

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/272675772>

# THERAPEUTIC ANTIOXIDANT ACTIVITY OF MONASCUS-FERMENTED DURIAN SEED: A POTENTIAL FUNCTIONAL FOOD INGREDIENT Sundus Tewfik

Article · January 2014

CITATIONS

0

READS

156

6 authors, including:



**Ignatius Srianta**

Widya Mandala Surabaya Catholic University

29 PUBLICATIONS 111 CITATIONS

[SEE PROFILE](#)



**Netty Kusumawati**

Widya Mandala Surabaya Catholic University

12 PUBLICATIONS 36 CITATIONS

[SEE PROFILE](#)



# THERAPEUTIC ANTIOXIDANT ACTIVITY OF *MONASCUS*-FERMENTED DURIAN SEED: A POTENTIAL FUNCTIONAL FOOD INGREDIENT

**Ignatius Sriantha\*, Ira Nugerahani, Netty Kusumawati,  
Elisabet Suryatanijaya and Christine Subianto**  
Widya Mandala Catholic University Surabaya, Indonesia

Department of Food Technology, Widya Mandala Catholic University Surabaya,  
Jalan Dinoyo 42-44, Surabaya 60625, Indonesia  
E-mail: sriantha\_wm@yahoo.com

**Sundus Tewfik**  
London Metropolitan University, UK

Faculty of Life Sciences, School of Human Sciences, London Metropolitan University,  
166-220 Holloway Road, London N7 8DB, UK

**Ihab Tewfik**  
University of Westminster, UK

Department of Human and Health Sciences, University of Westminster,  
115 New Cavendish Street, London W1W 6UW, UK

## ABSTRACT

**Background:** the phytochemical characteristic of *Monascus*-Fermented Products (MFPs) is well documented. During fermentation, *Monascus* produce various bioactivities metabolites that have an antioxidant, anti-hypertension, anti-cholesterol, anti-cancer, anti-inflammatory and anti-diabetics effects.

**Purpose:** to evaluate the antioxidant activity of *Monascus*-fermented durian seed extracts.

**Methods:** 50 gm of small cut durian seed was inoculated with *Monascus* sp. KJR2, which was employed as starter culture, to produce the MFPs. Dried MFDS was extracted at serial ethanol concentrations (0, 20, 40, 60, 70 and 80%) and tested against DPPH radical scavenging activity, phosphomolybdenum reduction and Ferric Reduction Activity Power (FRAP). Additionally, total phenolic and pigments contents were determined.

**Results:** the MFDS possesses antioxidant activity through DPPH radical scavenging, phosphomolybdenum reduction and FRAP. The highest DPPH radical scavenging of the MFDS extract is at ethanol concentration of 40%, FRAP at 60%, whereas the water extract possesses the highest reducing power of phosphomolybdenum assay. Total phenol and *Monascus* pigments contribute to the phosphomolybdenum reduction, but not to DPPH radical scavenging and FRAP.

\*Corresponding author

**Conclusion:** the phytochemical benefit of fermented durian seed extract has been ascertained as potential antioxidant food ingredient and reinstates its promising position in the region as effective indigenous traditional medicine.

**Keywords:** antioxidant activity; *Monascus*; durian seed; total phenolic; pigment.

**Reference** to this paper should be made as follows: Srianta, I., Nugerahani, I., Kusumawati, N., Suryatani, E., Subianto, C., Tewfik, S. and Tewfik, I. (2014) 'Therapeutic Antioxidant Activity of *Monascus*-Fermented Durian Seed: A Potential Functional Food Ingredient', *Int. J. Food, Nutrition and Public Health*, Vol. 7, No. 1, pp.53–59.

## 1. INTRODUCTION

For hundreds of years, *Monascus*-Fermented Products (MFPs) have been consumed traditionally in Asian countries, as food ingredients and traditional medicine. During fermentation, *Monascus* produces various metabolites which have biological activities that is, antioxidant, anti-hypertension, anti-cholesterol, anti-cancer, anti-inflammatory and anti-diabetic activities (Higashikawa et al., 2012; Lee et al., 2006; Li et al., 1998; Wei et al., 2003; Yang and Mousa, 2012). Oxidative stress is a main cause of the lack of normal body cell function, related to aging and various degenerative diseases such as atherosclerosis, cancer, diabetes, Alzheimer and Parkinson (Shi et al., 2012).

Studies on antioxidant activities of MFPs initiated by Aniya et al. (1999) through screening of 40 fungi species. They reported that 13 species of *Monascus* showed high DPPH scavenging activity (>40%) with *Monascus anka* had the highest antioxidant activity. Consequently, studies have been carried out on *Monascus* fungi to produce *Monascus*-fermented rice with antioxidant activity (Aniya et al., 2000; Dhale et al., 2007; Lee et al., 2008, 2009; Mohan-Kumari et al., 2011; Taira et al., 2002; Yang et al., 2006).

Some researchers had developed non-rice MFPs with antioxidant activity that is, *Monascus*-fermented adlay, *Monascus*-fermented soybean and *Monascus*-fermented dioscorea (Lee et al., 2008; Li et al., 2013; Shi et al., 2012; Tseng et al., 2006, 2012). Our recent study showed that *Monascus* fungi could grow on durian seed medium and produce various metabolites (Srianta et al., 2012, 2014), however, the evaluation of the antioxidant activity has not been fulfilled to date. Therefore, the specific objective of this study was to study the antioxidant activity of *Monascus*-fermented durian seed extracts.

## 2. MATERIALS AND METHODS

### 2.1 Culture

*Monascus* sp. KJR2 was maintained on Saboraud's Dextrose Agar (SDA) slant, preserved at 4°C and subcultured monthly. Following the growth of *Monascus* sp. KJR2 on SDA slants (at room temperature 30°C) under static conditions for 14 days, 10 mL of sterile distilled water was added and the spores were scraped under aseptic conditions. 0.1 mL of the spore suspension was inoculated into Saboraud's Dextrose Broth (SDB) and then was incubated at room temperature (30°C) for 10 days. It was used as starter culture to produce *Monascus*-fermented durian seed.

### 2.2 Production of MFDS

Durian seeds were obtained from local durian seller. Durian seeds were stored in a freezer (−4°C) until used. Durian seeds were boiled in a CaCO<sub>3</sub> solution of 5% w/v for 10 min. After the seed coat were peeled off, the seeds were cut into small size of 1 cm×1 cm×1 cm. A 50 g of small cut durian seed were transferred into 300 mL flask, mixed thoroughly, autoclaved at 121°C for 15 min, then left to cool to room temperature, inoculated with the spore suspension of *Monascus* sp. KJR2 and incubated at room temperature (30°C) for 14 days in static conditions (with manual shaking daily). *Monascus*-fermented durian seed were dried in an air drying oven at temperatures 45°C for 24 hr.

### 2.3 MFDS extraction

The dried MFDS was extracted at various ethanol concentration that is, 0; 20; 40; 60; 70 and 80%. The angkak powder was mixed with distilled water/ethanol at ratio 1:5, shaken in waterbath at 200 rpm for 1 hr, then centrifuged at 5000 g, 27°C for 30 min. The supernatant was filtered using Whatman no. 1. The filtrate was analysed

for the antioxidant activity through DPPH radical scavenging activity, phosphomolybdenum and Ferric reducing ability power, total phenolic content and pigments content.

## 2.4 DPPH scavenging activity assay

DPPH scavenging activity assay was carried out according to Tseng et al. (2006). A 3.8 mL sample extract was added to 0.2 mL DPPH (50 mg in 100 mL metanol) in a wrapped glass tube. The tube was withstand in a dark room for 30 min. The absorbance was measured at  $\lambda$  517 nm. The percentage (%) inhibition was calculated with the control basis of DPPH solution absorbance value.

## 2.5 Ferric Reduction Activity Power (FRAP) assay

FRAP assay was carried out according to Kraboun et al. (2013). A 3.8 mL of FRAP reagent of mixed solution (Buffer asetat: TPTZ:  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$  = 10:1:1) was transferred to a glass tube, added with 0.2 mL sample extract, then homogenised. The tube was withstand in a dark room for 30 min, then the absorbance was measured at  $\lambda$  593 nm. Gallic acid was used as a standard.

## 2.6 Phosphomolybdenum assay

Phosphomolybdenum assay was carried out according to Chairote et al. (2009). The extracts were mixed with the reagent solution (0.6 M sulfuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate) in a glass tube. The tubes were incubated at 95°C for 90 min. After cooling to room temperature, the absorbance of the solution was measured at 725 nm. The total antioxidant capacity was expressed based on gallic acid equivalents.

## 2.7 Total phenolic content analysis

Total phenolic content of the angkak extract was determined with Folin-Ciocalteu reagent according to the method Lee et al. (2008) with slight modification, using Gallic Acid as a standard. A 0.1 mL of extract was placed into a 10 mL measuring flask and 0.5 mL of Folin-Ciocalteu reagent was added to the extract. The measuring flask was allowed to stand at room temperature for 5 min. Then, 1.5 mL of 20% (w/v)  $\text{Na}_2\text{CO}_3$  was added to the mixture. The mixture was adjusted until the volume

reaches 10 mL with distilled water. After 30 min at room temperature, absorbance was measured at 765 nm versus a blank by using a spectrophotometer (Shimadzu UV 1800, Japan). Total phenol value was expressed as mg Gallic Acid Equivalent/g.

## 2.8 Pigments content analysis

The *Monascus* pigments content was analysed according to Babitha et al. (2006) with slight modification. Absorbance of the angkak extract was measured using spectrophotometer (Shimadzu, UV 1601) at 392 nm, 470 nm and 501 nm for yellow, orange and red pigments, respectively. Pigment content was expressed as Absorbance (nm) at the wavelength per gram of dry substrate (AU/g).

## 2.9 Data analysis

The data were analysed using Analysis of Variance (ANOVA) at  $\alpha = 5\%$ . If the ANOVA test results indicate a significant effect, this was followed by Duncan's Multiple Range Test (DMRT) at  $\alpha = 5\%$  to determine the level of treatment that gives a significant difference.

# 3 RESULTS AND DISCUSSION

## 3.1 Antioxidant activity

Table 1 shows the antioxidant activity of *Monascus*-fermented durian seed extracts at various ethanol concentration (%).

Those extracts have antioxidant activity through DPPH scavenging, phosphomolybdenum reduction and Ferric reduction. There are no trend antioxidant activity through DPPH scavenging and Ferric reduction at increasing ethanol concentration, but phosphomolybdenum reduction activity decrease with increasing ethanol concentration.

MFDS extracts shows DPPH radical scavenging activity. Other studies also reported that *Monascus* fermented rice, soybean and adlay possess DPPH radical scavenging activity (Lee et al., 2008, 2009; Tseng et al., 2006; Yang et al., 2006). The DPPH radical scavenging of MFDS water extract at 0.2 g/mL was 35.26%, whereas MFDS ethanolic extracts at the same concentration was higher in a range of 43.19 and 56.26%. The similar findings also reported for water and ethanolic extracts of *Monascus* fermented soybean. At 5 mg/ml, scavenging abilities of the cold water

**Table 1** Antioxidant activity of *Monascus*-fermented durian seed extracts at various ethanol concentration (%)

Ethanol concentration (%)	DPPH radical scavenging activity (% inhibition)	Phosphomolybdenum (mg GAE/g)	FRAP (mg GAE/g)
0	35.26 <sup>a</sup>	256.99 <sup>e</sup>	65.32 <sup>b</sup>
20	43.19 <sup>b</sup>	239.01 <sup>d</sup>	91.68 <sup>d</sup>
40	56.26 <sup>e</sup>	229.01 <sup>d</sup>	72.98 <sup>c</sup>
60	51.37 <sup>c</sup>	222.99 <sup>c</sup>	93.45 <sup>e</sup>
70	54.03 <sup>d</sup>	204.75 <sup>b</sup>	59.92 <sup>a</sup>
80	49.45 <sup>c</sup>	152.60 <sup>a</sup>	90.29 <sup>d</sup>

Note: The different notation in the same column indicate the significant difference at  $\alpha=5\%$ .

extracts from *Monascus* fermented soybean with two *Monascus* different strains on DPPH radicals were 36.5% and 56.4%, whereas that of the ethanolic extracts were higher of 50.3 and 88.3% (Lee et al., 2008, 2009).

This indicated that DPPH radical scavenger components of MFDS and *Monascus* fermented soybean were more soluble in ethanol than in water. The highest DPPH radical scavenging activity of the MFDS extract is at ethanol concentration of 40%. Whereas, ferric reduction activity of MFDS extract of 0.2 g/mL at various ethanol concentration is in a range of 59.92 and 93.45 mg GAE/g. The highest FRAP is at ethanol concentration of 60%.

The antioxidant capacity of MFDS through phosphomolybdenum reduction assay is in a range of 152.60 and 256.99 mg GAE/g, equivalent to 31.32

and 51.39 mg GAE/mL. Those values are higher than those of *Monascus* fermented rice that in a range of 0.15 and 0.53 mg GAE/mL (Chairote et al., 2009). These results also showed that water extract posses higher activity than those of all ethanolic extracts. It indicated that the components contribute to the activity is that of more soluble in water.

### 3.2 Antioxidant components

Study on the antioxidant components of MFDS, total phenol and pigments contents has been examined. Table 2 shows total phenol and pigments content of MFDS extracts at various ethanol concentrations, whereas Table 3 shows the correlation of those components to the antioxidant

**Table 2** Total phenolic and pigments content of *Monascus*-fermented durian seed extracts at various ethanol concentrations (%)

Ethanol concentration (%)	Total phenolic content (mg GAE/g)	Pigment content (AU/g)		
		Yellow	Orange	Red
0	3.58 <sup>e</sup>	1.121 <sup>d</sup>	0.604 <sup>d</sup>	0.464 <sup>c</sup>
20	3.61 <sup>e</sup>	1.103 <sup>d</sup>	0.601 <sup>d</sup>	0.548 <sup>d</sup>
40	2.90 <sup>d</sup>	1.178 <sup>e</sup>	0.620 <sup>e</sup>	0.608 <sup>e</sup>
60	2.36 <sup>c</sup>	0.815 <sup>c</sup>	0.426 <sup>c</sup>	0.479 <sup>c</sup>
70	1.93 <sup>b</sup>	0.691 <sup>b</sup>	0.380 <sup>b</sup>	0.434 <sup>b</sup>
80	1.15 <sup>a</sup>	0.511 <sup>a</sup>	0.287 <sup>a</sup>	0.346 <sup>a</sup>

Note: The different notation in the same column indicate the significant difference at  $\alpha=5\%$ .

**Table 3 Correlation of antioxidant activity and total phenol or pigments**

	DPPH radical scavenging activity	Phosphomolybdenum assay	FRAP assay
Total phenol	−0.5789	0.9431	−0.1329
Yellow pigment	−0.3413	0.8884	−0.1875
Orange pigment	−0.3787	0.8850	−0.1977
Red pigment	0.1297	0.7034	−0.0507

activity. The results indicated that total phenol and pigments content positively contributes to the phosphomolybdenum reduction. However the total phenol and pigments contents showed negative correlation to the DPPH radical scavenging and FRAP. The negative correlations of *Monascus* fermented waxy corn pigment intensity to DPPH radical scavenging and FRAP were also reported by Kraboun et al. (2013), but the values are higher than of this study. This can be explained on the basis that other metabolites such as monacolin K, GABA, and or dihydromonacolin MV contributes to the DPPH radical scavenging and FRAP.

#### 4 CONCLUSIONS

The MFDS possessed antioxidant activity through DPPH radical scavenging, phosphomolybdenum reduction and FRAP. The highest DPPH radical scavenging of the MFDS extract is at ethanol concentration of 40%, FRAP at 60%, whereas the water extract possesses the highest reducing power of phosphomolybdenum assay. Total phenol and *Monascus* pigments contribute to the phosphomolybdenum reduction, but not to DPPH radical scavenging and FRAP. The phytochemical benefit of fermented durian seed extract has been ascertained as potential antioxidant food ingredient and restores its promising position in the indigenous traditional medicine in the region.

#### ACKNOWLEDGEMENT

Thanks to Directorate General of Higher Education, Ministry of National Education, Republic of Indonesia for the financial support

through competitive research Penelitian Hibah Bersaing with contract number 0006/SP2H/PP/K7/KL/II/2012.

#### REFERENCES

- Aniya, Y., Yokomakura, T., Yonamine, M., Shimada, K., Nagamine, T., Shimabukuro, M., and Gibo, H. (1999) 'Screening of antioxidant action of various molds and protection of *Monascus anka* against experimentally induced liver injuries of rats', *General Pharmacology*, Vol. 32, pp.225–231.
- Aniya, Y., Ohtani, I.I., Higa, T., Miyagi, C., Gibo, H., Shimabukuro, M., Nakanishi, H. and Taira, J. (2000) 'Dimerumic acid as an antioxidant of the mold', *Monascus anka*, *Free Radical Biology and Medicine*, Vol. 28, No. 6, pp.999–1004.
- Babitha, S., Soccol, C.R. and Pandey, A. (2006) 'Jackfruit seed – a novel substrate for the production of *Monascus* pigments through solid state fermentation', *Food Technology and Biotechnology*, Vol. 44, No. 4, pp.465–471.
- Chairote, E., Chairote, G. and Lumyong, S. (2009) 'Red yeast rice prepared from Thai glutinous rice and the antioxidant activities', *Chiang Mai Journal of Science*, Vol. 36, No. 1, pp.42–49.
- Dhale, M.A., Divakar, S., Kumar, U. and Vijayalakshmi, G. (2007) 'Isolation and characterization of dihydromonacolin-MV from *Monascus purpureus* for antioxidant properties', *Applied Microbiology and Biotechnology*, Vol. 73, pp.1197–1202.
- Higashikawa, F., Noda, M., Awaya, T., Ushijima, M. and Sugiyama, M. (2012) 'Reduction of serum lipids by the intake of the extract of garlic fermented with *Monascus pilosus*: A randomized, double-blind, placebo-controlled clinical trial', *Clinical Nutrition*, Vol. 31, pp.261–266.
- Kraboun, K., Tochampa, W., Chatdamrong, W. and Kongbangkerd, T. (2013) 'Effect of monosodium glutamate and peptone on antioxidant activity of monascus waxy corn', *International Food Research Journal*, Vol. 20, No. 2, pp.623–631.



- Lee, C.L., Wang, J.J., Kuo, S.L. and Pan, T.M. (2006) 'Monascus fermentation on dioscorea for increasing the production of cholesterol-lowering agent-Monacolin K and antiinflammation agent-monascin', *Applied Microbiology and Biotechnology*, Vol. 72, pp.1254–1263.
- Lee, Y.L., Yang, J.H. and Mau, J.L. (2008) 'Antioxidant properties of water extracts from *Monascus* fermented soybeans', *Food Chemistry*, Vol. 106, pp.1128–1137.
- Lee, Y.L., Yang, J.H. and Mau, J.L. (2009) 'Antioxidant properties of ethanolic and methanolic extracts from *Monascus*-fermented soybeans', *Journal of Food Biochemistry*, Vol. 33, pp.707–727.
- Li, P.C., Tsai, W.H. and Chien, C.T. (2013) 'Dietary *Monascus adlay* supplements facilitate suppression of cigarette smoke-induced pulmonary endoplasmic reticulum stress, autophagy, apoptosis and emphysema-related PLGF in the rat', *Food Chemistry*, Vol. 136, No. 2, pp.765–774.
- Li, C., Zhu, Y., Wang, Y., Zhu, J.S., Chang, J. and Kritchevsky, D. (1998) '*Monascus Purpureus*-fermented rice (red yeast rice): a natural food product that lowers blood cholesterol in animal models of hypercholesterolemia', *Nutrition Research*, Vol. 18, No. 1, pp.71–81.
- Mohan-Kumari, H.P., Dhale, M.A. and Vijayalakshmi, G. (2011) 'Antioxidant effect of red mould rice in hypercholesterolemic Wistar male rats', *Cell Biochemistry and Function*, Vol. 29, pp.597–602.
- Shi, Y.C., Yu, C.W., Liao, V.H.C. and Pan, T.M. (2012) '*Monascus*-fermented dioscorea enhances oxidative stress resistance via DAF-16/FOXO', *Caenorhabditis elegans*, *PLoS ONE*, Vol. 7, No. 6, p.e39515.
- Srianta, I., Hendrawan, B., Kusumawati, N. and Blanc, P.J. (2012) 'Study on durian seed as a new substrate for angkak production', *International Food Research Journal*, Vol. 19, No. 3, pp.941–945.
- Srianta, I., Ristiarini, S., Nugerahani, I., Sen, S.K., Zhang, B.B. and Blanc, P.J. (2014). Recent research and development of *Monascus* fermentation products', *International Food Research Journal*, Vol. 21, No. 1, pp.1–12.
- Taira, J., Miyagi, C. and Aniya, Y. (2002) 'Dimerumic acid as an antioxidant from mold, *Monascus anka*: the inhibition mechanisms against lipid peroxidation and heme-protein-mediated oxidation', *Biochemical Pharmacology*, Vol. 63, pp.1019–1026.
- Tseng, K.C., Fang, T.J., Chiang, S.S., Liu, C.F. Wuc, C.L. and Pan, T.M. (2012) 'Immunomodulatory activities and antioxidant properties of polysaccharides from *Monascus*-fermented products in vitro', *Journal of the Science of Food and Agriculture*, Vol. 92, pp.1483–1489.
- Tseng, Y.H., Yang, J.H., Chang, H.L., Lee, Y.L. and Mau, J.L. (2006) 'Antioxidant properties of methanolic extracts from monascadlay', *Food Chemistry*, Vol. 97, pp.375–381.
- Wei, W., Li, C., Wang, Y., Su, H., Zhu, J. and Kritchevsky, D. (2003) 'Hypolipidemic and anti-atherogenic effects of long-term Cholestin (*Monascus purpureus*-fermented rice, red yeast rice) in cholesterol-fed rabbits', *Journal of Nutritional Biochemistry*, Vol. 14, pp.314–318.
- Yang, C.W. and Mousa, S.A. (2012) 'The effect of red yeast rice (*Monascus purpureus*) in dyslipidemia and other disorders', *Complementary Therapies in Medicine*, Vol. 20, No. 6, pp.466–474.
- Yang, J.H., Tseng, Y.H., Lee, Y.L. and Mau, J.L. (2006) 'Antioxidant properties of methanolic extracts from monascadlay', *LWT-Food Science and Technology*, Vol. 39, pp.740–747.

## BIOGRAPHICAL NOTES

**Ignatius Srianta** is Lecturer in Department of Food Technology, Widya Mandala Surabaya Catholic University. He focuses on food safety and bioprocess researches. He published/presented his research papers in national journals/seminars and international seminars. Survey, consulting and training on food safety for school stakeholders, food industry practicists and society are his activities. He coordinated the food safety program for elementary school in Surabaya, Indonesia as part of a joint program between Widya Mandala Surabaya Catholic University and Health Agency of Surabaya City Governance in 2007. He already done research in Food Protein Research Center, Texas A&M University, College Station, Texas, USA as part of the Education for Community of Food Enterprises Development (ECFED) Program, joint program between Widya Mandala Surabaya Catholic University and Texas A&M University. He participated in

a short course on soybean oil extraction and processing, conducted by Food Protein Research Center, Texas A&M University, College Station, Texas, USA. He was also a Researcher at the Technical Development Center of PT Ajinomoto Indonesia in 1999–2000.

**Ira Nugerahani** is a Senior Lecturer in the Department of Food Technology, Widya Mandala Surabaya Catholic University. She is the Head of Food Microbiology Laboratory. She is a Member of Indonesian Association of Food Technologists. She has teaching experiences in food microbiology and traditional fermented food as well on research, training and publication in the area of food technology.

**Netty Kusumawati** is a Lecturer in Department of Food Technology, Widya Mandala Surabaya Catholic

University. She is the Head of Chemistry Laboratory. She is a Member of Indonesian Association of Food Technologists. She has teaching experiences in food microbiology and food hygiene and sanitation as well on research, training and publication in the area of food technology.

**Elisabet Suryatanijaya** is an Alumnus of Food Technology Department, Faculty of Agricultural Technology, Widya Mandala Surabaya Catholic University. She was an Assistant Lecturer in Several Laboratory Works.

**Christine Subianto** is an Alumnus of Food Technology Department, Faculty of Agricultural Technology, Widya Mandala Surabaya Catholic University. She was an Assistant Lecturer in several Laboratory Works.

**Dr. Sundus Tewfik** is the Course Leader for Herbal Medicinal Sciences at the Faculty of Life Sciences, School of Human Sciences, London Metropolitan University. As a Pharmaceutical scientist she Lectures in Conventional and Herbal Pharmacology. She is a qualified Biologist. She holds a Masters in Applied Microbiology and PhD in Pharmacognosy from University of Westminster. She is registered as 'Biomedical Scientist' at the Health Professional Council (HPC) – UK as well as fellow of the Institute of Biomedical Science. Additionally, she 'Chartered Scientist' at the Science Council, UK. She

has carried out numerous research projects on various aspects of herbal medicine; biochemical analyses, anti-microbial testing, isolation/identification of 'biologically active' components and quality control of herbal products and botanical supplements. She current research interests include the use of phytochemicals in human nutrition domain, focusing on how functional foods and nutraceuticals influence health outcomes and health risks to individuals and communities.

**Dr. Ihab Tewfik** is the Course Leader for BSc. (Hons.) of Human Nutrition, Department of Human and Health Sciences, University of Westminster. Besides his biochemistry background, he holds Master and Doctorate in Public Health, Nutrition Department, University of Alexandria in addition to PhD from London South Bank University. He is a Registered Practitioner in Higher Education – UK, as well as Fellow of the Royal Society of Public Health (FRSPH). He has carried out 11 research projects for UNICEF-UN in aspects of public health nutrition and food safety and has published a number of publications in refereed journals and international conferences. As a Registered Public Health Nutritionist at the Nutrition Society, he has organised several international conferences, workshops, CPD and short training courses on Nutrition related diseases and Public Health. He is Member of the Editorial Advisory Board of various international scientific journals.