



*Joint meeting between the Belgian Nutrition Society, The Nutrition Society and Société Française de Nutrition was held at the Faculté de Médecine Lille on 28–29 May 2013*

## Conference on ‘Sustainable diet and food security’ Symposium 1: Global challenges related to sustainable diet

# Seasonality and dietary requirements: will eating seasonal food contribute to health and environmental sustainability?

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Eating more seasonal food is one proposal for moving towards more sustainable consumption patterns, based on the assumption that it could reduce the environmental impact of the diet. The aim of the present paper is to consider the implications of eating seasonal food on the different elements of sustainability (i.e. health, economics, society), not just the environment. Seasonality can be defined as either globally seasonal (i.e. produced in the natural production season but consumed anywhere in the world) or locally seasonal (i.e. produced in the natural production season and consumed within the same climatic zone). The environmental, health, economic and societal impact varies by the definition used. Global seasonality has the nutritional benefit of providing a more varied and consistent supply of fresh produce year round, but this increases demand for foods that in turn can have a high environmental cost in the country of production (e.g. water stress, land use change with loss of biodiversity). Greenhouse gas emissions of globally seasonal food are not necessarily higher than food produced locally as it depends more on the production system used than transportation. Eating more seasonal food, however, is only one element of a sustainable diet and should not overshadow some of the potentially more difficult dietary behaviours to change that could have greater environmental and health benefits (e.g. reducing overconsumption or meat consumption). For future guidelines for sustainable diets to be realistic they will need to take into account modern lifestyles, cultural and social expectations in the current food environment.

### Seasonality: Health: Environment: Sustainable diet: Food culture

The issue of eating more seasonal food has been stimulated by recent debates about how to shift current dietary intakes towards more sustainable consumption patterns to reduce the high the environmental impact of the diet. Eating more seasonal and local food, particularly fruit and vegetables, is one of the dietary changes proposed to achieve a more sustainable diet<sup>(1,2)</sup>. This has become a popular message being advocated by non-governmental organisations, promoted through media campaigns (e.g. celebrity chefs, food magazines, websites) and is being considered as part of sustainable eating guidelines<sup>(2–4)</sup>. Some believe that the promotion of seasonal food also has an important role in reconnecting

people with the origins of the food they eat and provides a better understanding of natural growing and production seasons of food<sup>(5)</sup>.

A year-round supply of fresh produce has been made possible through the intensification of agriculture, the use of new technologies, extending natural production and growing seasons and increased international trade. The expansion of global food markets has created a food culture with a wide variety of foods in many developed countries, where previously this was not possible. While this has given a more varied diet in many countries, this global demand has come at a high environmental cost with higher energy usage, more land use change

**Abbreviations:** GHGE, greenhouse gas emissions.

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(resulting in loss of environmental biodiversity) and a loss of species and crop diversity due to an increased use of monocultures in agriculture<sup>(6)</sup>. However, to understand the real environmental, health, economic and social benefits of eating seasonal produce, and the limitations, the whole food system needs to be considered. The purpose of the present paper is to explore the environmental and possible health impact of eating seasonal food and how realistic and practical it would be for the population.

### Defining seasonality

As with many other aspects of sustainable diets the definition of seasonality is not as simple as it first appears. The interpretation of seasonal food can vary depending on who is using it and the context in which it is being used. Many consumers for example associate seasonal with locally produced food, but by other definitions local is not a necessary criterion for seasonal food. For many people seasonality is associated with fruit and vegetables but not linked to other crops or animals production. The complexity of what are seasonal foods only emerges when trying to define it. For example, is a food produced in the natural growing season in another country then imported and consumed in the UK seasonal, or is a food that is grown locally in the natural growing season then stored and eaten 6 months later still seasonal?

A recent study commissioned by the Department for environment, food and rural affairs (DEFRA) proposed two definitions of seasonal food, the first based on where the food is produced, and the second on where it is produced and consumed: 1. Produced in season (global seasonality): Food that is outdoor grown or produced during the natural growing/production period for the country or region where it is produced. It need not necessarily be consumed locally to where it is produced. 2. Produced and consumed in season (local seasonality): Food that is produced and consumed in the same climatic zone without high-energy use for climate modification or storage.<sup>(7)</sup> For the production-based definition, sometimes referred to as global seasonality, the food is produced during the natural growing or production season but is not necessarily consumed in the same place that it was grown; apples grown in season naturally outdoors in New Zealand and eaten in Europe in the spring and summer by this definition would be globally seasonal. The production and consumption based definition requires the food to be produced and consumed in the natural growing or production season within the same climatic zone. This is often interpreted as locally seasonal food, which opens another debate about what distance constitutes local<sup>(8)</sup>, but in the present paper it will simply be referred to as local seasonality. The most important aspect of both these definitions is that the food is grown or produced outdoors in their natural season without the use of additional energy, thereby not creating additional greenhouse gas emissions (GHGE).

While these definitions at first appear straightforward they can get tangled up in the details. Sumberg &

Sharpe<sup>(9)</sup> questioned specific aspects of the definitions, particularly relating to being produced 'outdoors' (e.g. do unheated plastic tunnels constitute outdoors or should seedlings started in heated greenhouses then grown outdoors in the natural growing season be excluded?) and the 'natural growing/production season' (e.g. would crops bred to extend the natural growing seasons be included?). In the future, identifying when and where foods are in season is likely to become less clear for many people as the natural growing season of many products will change with predicted climatic changes<sup>(10)</sup>. This highlights some of the complexities that can cloud our understanding of seasonality and how the environmental, health, economic and social consequences could vary with different definitions.

In terms of nutrition and health, local seasonality could have implications for reducing the availability and variety of food throughout the year, especially in countries with limited growing and production seasons. Historically this has been overcome by storing and preserving food but this can require additional energy, whether it is freezing, canning, drying food or storing in modified atmospheres, and therefore may conflict with the DEFRA definition of local seasonality. Not storing food, by which ever means, has implications for not just availability but also increasing food waste. The GHGE associated with producing food then throwing it away uneaten will be higher than the emissions from preserving food. Balancing these types of trade-offs are important for ensuring future food security, minimising the environmental cost and maximising nutritional quality of the diet.

### Perception of seasonal food

The perception, awareness and understanding of seasonal food are important if consumers are to be encouraged to eat more seasonal food. Seasonal food is often associated with locally produced food, better quality food or limited food choice and for some it is food associated with annual cultural events. Food is an emotive issue and local seasonal food for some consumers can have an idealistic and 'romanticised' image but it is not necessarily a more sustainable food system. In many studies it is difficult to disentangle seasonal food from local food and fruit and vegetables are more commonly viewed as seasonal by consumers than other staple foods such as meat, cereals or bread<sup>(11,12)</sup>. Local and seasonal fruit and vegetables are often described as tastier, fresher and better quality than the equivalent imported produce or those produced out of season. However, it is also often viewed as more expensive, less convenient, more time consuming to source and limits the variety of food in the diet, which would inhibit the purchase of only seasonal food; these perceived barriers have been found to be similar across socio-economic groups<sup>(13)</sup>.

The evidence about whether people are more willing to pay more for seasonal food is inconclusive. Some surveys suggest that consumers would pay more<sup>(14,15)</sup>; in other studies people say they would be willing to pay

more for local food but not seasonal food, but this tends to be a more common view held by older and higher income groups<sup>(16)</sup>. Johnston *et al.*<sup>(17)</sup> argue that an interest in eating more local and seasonal food, often viewed as ethical eating, tends to be a more common aspiration within higher socio-economic classes. The idea of consuming more local food, however, is not always seen as beneficial. Hospido<sup>(18)</sup> found that while in principle many people supported local food production, some did not like the visual impact it can have on the landscape (e.g. polytunnels) or the social impact of workers coming into the local community.

Finally, seasonal foods are sometimes associated with food items eaten at specific times of the year linked to cultural events rather than the natural growing or production seasons. Foods such as chocolate eggs at Easter or turkey at Christmas that are abundant in shops only at certain times of the year can give the perception of being seasonal food<sup>(19)</sup>. Given the different interpretations of seasonal food public messages to promote eating more seasonal food will need to be clearly defined.

#### **Implications of seasonality for sustainable consumption patterns and food security**

Given the complexity of sustainable diets a reductionist approach is often taken to the problem, where only one or two elements of sustainability are studied in detail without considering wider implications or potential unintended consequences. Eating seasonal food is being advocated as one element of a sustainable diet, often interpreted as local food, but the true environmental, health, economic and social benefits and limitations need to be compared with providing a year-round supply of fresh produce. A recent review that took a more holistic approach to the question of eating field grown seasonal fruit and vegetables reported that whilst the evidence suggests that it could have a positive impact on environmental sustainability, there may be negative consequences for public health and economics stability but the impact on social inequalities was unclear<sup>(2)</sup>.

#### *Environmental implications*

The environmental impact of the food system is multi-dimensional, with implications for climate change (i.e. GHGE), water use, land use, biodiversity, soil degradation and pollution. There are very few studies that have explored all these issues together in relation to seasonality, most have focused on GHGE in relation to climate change. GHGE are produced throughout the lifecycle of a product from production to processing, distribution, retail, consumption and waste disposal and overall the food system accounts for 20–30% of the total GHGE in the UK<sup>(1)</sup>. One of the benefits of eating seasonal food is that it reduces GHGE because it does not require the high-energy input from artificial heating or lighting needed to produce crops out of the natural growing season. There are many case studies in the literature that show that the total GHGE of some food

produced out of season in the UK in heated glasshouses are higher than the same product grown naturally in season abroad and transported to the UK<sup>(18,20)</sup>. The high-energy use (therefore GHGE) needed for heating and lighting to grow products out of season (e.g. tomatoes) can have higher GHGE than the emissions associated with transportation. Some products grown abroad and transported to the UK can have lower total GHGE than the same food produced in the UK and stored for consumption out of season (e.g. apples from New Zealand<sup>(21)</sup> or raspberries from Spain<sup>(22)</sup>). In other cases where more efficient production methods are used, even when including transportation to the UK they can have a lower total GHGE than producing the same food in the UK (e.g. dairy from New Zealand<sup>(23)</sup>).

Observing that GHGE can be lower even when some foods are transported to the UK brings into question the popular view that ‘food miles’ (i.e. the distance food travels) have one of the greatest environmental impacts in terms of the diet<sup>(12,24)</sup>. Its popularity as a concept and use as a pseudo indicator of environmental sustainability has led to food miles being used as a marketing tool and in food labelling, which has fuelled many of the arguments for eating local and seasonal food. The term food miles, however, has been taken out of the original context for which it was first devised and been inappropriately used for carbon accounting<sup>(25)</sup>. The term food miles was first coined by Tim Lang in the early 1990s with the aim of re-injecting a more social and cultural dimension to our thinking about food and reconnecting people with where their food comes from, not as a measure of the environmental impact<sup>(5)</sup>.

Despite the instinctive view that transporting food long distance across the world will always have a higher environmental cost in terms of GHGE than local, seasonal food is not supported by the evidence. Recent studies describe why it is a poor proxy for environmental sustainability<sup>(23,26,27)</sup>. First, food miles in both the UK and the USA only account for about 10–11% of the total GHGE within the food system<sup>(26,28)</sup> with the vast majority of emissions coming from production and processing of food. Second, a recent study found that 82% of the total food miles occur within the UK, of which more than half come from consumers driving to and from food shops<sup>(26)</sup>. Similarly in the USA, of the 11% of GHGE-associated food miles, only 4% is from transporting food from the producer to the retailers<sup>(28)</sup>. Finally, food miles do not make any distinction about the mode of transportation, which can have very different emissions<sup>(27)</sup>, and it should be noted that air-freighted fruit and vegetables account for <0.1% of the UK GHGE. These studies illustrate that focusing only on food miles and local food to reduce GHGE is likely to be ineffective. To put it into context, Weber & Matthews<sup>(28)</sup> demonstrated that replacing the energy from red meat and dairy products with chicken, fish, eggs or vegetables one day each week would result in a significantly greater reduction in GHGE than the extreme option of buying only locally sourced food (i.e. zero delivery miles).



GHGE are only one dimension of the environmental impact of our food choices. As others have highlighted the current and predicted future demand for food is putting significant pressure on many of the finite natural resources in the world, such as water, land and minerals<sup>(29,30)</sup>. In terms of seasonality GHGE may not be a major driver, but these other environmental considerations need to be taken into account. Foster *et al.*<sup>(22)</sup> compared raspberries produced in the UK and Spain and demonstrated that in terms of GHGE there was little difference but the water stress placed on the country was significantly higher in Spain. Adopting a global seasonality approach to food supplies may not have major consequences for GHGE but to meet demands it could create greater water stress in already water scarce countries. A similar argument could be made against increasing the global supply of fresh food year-round because of the increased land it will require, which will have knock-on effects for loss of environmental biodiversity. Historically agricultural intensification and expansion has led to a production model where nutritional intakes are dominated by only a few crop species and monocultures leading to the loss of important nutrient dense cultivars of plants in the diet. It is estimated that about 90% of our food supply is now derived from plants coming from a total of only about 100 crop species<sup>(31)</sup>.

Conversely, becoming heavily dependent on locally produced food or from single regions of the world reduces resilience in the food system to adverse and extreme weather events, which are predicted to become more frequent with global warming and climate change<sup>(10)</sup>. Increasingly, major crop failures are being seen resulting from extreme weather events, such as droughts, flooding and unpredictable fluctuations in temperature, which increases food prices and limits the availability of food across the whole food chain. It is not only the crop yield that can be affected by climatic extremes, but it can also alter the nutrient composition of the crop.

Studies have consistently shown that the idea of eating seasonal food resonates with many consumers and it is a behaviour change they say they would be willing to make, but the environmental gains are likely to be relatively minor compared with making other pro-environmental behaviours<sup>(4)</sup>. Combining several environmental criteria Jungbluth *et al.*<sup>(32)</sup> compared different dietary scenarios (e.g. becoming vegetarian, reducing food waste, reducing obesity, eating local food, organic food, a more balanced diet, eating seasonal food) and of all these eating seasonal food was found to have the smallest benefit. In contrast, consumer's believe that eating only seasonal fruit and vegetables have a greater environmental benefit than eating less meat<sup>(33)</sup>, and a behaviour change they would be more willing to adopt<sup>(34)</sup>.

#### *Nutritional and health implications*

Possible dietary and health related concerns about eating only seasonal fruit and vegetables are first, whether it would reduce intakes and second, if it is possible to meet nutrient requirements for health throughout the year. This obviously depends on availability and this

will vary depending on where you live in the world and which definition of seasonality you use; local or global. Taking the case of local seasonality in the UK (produced and consumed in the same climatic zone), it would be possible to eat only seasonal food but perhaps not very appealing due to limited variety of produce during the winter months.

The most recent National Diet and Nutrition Survey reports that only 31% of adults (aged 19–64 years) and 9% of children (aged 11–18 years) in the UK meet the recommended '5-a-day' intake for fruit and vegetables<sup>(35)</sup> and this is within a food environment where there is usually a wide variety of fresh produce. Eat Seasonably<sup>(3)</sup>, a UK government supported initiative, have produced charts showing when fruit and vegetables are in season and during the winter in the UK there would be no fruit and a very limited range of vegetables. Limiting fruit and vegetables to fewer and possibly less appealing items could risk reducing intakes of fruit and vegetables even further. It is, however, important to note that not all fruit are commonly consumed out of season. Purchase data for strawberries and raspberries in the UK show that the vast majority of sales occur only during the summer months, with very few purchased out of season even though they can be found in supermarkets<sup>(22,36)</sup>.

For centuries fresh produce has been stored to extend the period that food is available. While storage and transportation can be associated with the loss of some micronutrient and bioactive compounds of produce<sup>(37)</sup>, these losses are minimal in terms of health when compared with the alternative of not eating them at all. Some methods of preservation can actually increase the nutrient quality of a product; for example nutrients such as lycopene and  $\beta$ -carotene in processed tomatoes are more bio-available than in fresh tomatoes<sup>(38)</sup>. From an environmental perspective storing and preserving fresh produce uses additional energy, but trade-offs between health and the environment need to be weighed up.

The second possible nutritional concern relates to whether nutrient requirements could be met if the food was restricted to only seasonal foods, particularly in winter. Studies modelling different dietary scenarios have demonstrated that it is possible to meet energy and nutrient requirements based on a very small number of foods and very limited range of vegetables<sup>(39)</sup>. This demonstrates that it is theoretically possible but the type of diet is likely to be unacceptable to most of the population. A study using the methodology developed for the Livewell project (i.e. meet dietary requirements and minimising GHGE<sup>(40)</sup>) was repeated with the additional criteria of only including fruit and vegetables available in the UK in December (using Eat Seasonably<sup>(3)</sup> definitions)<sup>(41)</sup>. Although nutrient requirements were met it was not possible to create a diet that would be seen by most people in the UK as acceptable using only using seasonal fruit and vegetables in the winter. To achieve a realistic 7-d menu fruit in season abroad (e.g. oranges), stored in the UK (e.g. apples) or preserved (e.g. dried fruit) had to be added to the diet, as well as some basic vegetables, such as onions or tomatoes that were taken





from storage or tinned items used. The study illustrated that while it would be possible to eat only seasonal food and meet dietary requirements, the limited range of foods is likely to be unacceptable in modern society.

The nutrient composition of plants and animals can vary by season and by the cultivar of plants selected to optimise yields in different growing conditions. The  $\omega$ -3 levels of fish in the wild, for example, decrease when fish are spawning and the magnitude of the change and time of year varies for different species<sup>(42)</sup>. From a nutritional perspective, the fluctuation is relatively small when compared with dietary recommendations and is unlikely to have a significant impact on the diet. Also, with an increasing amount of fish being produced in aquaculture, any natural seasonal fluctuations are minimal because the fatty acid composition of the fish is controlled by the composition of feed rather than by season. It is similar for farmed cattle, where the nutrient composition of the meat today varies more according to the type of feed, which can be seasonal, and the breed of the animal rather than any natural seasonal effects<sup>(43)</sup>.

Agricultural intensification has meant that the cultivar of crops and plants tend to be selected to maximise yields and resistance to disease within the growing conditions rather than to optimise the micronutrient composition. This is particularly relevant in countries where crops and cultivars have been changed to maximise yields, neglecting the nutrient composition of the food, which has had detrimental impacts on the micronutrient composition of the diet of local people<sup>(44)</sup>. Burlingame *et al.*<sup>(45)</sup> reviewed the variations in nutrient composition of different varieties of crops and found that, for example the  $\beta$ -carotene content of bananas varies from  $<1 \mu\text{g}/100 \text{g}$  for some cultivars to  $8500 \mu\text{g}/100 \text{g}$  for others, and similarly the iron content of rice can vary from 0.7 to 6.4 mg/100 g by cultivar. Ignoring the micronutrient properties of different cultivars and focusing on yields (i.e. energy) has the potential for the difference between micronutrient deficiency and micronutrient adequacy in many populations. If agricultural systems are intensified further to meet greater global dietary demands and are based only on yields this could become a major concern for nutrition and health. With climatic changes, different cultivars will be sought and breeds will need to be selected to adapt to the changing conditions but it is essential that the nutrient composition is considered; this is being referred to by the Food and Agriculture Organization as a nutrition-sensitive approach to agriculture<sup>(46)</sup>.

#### *Social and economic implications*

The social and economic implications are as important as health and environment if moves towards sustainable consumption patterns are to be realistic. In the report *Setting the Table*<sup>(2)</sup>, the authors concluded that eating more seasonal field-grown fruit and vegetables could have negative consequences for economic stability by increasing the seasonality of labour requirements and creating instability in employment. Also, relying solely on

local and seasonal food is a high-risk strategy for both producers and consumers because crop production is vulnerable to the climate. Supplying only local markets may not be economically viable for a lot of current farming practices, which rely financially on larger more stable export markets. Farmers markets are often seen as a way of getting local seasonal food to communities but in reality these account for only a tiny fraction of farm sales<sup>(47)</sup>. Much of the interest in local and seasonal food has been generated through a desire to support the local economy and farmers, and is often used as a marketing tool by larger retailers and companies. In reality, however, buying seasonal food tends to be very low down in the priorities that influence peoples' purchasing decisions; a recent survey showed that only 2% of respondents said that seasonality was a factor in their decision making compared with about a quarter of the respondents who said price and brand were important<sup>(48)</sup>.

Probably the most important part in moving towards more sustainable consumption patterns is to understand how the proposed changes could fit in today's society and change social norms. The greatest challenge is to engage the population, whether it is to eat seasonal food, to eat less meat and dairy products, not to over consume energy or to reduce food waste. For many people these changes will require a significant behaviour and dietary change and in a direction that may not necessarily be associated with being pleasurable. The magnitude of this task should not be underestimated; we only need to look at the trends in obesity and failure over the last two decades to improve the diet of the population. Nutritionists' focus tends to be health, while for environmental scientists it is limiting the environmental impact. Winkler<sup>(49)</sup>, however, recently pointed out that perhaps one factor contributing to the failures in improving the population's diet has been because we forget that many people are not interested in healthy eating or have different priorities with food. He describes how some people 'are repelled by well-meaning advice that comes across as hectoring'. The same could be argued about the environmental concerns related to dietary choices.

In modern cultures time pressure, competing priorities and desire for instant gratification are all perceived as barriers to changing dietary patterns. Real or perceived they need to be considered in dietary recommendations if changes are to be realistic<sup>(50)</sup>. Convenience foods are a large part of modern diets; Buckley *et al.*<sup>(51)</sup> characterised about half of UK consumers as 'kitchen evaders' or 'convenience-seeking grazers'. The food industry has responded to, some might argue have created, modern lifestyles and expectations of convenience. Whatever the main cause the food system needs to change at every level as it is currently neither healthy nor environmentally sustainable but the different cultural aspect of eating and societal expectations cannot be ignored if realistic and effective policy solutions are to be found<sup>(52)</sup>. Concerns about future health and the environment alone are unlikely to change the dietary patterns of the whole population because eating is also about pleasure, expectations and culture.



### The practicalities and reality of only eating seasonal food

There are several examples of projects that have been set up to encourage consumption of local and seasonal food to reduce the environmental impact of the diet, including the Fife Diet in Scotland<sup>(53)</sup>, 100 mile diet in Canada<sup>(54)</sup> and the Nordic diet<sup>(55)</sup>. Some people have taken these diets to an extreme by attempting for 1 year to eat only food produced locally. The 100 mile diet was started by a couple who wanted to see if it was possible over 1 year to eat only locally produced food, all foods not just fruit and vegetables, within a 100 mile radius of Vancouver city<sup>(54)</sup>. While they did achieve it, they described the time needed to acquire and prepare food was often the equivalent to a part-time job and achieving a varied and balanced diet throughout the year was challenging, even with preserving foods for winter months. This is obviously an extreme approach to local and seasonal eating but it serves to highlight some of the barriers that need to be considered even with a less intense approach.

### Conclusions

Drawing together current evidence of the environment, health, economics and society consequences of eating seasonal food highlights the complexity of what could initially be seen as a simple concept. Relying on local seasonal food year-round could reduce fruit and vegetable consumption, but the environmental impacts on water stress, land use change and biodiversity could be less than for a globally seasonal diet. It could, however, limit international trade with implications for economic stability and resilience within the global food market. Based on the current evidence there is no clear advantage or disadvantage for advocating a food system of only global or locally seasonal food production. Trade-offs are needed to maximise dietary quality and minimise the environmental cost of dietary intakes, which requires a holistic approach to address the issue of sustainable diets. A reductionist approach focusing only on individual elements of sustainability is likely to lead to unintended consequences. Eating more seasonal food has benefits but it is only one small aspect of a sustainable diet and in terms of dietary change it should not overshadow some of the potentially more difficult dietary behaviours to change that are likely to have greater benefits (e.g. overeating or meat consumption). To achieve more sustainable consumption patterns will require commitment and action across the whole food system from producers, retailers, government to consumers. To have any realistic chance of changing dietary behaviour, future guidelines for sustainable diets will need to consider modern lifestyles, cultural and social expectations and the food environment in which food choices are made.

### Acknowledgements

The author thanks Dr Janet Kyle for her contribution to this work and Éimear Crowley for her assistant with the literature review.

### Financial support

There was no specific funding associated with the preparation of this manuscript. The author's work is primarily funded through the Scottish Government Rural and Environment Science and Analytical Services research programme.

### Conflict of Interest

None.

### References

- Garnett T (2008) *Cooking Up a Storm: Food, Greenhouse Gas Emissions and Our Changing Climate*. Surrey: University of Surrey, Food Climate Research Network, Centre for Environmental Strategy.
- Sustainable Development Commission (2009) Setting the Table: Advice to Government on Priority Elements of Sustainable Diets. [http://www.sd-commission.org.uk/data/files/publications/Setting\\_the\\_Table.pdf](http://www.sd-commission.org.uk/data/files/publications/Setting_the_Table.pdf)
- Eat Seasonably (2013) [www.eatseasonably.co.uk](http://www.eatseasonably.co.uk)
- Department for Environment, Food and Rural Affairs (2008) A Framework for Pro-environmental Behaviours. London: HMSO; available at <http://archive.defra.gov.uk/evidence/social/behaviour/documents/behaviours-jan08-report.pdf>
- Lang T (2006). 'Food Miles'. *Slow Food* (Bra, Cuneo Italy), 19 May 2006, p. 94–97. [http://www.city.ac.uk/\\_data/assets/pdf\\_file/0007/167893/Slow-Food-fd-miles-final-16-02-06.pdf](http://www.city.ac.uk/_data/assets/pdf_file/0007/167893/Slow-Food-fd-miles-final-16-02-06.pdf)
- DeClarke F (2013) Harnessing biodiversity: from diet to landscapes. In *Diversifying Food and Diet*, pp. 17–34 [J Franzo, D Hunter, T Borelli and F Mattei editors]. Oxon, UK: Routledge.
- DEFRA (2012) Understanding the environmental impacts of consuming foods that are produced locally in season. Project FO0412. <http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=16390>
- Edwards-Jones G (2010) Does eating local food reduce the environmental impact of food production and enhance consumer health? *Proc Nutr Soc* **69**, 582–591.
- Sumberg J & Sharp L (2009) Is it possible to find a meaningful definition of the term 'seasonal food'? [http://www.sustainweb.org/pdf2/NEF\\_What\\_is\\_seasonal\\_food\\_2009.pdf](http://www.sustainweb.org/pdf2/NEF_What_is_seasonal_food_2009.pdf): Food
- Linderholm HW (2006) Growing season changes in the last century. *Agric Forest Meteorol* **137**, 1–14.
- Wilkins J, Bowdish E & Sobal J (2002) Consumer perceptions of seasonal and local foods: a study in a U.S. community. *Ecol Food Nutr* **41**, 415–439.
- Brooks M, Foster C, Holmes M *et al.* (2011) Does consuming seasonal foods benefit the environment? Insights from recent research. *Nut Bull* **36**, 449–453.
- Chambers S, Lobb A, Butler L *et al.* (2007) Local, national and imported foods: a qualitative study. *Appetite* **49**, 208–13.
- Which? Consumer Report (2013) The future of food, giving consumers a say. [http://press.which.co.uk/wp-content/uploads/2013/04/Future-of-Food-Report-2013\\_Final.pdf](http://press.which.co.uk/wp-content/uploads/2013/04/Future-of-Food-Report-2013_Final.pdf)
- Thornton A (2009) *Public Attitudes and Behaviours Towards the Environment - Tracker Survey: A Report to the Department for Environment*. London: Food and Rural Affairs, TNS, DEFRA.



16. Arnoult M, Lobb A & Tiffin A (2010) Willingness to pay for imported and seasonal foods: A UK survey. *J Int Food Agribusiness Market*, **22**, 234–251.
17. Johnston J, Szabo M & Rodney A (2011) Good food, good people: understanding the cultural repertoire of ethical eating. *J Consum Cult* **11**, 293–318.
18. Hospido A, Canals LM & McLaren S (2012) The role of seasonality in lettuce consumption: a case study of environmental and social aspects. *Int J Life Cycle Assess* **14**, 381–391.
19. Bows A, Dawkins E & Gough C (2012) What's Cooking? *Adaptation & Mitigation in the UK Food System, Sustainable Consumption Institute*, The University of Manchester. <http://www.sci.manchester.ac.uk/uploads/sci-whats-cooking-july-13-2012-.pdf>
20. Webb J, Williams AG, Hope E *et al.* (2013) Do foods imported into the UK have a greater environmental impact than the same foods produced within the UK? *Int J Life Cycle Assess* **18**, 1325–1343.
21. Canals Mi, Cowell SJ, Sim S *et al.* (2007) Comparing domestic *versus* imported apples: a focus on energy use. *Env Sci Pollut Res* **14**, 338–344.
22. Foster C, Holmes M, Wiltshire J *et al.* (2012) The environmental effects of seasonal food purchase: a case study. 8th Int. Conf. LCA in the Agri-Food Sector, 620. <https://colloque4.inra.fr/var/lcafood2012/storage/fckeditor/file/Proceedings/Proceedings%20-%20LCA%20Food%202012%20-%20ISBN.pdf>
23. Saunders C & Barber A (2008) Carbon footprints, life cycle analysis, food miles: global trade trends and market issues. *Polit Sci* **60**, 73–88.
24. Tobler C, Visschers VHM, Siegrist M (2011) How do consumers assess the environmental friendliness of vegetables? *Environ Behav* **43**, 591–611.
25. Desrochers P, Shimizu H (2008) Yes, We Have No bananas: A Critique of the 'Food-Miles' Perspective. Mercatus Policy Series, Policy Primer 8. [http://mercatus.org/sites/default/files/publication/Yes\\_We\\_Have\\_No\\_Bananas\\_\\_A\\_Critique\\_of\\_the\\_Food\\_Mile\\_Perspective.pdf](http://mercatus.org/sites/default/files/publication/Yes_We_Have_No_Bananas__A_Critique_of_the_Food_Mile_Perspective.pdf)
26. Smith A, Watkiss P, Tweddle G *et al.* (2005) The Validity of Food Miles as an Indicator of Sustainable Development: Final report. DEFRA report ED50254. <http://archive.defra.gov.uk/evidence/economics/foodfarm/reports/documents/foodmile.pdf>
27. Coley DA, Howard M, Winter M (2011) Food miles: time for a re-think? *Brit Food J* **113**, 919–934.
28. Weber CL & Matthews HS (2008) Food miles and the relative climate impact of food choices in the United States. *Environ Sci Technol* **42**, 3508–3513.
29. Beddington J (2009) *Food, Energy, Water and the Climate: A Perfect Storm of Global Events?* London, UK: Government Office for Science. Available at: <http://www.bis.gov.uk/assets/goscience/docs/p/perfect-storm-paper.pdf>
30. Foresight (2011) *The Future of Food and Farming Final Project Report*. London: The Government Office for Science.
31. Heywood VH (2013) Overview of agricultural biodiversity and its contribution to nutrition and health. In *Diversifying Food and Diet*, pp. 35–67 [J Franzo, D Hunter, T Borelli and F Mattei editors] Oxon, UK: Routledge.
32. Jungbluth N, Itten R, Schori S (2012) Environmental impacts of food consumption and its reduction potentials. 8th Int. Conf. LCA in the Agri-Food Sector, pp. 104–109. <https://colloque4.inra.fr/var/lcafood2012/storage/fckeditor/file/Proceedings/Proceedings%20-%20LCA%20Food%202012%20-%20ISBN.pdf>
33. Tobler C, Visschers VHM, Siegrist M (2011) Eating green. Consumers' willingness to adopt ecological food consumption behaviors. *Appetite* **57**, 674–682.
34. Vanhonacker F, Van Loo EJ, Gellynck X *et al.* (2013) Flemish consumer attitudes towards more sustainable food choices. *Appetite* **62**, 7–16.
35. Bates B, Lennox A, Prentice A *et al.* (2011) *National Diet and Nutrition Survey: Headline Results from Years 1, 2 and 3 (Combined) of the Rolling Programme 2008/09–2010/11*. London: Department of Health.
36. Revoredo-Giha C, Leat P, Kupiec-Teahan B *et al.* (2011) How local and seasonal is the consumption of soft fruit in Scotland? 85th Annual Conference Agricultural Economics Society, Warwick University. Available at: [http://ageconsearch.umn.edu/bitstream/108775/2/85Revoredo-Giha\\_leat\\_teahan\\_lamprinopoulou.pdf](http://ageconsearch.umn.edu/bitstream/108775/2/85Revoredo-Giha_leat_teahan_lamprinopoulou.pdf)
37. Goldberg G, Macevilly C, Peltola K (2008) The effect of agronomy, storage, processing and cooking on bioactive substances in food. In *Plants: Diet and Health: The Report of a British Nutrition Foundation Task Force*. London: British Nutrition Foundation.
38. Hwang E-S, Stacewicz-Sapuntzakis M, Bowen PE (2012) Effects of heat treatment on the carotenoid and tocopherol composition of tomato. *J Food Sci* **77**, 1109–1114.
39. Macdiarmid JI, Kyle J, Horgan GW *et al.* (2012) Sustainable diets for the future: can we contribute to reducing greenhouse gas emissions by eating a healthy diet? *Am J Clin Nutr* **96**, 632–639.
40. Macdiarmid JI, Kyle J, Horgan G *et al.* (2011) Livewell: A Balance of Healthy and Sustainable Food Choices. WWF-UK. [http://assets.wwf.org.uk/downloads/livewell\\_report\\_jan11.pdf](http://assets.wwf.org.uk/downloads/livewell_report_jan11.pdf)
41. Kyle J, Fyfe C, Horgan GW *et al.* (2011) Livewell Christmas. WWF-UK. [http://assets.wwf.org.uk/downloads/livewell\\_xmas\\_lists.pdf](http://assets.wwf.org.uk/downloads/livewell_xmas_lists.pdf)
42. Zotos A & Vouzanidou M (2012) Seasonal changes in composition, fatty acid, cholesterol and mineral content of six highly commercial fish species of Greece. *Food Sci Technol Int*, **18**, 139–49.
43. Daley CA, Abbott A, Doyle PS *et al.* (2010) A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef. *Nutr J* **9**, 10.
44. Litaladio N, Burlingame B, Crews J (2010) Horticulture, biodiversity and nutrition. *J Food Compost Anal* **23**, 481–485.
45. Burlingame B, Charrondiere R, Mouille B (2009) Food composition is fundamental to the cross-cutting initiative on biodiversity for food and nutrition. *J Food Compost Anal* **22**, 361–365.
46. Thompson B & Amoroso L (2011) *FAO's Approach to Nutrition-Sensitive Agricultural Development* Rome: FAO. [http://www.fao.org/fileadmin/user\\_upload/agn/pdf/FAO\\_Approach\\_to\\_Nutrition\\_sensitive\\_agricultural\\_development.pdf](http://www.fao.org/fileadmin/user_upload/agn/pdf/FAO_Approach_to_Nutrition_sensitive_agricultural_development.pdf)
47. Food and Farming Canada (2009) <http://www.foodandfarmingcanada.com/2009/10/30/canadas-farms-not-suited-to-100-mile-diet/> (accessed November 2013).
48. Kemp K, Inch A, Holdsworth DK *et al.* (2010) Food miles: do UK consumers actually care? *Food Policy* **35**, 504–513.
49. Winkler JT (2013) Brutal pragmatism on food. *BMJ* **346**, 3728.
50. Brewis J & Jack G (2005) Pushing speed? The marketing of fast and convenience food. *Consumption Markets Culture* **8**, 49–67.



51. Buckley M, Cowan C, McCarthy M (2007) The convenience food market in Great Britain: convenience food lifestyle (CFL) segments. *Appetite* **49**, 600–17.
52. Seyfang G (2004) Consuming Values and Contested Cultures: a critical analysis of the UK Strategy for sustainable consumption and production. *Rev Soc Econ* **62**, 323–338.
53. Fife Diet (2013) FifeDietinScotland.<http://www.fifediet.co.uk/> (accessed November 2013).
54. Global Public media (2009) Deconstructing Dinner: The 100-mile diet local food strategies. <http://old.globalpublic-media.com/transcripts/858> (accessed November 3013).
55. The Nordic Diet. [http://foodoflife.dk/opus/english/wp/nordic\\_diet/basis\\_nnd](http://foodoflife.dk/opus/english/wp/nordic_diet/basis_nnd) (accessed November 2013).