



Review

Concepts for further sustainable production of foods



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ABSTRACT

This paper presents an overview of current production methods for food and food ingredients, and describes options for making healthier foods in a more sustainable manner. The current manner of producing food products has a large impact on the environment. Three main causes are responsible for inefficiencies in food production. Those are the increased use of products from animal origin, the inefficient use of food products once produced, resulting in waste generation, and the current set-up of food processes and processing chains. In this paper, we will summarize recent developments and sketch future scenarios for novel designs for food processes and process chains aimed at reduced environmental impact. Future processes can be improved through avoiding dilution and minimize drying, while ingredient production should focus on functionality rather than purity. As a consequence, ingredient production will be tailored for specific applications rather than for general use. The fractionation processes have to become smaller, more flexible and to be placed in the vicinity of the application. Focus on functionality allow the use of milder process conditions during fractionation leading to modern food products with less refined ingredients, which have potential to coincide with a healthier diet.

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1. Introduction

The current manner of producing foods is not very efficient. In Western-style diets, there is a large difference between the amount of energy consumed by the consumers in the form of the food products, and the amount of energy and resources required to

produce those products. The same holds for the protein consumption. The amount of protein originally produced through photosynthesis (and available for the production of protein foods) is about 7 times the amount of protein consumed in Western dietary patterns (Tilman et al., 2011). In other, less wealthy parts of the world, with incomes less than \$5000/year, this ratio is not above 2 (Boye and Arcand, 2013), which demonstrates that Western dietary habits are not very efficient in usage of natural resources and energy consumption.

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The inefficient exploitation of resources and energy is related to three main causes. Firstly, Western dietary pattern is characterized by high intakes of foods from animal origin like meat, dairy products and eggs. Animal feed, which mainly consists of plant based material, is used by animals for maintenance, and only part is converted into comestible products (i.e. meat, milk and eggs). An important advantage of livestock is that low quality plant (protein) can be converted into higher quality protein, making its use obvious in areas where soil or climate makes it difficult to grow alternative crops. However, the intensive manner of livestock farming nowadays requires rich in high quality protein feed products that are suitable for direct human consumption as well. Overall, it is worth mentioning that the livestock production has an enormous impact on the environment, which is, remarkably, still underestimated (Stehfest et al., 2009). The energy used for the processing and transport of livestock products exceeds that for plant-based products, and contributes about 1% to total world-wide energy use (Steinfeld et al., 2006). Generally, more income results in an increased consumption of animal-based products, leading to larger environmental impact. The second cause for inefficiency relates to the generation of food waste in the chain. It is estimated that one quarter of the food produced, expressed as food energy content, is wasted (Kummu et al., 2012). In developed countries, the consumer accounts for about 42% of the waste generation in households, and about 39% of the total losses are generated during food manufacturing (Mirabella et al., 2014). For economic and environmental reasons, the large amount of food waste produced during manufacturing has been investigated for the recovery of valuable components and its potential for recycling or upgrading (Galanakis, 2012). Besides, improved management structures and quality monitoring in food chains can help to reduce waste production. An excellent report on food losses and waste in the context of sustainable food systems

that highlights the necessity of changes was recently published by FAO (Timmermans et al., 2014). The third cause relates to our current infrastructure of food process and supply chains. For storage purposes and in order to produce food products under controlled conditions, food industry is focused on the use of dry and purified raw materials. Focus on purity and global sourcing of ingredients requires stabilization of the ingredients, often through drying, while most transformations (e.g. fractionation) in food processes are carried out in excess of water, again requiring large drying duties for stabilization.

The Western food consumption pattern has resulted in a food chain with large negative consequences on the environment. Acker et al. (2013) studied food production systems in Arizona and concluded that these are highly energy and water intensive operations. The authors suggested that the environmental, ecological and social justice issues of modern industrial agriculture require a reassessment of how food systems are organised nowadays, including farm subsidies, consumer demand and preferences, engineering technologies, and water policy. Rosegrant et al. (2013) pointed out that governments and institutions have a responsibility by valuing the full cost of natural resource use. A reassessment of how we produce food is necessary to meet the future challenge, which is to guarantee food security (even with increasing demand for food) while mitigating the water consumption and land use. The development of more efficient and sustainable food processes can contribute to meet this challenge. Therefore, this paper reviews recent developments and future trends towards more sustainable processing of foods.

We will discuss the following aspects:

1. The current mode of food processing.
2. Adding value to by-products: the short term route to better use of raw materials.

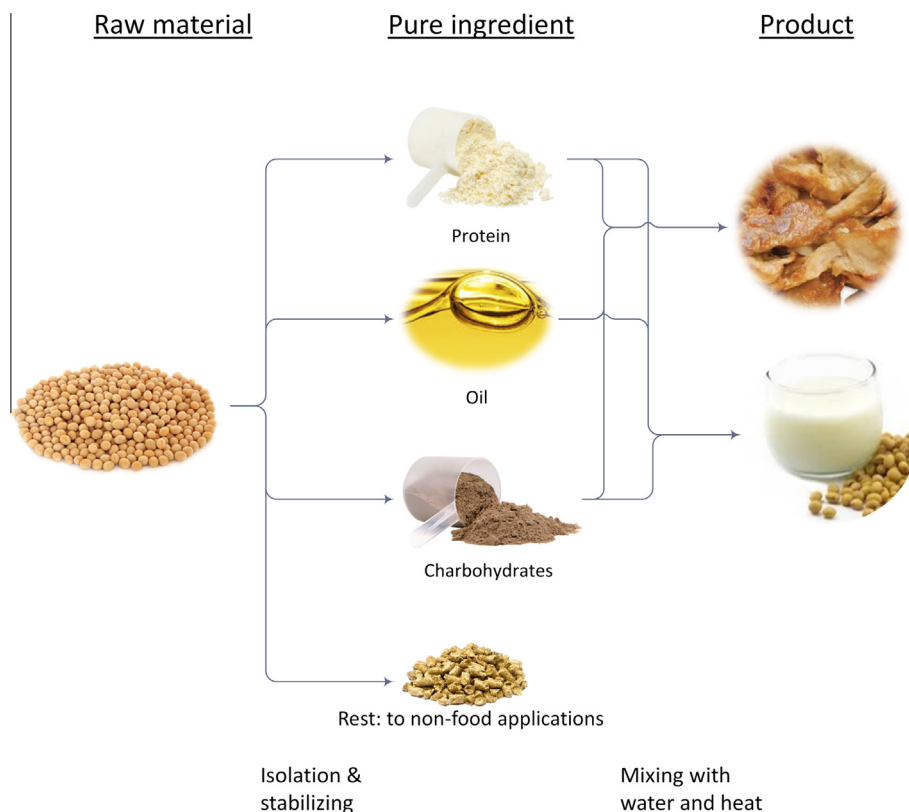


Fig. 1. Schematic outline of an example of the current production of food products.

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