

Culinary Herbs and Spices: The Challenge of Determining their Significance in the Maintenance of Health

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Knowledge of the bioactive properties of a food's constituents can be used to provide indications that the whole food confers benefit in the context of maintaining health by protecting against disease development. However, there are examples of studies in which the protective properties of bioactive constituents do not appear to manifest when the whole food is given/consumed as part of an intervention [1,2]. Some may thus ask, what is the use of research on bioactive food constituents? However, a far more pertinent question is, how can such research be developed so as to provide further insights into the true benefit of the whole food?

Such a question is being asked of culinary herbs and spices, which are foods that are a rich source of bioactive compounds, especially polyphenols [3,4]. These foods have been in use for centuries both for culinary and medicinal purposes, and research over the past decade has reported on the diverse range of properties that they possess via their bioactive constituents [5,6]. There is now ample evidence that culinary herbs and spices are sources of constituents that possess antioxidant, anti-inflammatory, anti-tumourigenic, anti-carcinogenic, and glucose and cholesterol lowering activities as well as properties that affect cognition and mood [6-20]. However, the actual role of these foods in the maintenance of health, specifically with regards to protecting against the development of chronic non-communicable diseases, is as yet unclear.

Some progress is being made to address this lack of clarity as a result of asking questions that concern how culinary herbs and spices are consumed. More information is now available concerning habitual intake levels, which are predictably much lower than for other plant derived foods known for their protective properties, and which vary considerably due to factors that include under-reporting and recipe variety for a given dish [4,21,22]. There is now also literature on the impact of cooking, and digestion *in vitro*, on the antioxidant capacity and anti-inflammatory activity of culinary herbs and spices [12-14]. Studies show that although changes to these activities occur as a result of these processes, the nature of the changes is dependent on the cooking method and it may also be influenced by the type of model used to simulate digestion [23].

Studies are also beginning to address questions concerning the impact of combining culinary herbs and spices with each other as well as with other foods. For example, Li et al. [24] reported that a marker for oxidative stress, urinary malondialdehyde, was decreased in subjects who consumed spiced hamburger meat when compared to subjects who consumed the non-spiced counterpart. They also reported a 'trend to decrease' plasma malondialdehyde in those that consumed spiced hamburger meat. However, other studies show that combining culinary herbs and spices, or combining them with other foods does not always result in an increase in the activity measured. These studies indicate that a number of factors influence the impact of such combinations and include: the complexities of the matrices that result from these combinations; the number and amount/concentration of the individual constituents; the number of foods that make up the combinations; any processing the food combinations have undergone; and the type of methods used to measure the activity of interest [4,25-28].

When considering the true benefit of a food, the issue of bioavailability also needs to be addressed and as yet there is a paucity of data concerning the bioavailability of bioactive compounds in culinary herbs and spices. Preliminary *in vitro* studies on culinary herbs indicate that for starting amounts that are typical of those used in food preparation, only small percentages of their (the herbs') total phenolic content and antioxidant capacity are made available [4]. Such findings suggest that any beneficial effect of these foods may, at best, be localised in the gut. The findings of Percival et al. [29] appear to support this suggestion based on antioxidant activity. They found that following the consumption of individual herbs and spices at amounts based on levels usually consumed in food, there was no increase in serum antioxidant activity. However, when bioavailability was measured based on protection against oxidative damage, and the expression of pro-inflammatory cytokines, *ex vivo*, some of the herbs and spices conferred protection. Two important observations that the authors of this study make are that: 1) The considerable inter- and intra-variability of subject serum antioxidant activity prevented statistical significance being achieved, suggesting that serum antioxidant activity is of very limited use when it comes to assessing the bioavailability of the herbs and spices

investigated; and 2) The appropriateness of the biomarker could be linked to the constituents, within the herbs and spices, that are bioavailable.

In conclusion, research done to date suggests that culinary herbs and spices have a significant role to play in the maintenance of health however it also highlights that a multifaceted approach is needed to elucidate their importance. The design of future studies will need to address the issues raised by this research to take us closer to understanding the true benefit of these foods.

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4. Opara EI, Chohan M (2014) Culinary herbs and spices: their bioactive properties, the contribution of polyphenols and the challenges in deducing their true health benefits. *Int J Mol Sci*.
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Curriculum Vitae

Name: Dr Elizabeth Opara

Qualifications

Date Obtained	Qualifications
June 1989	BSc (Hons) First Class, Medical Biochemistry, University of London
May 1993	D.Phil Biochemistry, Oxford University (Merton College)
June 2000	Postgraduate Certificate in Teaching and Learning in Higher Education, Kingston University

Career Positions Held to Date

Dates	Posts
August 1993 – December 1994	Post Doctoral Research Fellow, Surgical Nutrition and Metabolism Laboratory, Dept of Surgery, State University of New York, Health Science Center, Syracuse, NY, USA
July 1995 – June 1998	Higher Scientific Officer, Food Science Laboratory, Norwich, UK
July 1998 – September 2000	Lecturer in Human and Clinical Nutrition, Kingston University
September 2000 – December 2004	Senior Lecturer in Human and Clinical Nutrition; Course Director for Nutrition BSc (Hons), Kingston University
January 2005 – December 2013	Principal Lecturer in Human and Clinical Nutrition, Field Leader for Nutrition
January 2014 -	Associate Professor, Field Leader for Nutrition

Membership of Professional Bodies/Professional Practice

Date	Details
1991 –	Nutrition Society: Member since 1991
2004 -	Registered Nutritionist since 2004 (register managed by Association for Nutrition – AfN - since March 2010)
2008 -	Assessor for the UK Voluntary Register for Nutritionists (UKVRN)
2011-	Member of AfN Continuing Professional Development (CPD) Working Group and CPD assessor
2011-	Member of AfN Nutrition Science Working Group

Current Teaching and Administrative/Management Responsibilities

Undergraduate Teaching Responsibilities

Human Nutrition, Clinical Nutrition, Food Toxicology, Food Safety, Food Biotechnology, Research Methods and Skills.

Postgraduate Teaching Responsibilities

Research Methods and Skills

Course Administration/Management Responsibilities

Nutrition Field and Team Leader, Course Director for Nutrition BSc (Hons) Full Field and Joint Honours, Personal Tutor and Module Leader

External Examiner Responsibilities:

St Mary's University College (2009 - 2013): BSc/BA (Hons) Nutrition

University of Worcester (2010 - 2014): BSc (Hons) Nutrition

Research

Research Expertise

Bioactive compounds in culinary and medicinal plants

Research Group Membership

Theme leader for the Sport, Exercise, Nutrition and Public Health Research Group: <http://sec.kingston.ac.uk/research/research-groups/senphrg/>

Core member of the Cancer Research Group: <http://sec.kingston.ac.uk/research/research-groups/crg/>

Journal Reviewer

Reviewed papers for:

International Journal of Molecular Science

Journal of Agricultural and Food Chemistry

Journal of Food Biochemistry

Journal of Medicinal Plant Research

Journal of the Science of Food and Agriculture

Natural Product Research

Nutrition

Plant Foods for Human Nutrition

The British Journal of Nutrition

Member of the Editorial Advisory Board for Nutrition (The International Journal for Applied and Basic Nutritional Sciences): <http://www.journals.elsevier.com/nutrition/editorial-board/>

Member of the editorial board for Journal of Dietetics Research and Nutrition <http://www.enlivenarchive.org/dietetics-research-nutrition.php>

Completed Projects: PhD / MSc by Research Degrees

MSc by Research: Immunology of Human Breast Milk **Kom Paramasivam (2006)**

Ph.D. Impact of Chinese Herbal Remedies on Tumour Biology **Shaun Willimot (2007)**

MSc by Research: Bioavailability of Chinese Herbal Remedies **Elena Panagiotou (2007)**

Ph.D. The impact of digestion and gut bioavailability, *in vitro*, on the polyphenolic associated activity of cooked culinary herbs **Magali Chohan (2011)**

MSc by Research: Inhibition of cyclo-oxygenase -2 expression and β -catenin activation in colorectal cancer cells *in vitro*: an investigation of the chemopreventive action of common culinary spices **Iona Baker (2013)**

MSc by Research: Inhibition of cyclo-oxygenase -2 expression and β -catenin activation in colorectal cancer cells *in vitro*: an investigation of the chemopreventive action of common culinary herbs **Andrius Jaksevicius (2013)**

Current Projects: PhD

Elucidation of mechanisms by which culinary herbs and spices exert the inhibitory action of the growth of colorectal cancer cells *in vitro* **Andrius Jaksevicius** (commenced Nov 2013)

Research Student Examining

A Holloway PhD Kingston University: Antimicrobial effects of white tea extracts in combination with putative adjuncts against *Staphylococcus aureus* and other microbes of importance (November 2013)

Tamsyn Thring PhD Kingston University: Method development and application for the assessment of the anti-ageing and antioxidant properties of herbal remedies (December 2011)

Consultancy

Sport, Nutrition and Exercise Consultancy: <http://sec.kingston.ac.uk/services-for-business/research-and-consultancy/sport-and-exercise-consultancy/>

Output (Papers and Presentations – from 2004)

Chohan, Magali, Naughton, Declan P. and **Opara, Elizabeth I.** (2014) Determination of superoxide dismutase mimetic activity in common culinary herbs. SpringerPlus, 3(578), ISSN (print) 2193-1801

Opara, Elizabeth I. and Chohan, Magali (2014) Culinary herbs and spices: their bioactive properties, the contribution of polyphenols and the challenges in deducing their true health benefits. International Journal of Molecular Sciences, 15(10), pp. 19183-19202. ISSN (print) 1422-0067

Baker, I., Chohan, M. and **Opara E.I.** Impact of cooking and digestion, *in vitro*, on the antioxidant capacity and anti-inflammatory activity of cinnamon, clove and nutmeg. Plant Foods for Human Nutrition 2013 (DOI) 10.1007/s11130-013-0379-4 in the following form:

Jaksevicus, A, Baker, I, Mistry, C, Modjtahedi, H, and **Opara, E.I.** An investigation of the effect of culinary herbs and spices on the growth of colorectal cancer cells *in vitro*. **Presented at the Nutrition Society Postgraduate Conference, September 10th-11th 2012, Newcastle University.**

Chohan, M, Naughton, D.P, Jones, L and **Opara, E.I.** An investigation of the relationship between the anti-inflammatory activity, polyphenolic content and antioxidant activities of cooked and *in vitro* digested culinary herbs Oxidative Medicine and Cellular Longevity 2012 <http://www.hindawi.com/journals/oximed/2012/627843/>

Baker, I., Chohan, M and **Opara E.I.** The impact of cooking and digestion on the antioxidant capacity and polyphenol content of common culinary herbs. **Presented at the Nutrition Society Summer Meeting, Reading, UK, July 2011 Winner of Best Poster Communication Prize**

Chohan, M, Naughton, D.P, Jones, L and **Opara, E.I.** An investigation of the relationship between the anti-inflammatory properties and the polyphenolic antioxidant activity of culinary herbs. Polyphenols Communications 2010, 2: 361-362. Presented at the 25th International Conference on Polyphenols, Montpellier, France, August 2010

Willimot S., Barker J., Jones L. and **Opara E.I.** An *in vitro* based investigation of the cytotoxic effect of water extracts of the Chinese herbal remedy LD on cancer cells. Chemistry Central 2009 DOI:10.1186/1752-153X-3-12

Chohan, M, Naughton, D.P, Jones, L and **Opara, E.I.** The impact of digestion and absorption on the antioxidant capacities and polyphenol concentrations of a selection of cooked culinary herbs. Polyphenols Communications 2008, 2: 695-695. **Presented at the 24th International Conference on Polyphenols, Salamanca, Spain, July 2008**

Chohan, M., Forster-Wilkins, G. and **Opara, E.I.** Determination of the antioxidant capacity of culinary herbs subjected to various cooking and storage processes using the ABTS*+ radical cation assay Plant Foods for Human Nutrition 2008, 63(2): 47-52 DOI: 10.1007/s11130-007-0068-2

Willimot S., Barker J., Jones L. and **Opara E.I.** Apoptotic effect of Oldenlandia diffusa on the leukaemic cell line HL60 and human lymphocytes Journal of Ethnopharmacology 2007; 114: 290-299

Paramasivam K., Michie C., **Opara E.**, and Jewel A.P. Human Breast Milk Immunology: A Review. International Journal of Fertility and Women's Medicine 2006; 51(5):208-17.

Panagiotou E, Jones, LA and **Opara E.I.** An assessment of the use of an *in vitro* cell based model of the intestinal tract to investigate the bioavailability of the Chinese Herbal remedy Oldenlandia diffusa Planta Medica, 2006 72: 1052 (P236) **Presented at the GA 54th Annual Congress on Medicinal Plant Research, Helsinki, Finland, August 2006**

Opara E.I. Anticancer activity of Chinese Herbal Remedies. **Presented at the West Focus Meeting on the Modernisation of TCM Brunel University, April 2006**

Willimot S., Barker J., Jones L. and **Opara E.I.** Isolation of Tumour Modulatory Compounds in Chinese Herbal Remedies Through Activity-Guided Fractionation (Poster 073) **Presented at the GA 53rd Annual Conference, Florence, Italy, August 2005**

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Willimot S, **Opara E**, Jones L and Barker J. Apoptotic Induction in Cancer Cell Lines by Traditional Chinese Medicines. **Presented at the Conference on Traditional Chinese Medicines, Jodrell laboratory, Royal Botanic Gardens, Kew, June 11th-12th 2004 and Bioscience 2004, Glasgow, UK, July 2004**

Opara, E.I. The Safety and Efficacy of Traditional Chinese Medicine. British Journal of Nutrition 2004, 91: 171-173 (Editorial)

Google Scholar Publications List:

https://scholar.google.co.uk/citations?sortby=pubdate&hl=en&user=WOR14W4AAAAJ&view_op=list_works&cstart=0&pagesize=20

Other Outputs

Opara E. Food Allergy. In Frontiers in Nutritional Science, No.1: Nutrition and Immune Function, ed P.C. Calder, C.J. Field & H.S. Gill (2002) pp. 321-346. CABI Publishing, UK

Papers/abstracts submitted

Schwikkard Sianne L, James, Emily E, Mulholland, Dulcie A, Knirsh, Walter, Corson, Timothy, Jaksevicius, Andrius, and **Opara, Elizabeth** Novel, Bioactive Homoisoflavonoids from a Madagascan Rhodocodon species (Hyacinthaceae, sensu APG II) **submitted for presentation at GA 2015 BUDAPEST, 63rd International Congress and Annual Meeting of the Society for Medicinal Plant and Natural Product Research, August 2015**

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