Energy and protein metabolism and nutrition in sustainable animal production

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edited by:
James W. Oltjen
Ermias Kebreab
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EAAP – European Federation of Animal Science

The University of California

Department of Animal Science

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4th International Symposium on Energy and Protein Metabolism and Nutrition

Sacramento, California, USA

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The 4th EAAP International Symposium on Energy and Protein Metabolism and Nutrition was organized in Sacramento, California (USA) on 9-12 September 2013. A special symposium as tribute to the late Professor R. Lee Baldwin was also organized on 12 September 2013.

The symposium was chaired by:
- James Oltjen

The scientific programme of the symposium was co-chaired by:
- Ermias Kebreab
- Hélène Lapierre

In consultation with the International Scientific Committee:
- Mario Luis Chizzoti (Brazil)
- Matteo Crovetto (Italy)
- Kristen Johnson (Alternate, USA)
- Michael Kreuzer (Secretary, Switzerland)
- Hélène Lapierre (Canada)
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- James Oltjen (USA)
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and liaising with the National Scientific Committee:
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- Kris Johnson
- Kyle McLeod
- John McNamara
- Phil Miller
- Gordon Murdoch
- Daniel Ouellet (Editorial)
- Luis Tedeschi

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Preface

The 4th EAAP International Symposium on Energy and Protein Metabolism and Nutrition (ISEP) was held at the Sheraton Grand Hotel in Sacramento, California, USA from September 9th to September 12th, 2013. This followed the 3rd ISEP in Parma (2010), the 2nd ISEP in Vichy (2007), and the 1st ISEP in Rostock-Warneműnde (2003). These follow the previous Energy Symposium and Protein Symposium which were held separately, all under the auspices of the European Association of Animal Production and the Commission on Animal Nutrition; it is also the first time the symposium had been held in North America.

As world population increases, demand for food, particularly animal products, is expected to grow substantially. Because of limited area for expansion of animal agriculture and increased consumer concern for the environmental impact of animal production, gains in animal efficiency will have to be part of the solution. The 4th International Symposium on Energy and Protein Metabolism and Nutrition addressed key issues of how energy and protein are utilized and interact in farm animals from the molecular to the whole animal and even to the herd or group level of organization. Key issues addressed include energy/protein interactions, methodology such as *in vitro* and *in vivo* techniques, regulation including pre-natal programming and endocrine regulation, modeling/systems biology, products and health of animals, tissue metabolism, and environmental sustainability in agriculture. ISEP also included a tribute to the late Professor R. Lee Baldwin of the University of California, Davis, a leader in the field.

The 4th Symposium began with the premise that improved understanding of animal energetics and protein metabolism will be required for sustainable animal production. Over 200 participants, from 27 countries, made theatre and poster presentations; two-page abstracts for contributed papers and full length papers by invited speakers are contained herein.

Attendees at the ISEP heard significant new research, with invited speakers and oral and poster communications by participants. The Symposium combined fundamental research with applied research and practical applications. Because energy and protein metabolism and nutrition cannot be addressed separately, a better and deeper understanding of nutrient metabolism and nutrition can be achieved only by integrating the outcomes of scientists conducting research on different aspects.

Participants and accompanying persons were housed in one hotel and shared common meals in an effort to increase networking possibilities and stimulate interactions; they were also treated to a showcase of California agriculture and hospitality.

We thank all those who helped make this Symposium successful, especially the sponsors and the International, North American, and Local Organizing Committees. Finally, we would also like to thank all the participants for making possible a meeting with a great deal of interaction; we hope this meeting has given us more tools to address questions that need to be answered for a real sustainable agriculture scientifically.

James W. Oltjen

Keynotes

Feeding the planet: key challenges

M. Herrero
Commonwealth Scientific and Industrial Research Organisation, 306 Carmody Road, St Lucia 4067, QLD, Australia; m.herrero@cgiar.org

Abstract

The notion of feeding 9 billion people sustainably in the next forty years presents considerable challenges. Population growth and human dietary changes remain the key drivers of the large increases in future food demand. While the world food system can respond to meet this demand, there are challenges to ensure this happens sustainably, equitably and within our conceived limits of a safe environmental space. This paper discusses the key trends in food production and consumption, and the key challenges for feeding the planet. Especial attention is given to livestock, a key part of the puzzle for ensuring sustainable nutritional security and environmental sustainability for future generations.

Introduction

The global food system is experiencing profound changes as a result of anthropogenic pressures. The ever-increasing human population (to reach 9 billion by 2050) together with changes in consumption patterns (i.e. increasing demand for livestock products) caused by urbanization, increasing incomes, and nutritional and environmental concerns, are shaping what we eat, who eats, and how much, more than ever. The double burden of nutrition (overconsumption and under-nutrition) is defining research agendas, policies and conceptions about food in different ways around the world.

Against this background is a global food system that will have to improve its resource use efficiency and environmental performance significantly in order to ensure the sustainability of global food production and consumption within established planetary boundaries of greenhouse gas emissions, and water and nutrient use amongst others.

Livestock, the largest land use sector on Earth is an important part of this puzzle and many solutions to the challenges facing how to feed the world sustainably lie in how we manage this sector. This brief paper aims to discuss some of the key ways in which we could increase the sustainability of the world food system, and some of the challenges to overcome.

Key challenges: the future demand for food

Table 1 shows the FAO projections of global food consumption to 2050 (Alexandratos and Bruinsma, 2012). The main conclusions from these projections, as well as others (ie. IAASTD 2009), is that a shift to diets with more animal products and fats, is likely to happen, mostly in the developing world as a result of increased incomes and urbanization. While the consumption per capita of cereals is likely to stabilize, population growth will increase the total quantities of both meat (almost doubling) and cereals (50%) needed to feed the world in 2050.

The supply response of the global agriculture and livestock sectors is likely to be able to accommodate these demand increases (Alexandratos and Bruinsma, 2012). All recent projections have important common features: (1) Local production under current yield trends in many parts of the world, like Sub-Saharan Africa (SSA) and parts of Asia, will not be able to meet local food demand. Hence increases in food trade are projected to increase in the future in some parts of the world. This is a key aspect of balancing the food supply and demand equation. (2) While increases in the yields of crops and livestock have occurred in most regions of the world (apart from SSA), all projections show a variable increase in cropland and grassland expansion to meet demand (Smith *et al.*, 2010)

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Table 1. Projections of global demand for food to 2050 (Alexandratos and Bruinsma, 2012).

	2005/2007	2050
Population (millions)	6,584	9,306
Cereals for food (kg per capita)	158	160
Cereals for all uses (kg per capita)	314	330
Meat consumption (kg per capita)	38.7	49.4
Oil crops for food (kg per capita)	12.1	16.2
Oil crops for all uses (kg per capita)	21.9	30.5
Meat production (million tonnes)	258	455
Cereal yields, rice paddy (t/ha)	3.32	4.30
Arable land area (million ha)	1,592	1,661

and (3) also an increase in animal numbers, but with monogastric production (pork and poultry) growing at faster rates than ruminants (meat especially, and less so for milk). (4) These factors lead to net increases in greenhouse gas emissions (GHG) from the agricultural and livestock sectors, but a diminishing trend in the emissions intensities across commodities (GHG per unit of product). (5) projections of water use show increased pressure on total fresh water resources, notably on blue water (irrigation), and moderate increases in the efficiency of green water use (CA, 2007). Other studies have also demonstrated large quantities of reactive nitrogen used and a potential depletion of phosphorus stocks in the future (Bouwman *et al.*, 2011). Hence, food production can be attained under current productivity and demand trends, but not necessarily making inroads in the improvement of our environmental goals.

Several authors (Foley *et al.*, 2011; Garnett and Godfray, 2011; Godfray *et al.*, 2010; Herrero *et al.*, 2010) have suggested different mechanisms for improving the sustainability of the world food system. The three most often mentioned are:

1. Increasing productivity (managing the supply side): Increasing agricultural productivity and overall food production have been the pillar for designing strategies for feeding the world since the industrial revolution. Notable gains have been made in many parts of the world (developed countries and Latin America and Asia). There is significant ongoing research on how to sustainably intensify global food production, how to bridge yield gaps of crops and livestock and how to improve value chains so that both producers and consumers benefit from potential yield increases, while using less, the same, or slightly more inputs.
2. Reducing waste in food value chains. This subject has received attention recently (Godfray *et al.*, 2010), and it has been estimated that food waste can account for up to 40% of losses relative to food production. Figure 1 (Godfray *et al.*, 2010) shows that in the developing world these losses occur mostly due to post-harvest activities like deficient harvesting and storage methods, pests, export regulations and others. In the developed world this occurs mostly at the post-consumption stage, due to poor management of product sell-out dates in the value chain and direct food disposal by consumers (i.e. discarding food from fridges).
3. Consuming more sustainable diets (managing the demand for food): There is evidence that modifying what we eat could have significant impacts on the use of resources like land and water, it could reduce GHG emissions and it could have important health and nutritional benefits. A lot of emphasis has been put in the potential benefits of reducing red meat consumption and the promotion of 'healthy' diets (Stehfest *et al.*, 2009) (Table 2). These studies have shown that reductions in livestock consumption could lead to reduced land use change, directly from less land clearing for raising animals or for producing feed crops. These land sparing gains, in turn lead to lower GHG emissions in general.

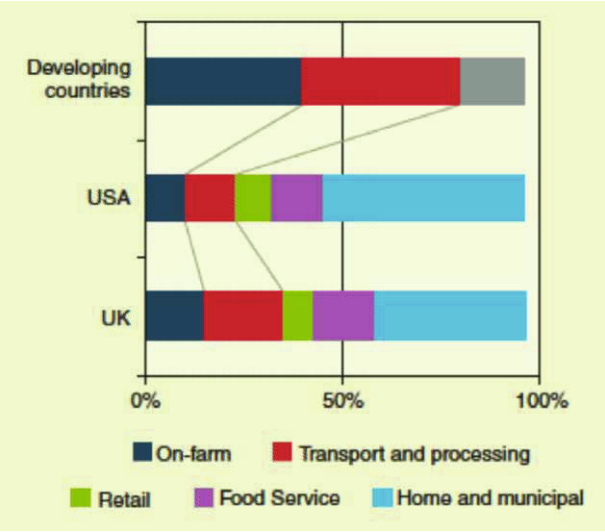

Figure 1. Make up of total food waste in developed and developing countries (Godfray et al.*, 2010).*

This is a significant finding. However, this space has not been explored sufficiently to provide suitable, practical, regional/country guidance for consumers and for policy makers to effect the necessary changes in local food systems, and to modify consumer behavior. At the global level, this concept has only been studied superficially, and without considering important dimensions such as dietary diversity and cultural preferences extending beyond measures of kilocalorie consumption, and what would be the social and economic impacts of reducing the size of the livestock sector. These additional dimensions are essential for understanding the biological and socio-economic implications of diet sustainability on the global food system. We need to go beyond simplistic recommendations like 'stop eating meat' to make this area of research useful, and provide alternatives and practical guidelines for achieving these kinds of gains. This is of particular importance for the developing world, where livestock product demand projections demonstrate that even with significant consumption growth, consumption per capita will remain significantly lower than in the developed world (IAASTD, 2009).

The implementation of these strategies is not straightforward. There are many challenges and trade-offs and they are complex because there are competing economic, social and environmental claims to their implementation. Additionally, human nature, the single biggest ingredient in this mix, plays a key role in defining our choices. These choices are not always in favor of long-term sustainability. More often the attainment of shorter term gains prevails, especially in a world of

Table 2. Land use emissions in 2000 and 2050 for the reference scenario and four variants of dietary composition (Stehfest et al.*, 2009).*

	GtCeq
2000	3.0
2000 – reference	3.3
2050 – no red meat	1.7
2050 – no meat	1.5
2050 – no animal products	1.1
2050 – healthy diet	2.1