITA			
16.1 Introduction	273	19. Red beet	315
16.2 Production and consumption of eggplant	273	KAVITHA RAVICHANDRAN, IRYNA SMETANSKA AND USHA ANTONY	
16.3 Proximate composition of eggplant	274		
16.4 Bioactive compounds in eggplant and their antioxidant properties	275	19.1 Introduction	315
16.5 Browning in eggplant	279	19.2 Nutritional and antinutritional composition	315
16.6 Postharvest changes in the quality of eggplant	279	19.3 Health benefits	316
16.7 Effect of cooking on the properties of eggplant	280	19.4 Betalains in red beet	317
16.8 Antioxidant activity studies on eggplant	282	19.5 Antioxidant properties	318
16.9 Health promoting properties of the bioactive compounds in eggplant	283	19.6 Genotype and environmental variations	319
16.10 Allergens in eggplant	284	19.7 Conclusion and future trends	319
16.11 Concluding remarks and future trends	284	Acknowledgment	320
References	284	References	320
Further reading	287		
<b>17. Green beans</b>	<b>289</b>	<b>20. Carrot</b>	<b>323</b>
SAVITA CHAURASIA		GEETHA SHREE NAGRAJ, SWARNA JAISWAL, NIAMH HARPER AND AMIT K. JAISWAL	
17.1 Background	289		
17.2 Health benefits	290	20.1 Background	323
17.3 Health risks of green beans	292	20.2 Health benefits	324
17.4 Nutritional and antinutritional composition	293	20.3 Nutritional and antinutritional composition	328
17.5 Antioxidant potential of green beans	294	20.4 Antioxidant phytochemicals	330
17.6 Factors influencing antioxidant content	296	20.5 Antioxidant properties	332
17.7 Other aspects	297	20.6 Factors influencing antioxidants content	333
17.8 Concluding remarks and future trends	298	20.7 Concluding remarks and future trends	334
Acknowledgment	298	References	334
References	298		
Further reading	300		
<b>21. Potato</b>	<b>339</b>		
SHUBHAM SHARMA, AMIT K. JAISWAL AND SWARNA JAISWAL			
21.1 Introduction	339		
21.2 History	340		
21.3 Nutrient content of potatoes	340		
21.4 Antinutrient content of potatoes	342		
21.5 Health benefits of potato	343		
21.6 Factors affecting nutritional composition	345		
21.7 Effect of processing method on potato	346		
Conclusion	346		
References	346		

## Part 5

### Roots and Tubers

---

## Section II

### Fruits

#### Part 6

##### Citrus Fruits

<p><b>22. Orange</b> <span style="float: right;">353</span>            ESMA TÜTEM, KEVSER SÖZGEN BAŞKAN, ŞEYDA KARAMAN ERSOY AND REŞAT APAK</p> <p>22.1 Orange <span style="float: right;">353</span>            22.2 Health benefits <span style="float: right;">354</span>            22.3 Nutritional composition <span style="float: right;">355</span>            22.4 Antioxidant phytochemicals <span style="float: right;">358</span>            22.5 Antioxidant properties <span style="float: right;">369</span>            22.6 Factors influencing antioxidants content <span style="float: right;">371</span>            22.7 Concluding remarks and future trends <span style="float: right;">373</span>            References <span style="float: right;">373</span></p> <p><b>23. Lemon</b> <span style="float: right;">377</span>            ALEXANDRA MARA GOULART NUNES MAMEDE, CAROLINE CORRÊA DE SOUZA COELHO, OTNIEL FREITAS-SILVA, HENRIQUETA TALITA GUIMARÃES BARBOZA AND ANTONIO GOMES SOARES</p> <p>23.1 Background <span style="float: right;">377</span>            23.2 Composition of nutrients and nonnutrients <span style="float: right;">377</span>            23.3 Health benefits <span style="float: right;">381</span>            23.4 Antioxidant phytochemicals and their properties <span style="float: right;">384</span>            23.5 Factors influencing antioxidant content <span style="float: right;">387</span>            23.6 Other aspects <span style="float: right;">388</span>            23.7 Concluding remarks and future trends <span style="float: right;">389</span>            Acknowledgment <span style="float: right;">390</span>            References <span style="float: right;">390</span></p> <p><b>24. Grapefruit</b> <span style="float: right;">393</span>            KOTAMBALLI N. CHIDAMBARA MURTHY, ALICE HEPSIBA, G.K. JAYAPRAKASHA AND BHIMANAGOUDA S. PATIL</p> <p>24.1 Minor citrus fruits <span style="float: right;">393</span>            24.2 Health benefits of <i>Citrus</i> fruits and grapefruit <span style="float: right;">394</span>            24.3 Evidence of the biological activities of citrus fruits and their constituents <span style="float: right;">395</span>            24.4 Nutritional and antinutritional composition of citrus/grapefruit <span style="float: right;">397</span>            Conclusion <span style="float: right;">400</span>            Acknowledgement <span style="float: right;">401</span>            References <span style="float: right;">401</span></p>	<p><b>25.2 Nutritional composition</b> <span style="float: right;">407</span>  <b>25.3 Impact of storage and processing effect</b> <span style="float: right;">414</span>  <b>25.4 In vivo metabolism after consumption of main blackberry compounds</b> <span style="float: right;">414</span>  <b>25.5 Review of reported biological activities of blackberries</b> <span style="float: right;">416</span>  <b>25.6 Concluding remarks and future trends</b> <span style="float: right;">420</span>            References <span style="float: right;">420</span></p> <p><b>26. Strawberries</b> <span style="float: right;">423</span>            CHUNYANG LI, HAN WU, KABO MASISI, LOVEMORE N. MALUNGA AND YUWEI SONG</p> <p>26.1 Background <span style="float: right;">423</span>            26.2 Health benefits <span style="float: right;">424</span>            26.3 Nutritional composition <span style="float: right;">424</span>            26.4 Antioxidant phytochemicals <span style="float: right;">426</span>            26.5 Antioxidant properties <span style="float: right;">430</span>            26.6 Factors influencing antioxidants content <span style="float: right;">431</span>            26.7 Other aspects <span style="float: right;">432</span>            26.8 Concluding remarks and future trends <span style="float: right;">433</span>            References <span style="float: right;">433</span>            Further reading <span style="float: right;">435</span></p> <p><b>27. Lingonberries</b> <span style="float: right;">437</span>            KELLY A. ROSS, YAW SIEW AND SAMIR C. DEBNATH</p> <p>27.1 Background <span style="float: right;">437</span>            27.2 Lingonberry production information <span style="float: right;">437</span>            27.3 Nutritional composition and bioactive compounds <span style="float: right;">441</span>            27.4 Health benefits associated with consumption of lingonberries <span style="float: right;">451</span>            27.5 Concluding remarks and future trends <span style="float: right;">452</span>            References <span style="float: right;">453</span></p> <p><b>28. Himalayan bayberries</b> <span style="float: right;">457</span>            INDRA D. BHATT, SANDEEP RAWAT AND RANBEER S. RAWAL</p> <p>28.1 Background <span style="float: right;">457</span>            28.2 Plant morphology <span style="float: right;">457</span>            28.3 Medicinal properties and other uses <span style="float: right;">458</span>            28.4 Nutritional composition <span style="float: right;">459</span>            28.5 Chemical composition <span style="float: right;">459</span>            28.6 Pharmacological and biological properties <span style="float: right;">461</span>            28.7 Potential of fruits <span style="float: right;">462</span>            28.8 Research gap and future prospective <span style="float: right;">462</span>            Conclusion <span style="float: right;">464</span>            References <span style="float: right;">464</span>            Further reading <span style="float: right;">465</span></p> <p><b>29. Blueberries</b> <span style="float: right;">467</span>            ALI RASHIDINEJAD</p> <p>29.1 Background <span style="float: right;">467</span>            29.2 Blueberry classification (origin and growing regions) <span style="float: right;">467</span>            29.3 Chemical composition of blueberry and relation with the structure of the fruit <span style="float: right;">468</span></p>
---	--

---

### Part 7

### Berries

<p><b>25. Blackberries</b> <span style="float: right;">407</span>            FABRICE VAILLANT</p> <p>25.1 Wild and cultivated varieties of blackberries <span style="float: right;">407</span></p>	
--	--

29.4 Bioactive compounds in blueberries and their antioxidant activity	472	33.5 Biological activity evidence based on fruit and its components study	541
29.5 Health benefits of blueberry fruit	476	33.6 In vitro and in vivo models-based evidence	542
29.6 Concluding remarks and future trends	480	33.7 Biological activity of major phytochemicals	543
References	480	Summary	544
		Acknowledgment	544
		References	544
<b>30. Indian gooseberry</b>	<b>483</b>		
KRISHNAPURA SRINIVASAN			
30.1 Introduction	483	<b>Part 9</b>	
30.2 Nutritional profile	484	<b>Other Fruits</b>	
30.3 Traditional medicinal uses in India and China	485		
30.4 Culinary and other uses	485	34. Pomegranate	549
30.5 Health effects of Indian gooseberries	485	SIBEL UZUNER	
Conclusion	492	34.1 Background	549
References	493	34.2 Nutritional and antinutritional compositions	550
		34.3 Antioxidant phytochemicals	552
		34.4 Antioxidative properties of pomegranate fruit parts and by-products	554
		34.5 Health benefits	554
		34.6 Factors influencing antioxidants content	556
		34.7 Bioavailability of the pomegranate phytochemicals	558
		34.8 Concluding remarks and future trends	558
		References	559
<b>Part 8</b>			
<b>Melons</b>			
<b>31. Papaya</b>	<b>499</b>	<b>35. Kiwifruit</b>	<b>565</b>
MARIBEL OVANDO-MARTÍNEZ AND GUSTAVO A. GONZÁLEZ-AGUILAR		SÉRGIO PÉREZ-BURILÓ, SILVIA PASTORIZA AND JOSÉ A. RUFÍAN-HENARES	
31.1 Introduction	499	35.1 Background and geographical context	565
31.2 Description and uses of papaya	499	35.2 Kiwifruit production	565
31.3 Bioactive compounds in papaya	504	35.3 Composition and nutritional value	567
31.4 Antioxidant properties	507	35.4 Functional properties of kiwifruit	573
31.5 Factors influencing antioxidant properties: genotype, environmental, agronomic conditions	508	35.5 Antioxidant capacity of kiwifruit	576
31.6 Importance of bioactive compounds in human health	509	35.6 Conclusions	578
31.7 Can papaya be considered a functional food?	509	References	579
31.8 Concluding remarks and future trends	510		
Acknowledgment	510	<b>36. Passion fruit</b>	<b>581</b>
References	510	MANUEL VIUDA-MARTOS, JOSÉ ANGEL PÉREZ-ALVAREZ AND JUANA FERNÁNDEZ-LÓPEZ	
<b>32. Watermelon</b>	<b>515</b>	36.1 Background	581
CHAFAIK HDIDER, IMEN TLILI AND RIADH ILAHY		36.2 Nutritional composition	581
32.1 Background	515	36.3 Antioxidant phytochemicals	582
32.2 Nutritional and antinutritional composition	516	36.4 Antioxidant properties	588
32.3 Antioxidant phytochemicals	518	36.5 Health benefits	589
32.4 Antioxidant properties of watermelon	521	36.6 Concluding remarks	592
32.5 Factors influencing antioxidants content	522	References	592
32.6 Watermelon by-products	526		
32.7 Health benefits	527		
32.8 Concluding remarks and future trends	528		
Acknowledgment	529		
References	529		
<b>33. Muskmelon</b>	<b>533</b>	<b>37. Apples: an apple a day, still keeping the doctor away?</b>	<b>595</b>
SHIVAPRIYA MANCHALI AND KOTAMBALLI N. CHIDAMBARA MURTHY		TORSTEN BOHN AND JAOUAD BOUAYED	
33.1 History and origin of melons	533	37.1 Background	595
33.2 Nutrition in muskmelon	534	37.2 Overview on nutritional and nonnutritional composition	595
33.3 Nutritional, health-promoting, and antinutritional composition	534	37.3 Health benefits	598
33.4 Health-promoting compounds	538		

37.4 Biocative phytochemicals—in vitro and cellular trials	601	41.8 Conclusion and future trends	678
37.5 Factors influencing bioactive content	605	References	679
37.6 Bioavailability of apple bioactive constituents	607		
37.7 Concluding remarks and future trends	609		
Acknowledgments	609	<b>42. Date palm</b>	681
References	609	CHIRAZ BEN SASSI, WAFA TALBI, TESNIME GHAZOUANI, SANA BEN AMARA AND SAMI FATTOUCH	
<b>38. Apricot</b>	613		
WANPENG XI AND YUN LEI		42.1 Background	681
38.1 Background	613	42.2 Nutritional value and biochemical composition	682
38.2 Health benefits	613	42.3 Health benefits	686
38.3 Nutritional and antinutritional composition	616	42.4 Antioxidant phytochemicals in date fruits	687
38.4 Antioxidant phytochemicals	620	42.5 Antioxidant properties (of fresh produce)	689
38.5 Antioxidant properties (of fresh produce)	622	42.6 Potential industrial applications and patented processes	689
38.6 Factors influencing antioxidants content	622	42.7 Concluding remarks and future trends	691
38.7 Concluding remarks and future trends	627	References	691
Acknowledgment	627		
References	627	<b>43. Grapes</b>	695
<b>39. Quinces</b>	631	RANJANA DAS AND CHIRANJIB BHATTACHARJEE	
FRANCISCA HERNÁNDEZ-GARCÍA AND ÁNGEL A. CARBONELL-BARRACHINA		43.1 Background	695
39.1 Introduction	631	43.2 General health benefits of grapes	696
39.2 Nutritional composition	632	43.3 Nutritional and antinutritional composition of grapes	698
39.3 Bioactive compounds	632	43.4 Antioxidant phytochemicals in different grape varieties	700
39.4 Sugars and organic acids composition	638	43.5 Antioxidant properties of grapes and application	701
39.5 Volatile compounds	638	43.6 Factors Influencing the antioxidant content in grape	702
39.6 Therapeutic properties	639	43.7 Other aspects	704
39.7 Processed products	640	43.8 Concluding remarks and future prospect	705
39.8 Other aspects	641	References	706
39.9 Conclusion and prospects	641		
References	641	<b>44. Prickly pear</b>	709
<b>40. Olive</b>	645	TÂNIA GONÇALVES ALBUQUERQUE, PAULA PEREIRA, MAFALDA ALEXANDRA SILVA, FILIPA VICENTE, RENATA RAMALHO AND HELENA S. COSTA	
MICHELE BALZANO, DEBORAH PACETTI, MONICA ROSA LOIZZO, ROSA TUNDIS, TIZIANA FALCO, MARIAROSARIA LEPORINI, PAOLO LUCCI, ANCUTA NARTEA, EDOARDO BARTOLUCCI AND NATALE G. FREGA		44.1 Background	709
40.1 Cultivation and production of olive fruit ( <i>Olea europaea</i> L.)	645	44.2 Nutritional composition	710
40.2 Bioactive compounds in olive pulp, peel, and stone	646	44.3 Bioactive compounds	715
40.3 Biological activities of the main olive triterpenoids acids	658	44.4 Functional properties of prickly pear components	720
40.4 Biological activities of oleuropein and its metabolites	662	44.5 The protective effect of prickly pear in human health	723
40.5 Conclusion and prospects	664	44.6 Concluding remarks	724
References	664	Acknowledgments	725
		References	725
<b>41. Pears</b>	671	<b>45. Persimmon</b>	729
TESNIME GHAZOUANI, WAFA TALBI, CHIRAZ BEN SASSI AND SAMÍ FATTOUCH		SÉRGIO PÉREZ-BURILÓ, SILVIA PASTORIZA AND JOSÉ A. RUFÍÁN-HENARES	
41.1 Background	671	45.1 Background and geographical context	729
41.2 Nutritional values	672	45.2 Persimmon production	729
41.3 Health benefits	674	45.3 Composition and nutritional value	730
41.4 Antioxidant phytochemicals in pears	675	45.4 Functional properties	733
41.5 Antioxidant properties (of fresh produce)	676	45.5 Antioxidant capacity and phytochemicals	735
41.6 Other aspects	677	45.6 Concluding remarks	741
41.7 Potential industrial applications and patented processes	678	References	742
		<b>Index</b>	745