Trends in Food Science & Technology 56 (2016) 115–125

Contents lists available at ScienceDirect

Trends in Food Science & Technology

journal homepage: http://www.journals.elsevier.com/trends-in-food-science-and-technology

Review

Role of food processing in food and nutrition security

Mary Ann Augustin [a, *], Malcolm Riley [b], Regine Stockmann [a], Louise Bennett [a], Andreas Kahl [b], Trevor Lockett [d], Megan Osmond [e], Peerasak Sanguansri [a], Welma Stonehouse [b], Ian Zajac [c], Lynne Cobiac [c]

[a] *CSIRO Agriculture & Food, 671 Sneydes Road, Werribee, VIC 3030, Australia*
[b] *CSIRO Health & Biosecurity, South Australian Medical Research Institute Building, North Terrace, Adelaide, SA 5000, Australia*
[c] *CSIRO Health & Biosecurity, Gate 13, Kintore Ave, Adelaide, SA 5000, Australia*
[d] *CSIRO Health & Biosecurity, Riverside Corporate Park, 11 Julius Avenue, North Ryde, NSW 2113, Australia*
[e] *CSIRO Agriculture & Foods, Riverside Corporate Park, 11 Julius Avenue, North Ryde, NSW 2113, Australia*

ARTICLE INFO

Article history:
Received 11 December 2015
Received in revised form
4 July 2016
Accepted 13 August 2016
Available online 16 August 2016

Keywords:
Food security
Nutrition security
Food supply chain
Food processing
Healthy diets
Consumer perception

ABSTRACT

Background: Food and nutrition security, a major global challenge, relies on the adequate supply of safe, affordable and nutritious fresh and processed foods to all people. The challenge of supplying healthy diets to 9 billion people in 2050 will in part be met through increase in food production. However, reducing food losses throughout the supply chain from production to consumption and sustainable enhancements in preservation, nutrient content, safety and shelf life of foods, enabled by food processing will also be essential.

Scope and approach: This review describes developments in primary food production systems and the role of food processing on population health and food and nutrition security. It emphasises the need to monitor the attitudes and values of consumers in order to better understand factors that may lead to negative perceptions about food processing.

Key findings and conclusions: For a resource constrained world, it is essential to have a balanced approach to both energy and nutrient content of foods. Environmental sustainability is critical and both the agrifood production and the food processing sectors will be challenged to use less resources to produce greater quantities of existing foods and develop innovative new foods that are nutritionally appropriate for the promotion of health and well-being, have long shelf lives and are conveniently transportable. Healthy diets which meet consumer expectations produced from resilient and sustainable agrifood systems need to be delivered in a changing world with diminishing natural resources. An integrated multi-sectoral approach across the whole food supply chain is required to address global food and nutrition insecurity.

1. Introduction

Food and nutrition security is a global challenge, and a prerequisite for a healthy and peaceful society. Food security exists when “all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”. Nutrition security “exists when secure access to an appropriately nutritious diet is coupled with a sanitary environment, adequate health services and care, in order to ensure a healthy and active life” (FAO, IFAD, & WFP, 2015).

About 795 million people in the world were undernourished in 2014–16 (FAO et al., 2015) while more than 2 billion people were overweight or obese in 2013 (Ng et al., 2014). To be able to feed the world population that is expected to increase from 7.3 billion today to 9 billion in 2050, an increase in agricultural productivity by 30–40% is required by 2050 just to meet the dietary energy needs. The energy gap can be addressed by reducing demand, lessening the current level of food waste or increasing food production (Keating, Herrero, Carberry, Gardner, & Cole, 2014). While considering food demand in terms of calories to fulfil energy needs is one way to examine global food requirements, fundamental requirements of macronutrients and micronutrients for good health

* Corresponding author.
E-mail address: maryann.augustin@csiro.au (M.A. Augustin).

http://dx.doi.org/10.1016/j.tifs.2016.08.005

need to be met. It is essential to take into account the potential overconsumption of nutrients, changing demographic structure, consumer choice and cultural context of diets.

Over the past 50 years, feeding our rapidly growing global population was achieved through increases in agricultural productivity (DeFries et al., 2015). Although intensification of agricultural production while minimizing environmental degradation will still be critical, this alone may not be sufficient to meet the nutritional demands of the projected population expansion. Food processing is required to increase useful life of foods, optimize nutrient availability and food quality, and reduce losses and waste. Biodiversity, ecosystems and cultural heritage are a consideration when developing affordable sustainable diets for all people. Sustainable diets have low environmental impacts and contribute to healthy life of present and future generations (Johnston, Fanzo, & Cogill, 2014). Reducing the prevalence of food insecurity today and in future will require technological solutions through collaborative efforts across agriculture, food, nutrition and health that are acceptable to society. It is clear that many considerations need to be factored into a discussion of food and nutrition security, which also include effective distribution channels between where food is produced and required, the differing food regulations in various regions, the role of indigenous foods, religion and culture, urbanisation, biodiversity and climate change (Burlingame & Dernini, 2012; Muchenje & Mukumbo, 2015; Rolle, 2011). An integrated multi-sectorial systems approach to food supply chain efficiency and sustainable diets is needed (Lake et al., 2012; van Mil, Foegeding, Windhab, Perrot, & van der Linden, 2014; Wu, Ho, Nah, & Chau, 2014). The focus of this review is on the role of innovative and sustainable primary production systems and food processing in addressing challenges in food and nutrition security.

2. Primary production systems

Resilient production systems for sustainable diets have to be developed and managed whilst mitigating climate change, preserving biodiversity and the environment, while taking into account societal needs and expectations. The productivity of food systems should focus on innovation for improving nutritional needs, and providing aid to farmers to adopt innovations for sustainable intensification and novel food sources (Ingram *et al.*, 2013). Consideration of multiple desirable endpoints requires consideration of synergies and trade-offs in the competing demands in production systems and sustainable diets so that food security is not compromised (Garnett, 2013).

2.1. Crop production systems

Biofortification of crops is one of the approaches that may be used for alleviating global nutrition insecurity (Arsenault, Hijmans, & Brown, 2015). Biofortification of crops that are part of the staple diet of local populations is an effective approach to improve the nutrient density and nutritional quality of the agricultural produce. The use of conventional plant breeding or transgenic methods may be used for introducing desirable nutrient traits into food crops. HarvestPlus, an interdisciplinary global alliance, has developed varieties of food crops with higher levels of micronutrients. Biofortified crops developed and released in the HarvestPlus program include cassava, maize and sweet potato high in vitamin A, high-iron beans and high-zinc wheat, millet and maize (www.harvestplus.org). These biofortified food staples which are denser in micronutrients provide a greater percentage of the recommended daily allowance and reduce malnutrition, especially in rural communities. The technical feasibility of providing micronutrient dense crops without affecting agronomic traits has been demonstrated and may be a cost effective method for reducing micronutrient deficiencies in vulnerable populations (Nestel, Bouis, Meenakshi, & Pfeiffer, 2006). The fortification of crops with the essential amino acids, lysine and methionine, has attracted attention because of the potentially limited supply of these amino acids, especially in developing countries where poor populations do not consume sufficient protein from animal sources. Advanced breeding methods have yielded higher protein maize. Transgenic approaches have been successful in increasing the level of lysine in Arabidopsis seeds, rice and soybean while increases in methionine have been obtained in Arabidopsis, alfalfa and potato leaves as well as in the storage proteins of canola, rice, soybean and rice. However more work is required to enable production of crops with increased levels of lysine and methionine with a normal phenotype (Galili & Amir, 2013).

Foods rich in dietary fibre and resistant starch have the potential to reduce the incidence of Type 2 diabetes and cardiovascular disease and improve metabolic and gut health and this led to interest in improving cereal grain carbohydrates for health outcomes (Lafiandra, Riccardi, & Shewry, 2014). Conventional plant breeding can produce barley grains with high levels of resistant starch and beta-glucan, and a low glycaemic index (Morell et al., 2003). A high beta-glucan, high amylose barley has been incorporated as an ingredient into a range of processed food products. A high resistant starch wheat has also been produced (Regina et al., 2015).

The benefits of long chain polyunsaturated omega-3 fatty acids (LC-PUFAs) for maintenance of good health, brain and eye development in early childhood and reducing the risk of cardiovascular diseases and inflammatory diseases are well recognised (FAO, 2010; Lorente-Cebrian et al., 2013). Gene technology has been used for the production of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in plants (Petrie et al., 2010). The ability to achieve a sustainable crop source of LC-PUFAs will reduce the reliance on fish and other marine sources.

2.2. Livestock production systems

Livestock is an important contributor to global diets. Meat and livestock are a good source of dietary protein. The consumption of meat and livestock products is increasing due to increasing population, especially in the developing world, with a demand for these foods, a growth in economic wealth and urbanisation. Strategies for improving the resilience of animal production systems need to be considered in the face of climate change, as higher temperatures affect the sustainability of livestock production and the quality and yield of animal products such as milk and eggs (Nardone, Ronchi, Lactera, Ranieri, & Bernabucci, 2010). For livestock production systems, there are challenges for achieving balance by resource minimization strategies which address the impact of land management on the ecosystem. A recent example is the use of tannin-rich ruminant feedstock to improve the production yield and quality of animal products in semi-arid areas (Mlambo & Mapiye, 2015). Improving the productivity and efficiency of livestock systems requires an understanding of the interactions between animal genetics and the environment and between the livestock, the plants and the soil within pastoral ecosystems (Greenwood & Bell, 2014; Herrero & Thornton, 2013).

Plant-based diets generally require less energy, land and water to produce compared to meat-based diets and from this perspective, lacto-ovo-vegetarian diets may be considered to be more sustainable than meat-based diets (Pimentel & Pimentel, 2003). However, livestock production provides the ability to generate food from environments unsuitable for other food production. Notably livestock efficiently converts low quality forage into energy dense meat and milk food products. Improving livestock productivity will