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Life cycle costs and environmental impacts of production and consumption of ready and home-made meals

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ABSTRACT

Consumption of ready-made meals is growing rapidly and yet little is known about their economic and environmental impacts. This paper focuses on the economic aspects to estimate the life cycle costs, value added and consumer costs of ready-made meals, in comparison with the equivalent meals prepared at home. Their life cycle environmental impacts are also considered. A typical roast dinner is considered, consisting of chicken, vegetables and tomato sauce. Different production and consumption choices are evaluated, including sourcing of ingredients, chilled or frozen supply chains and types of appliance used by the consumer to prepare the meal. The estimated life cycle costs of the ready-made meal range from £0.61–£0.92 per meal and for the home-made from £0.68–£1.12. The lowest life cycle costs are found for the chilled ready-made meal heated in a microwave, 11% below the costs of the best home-made option. The life cycle costs of the frozen meal are similar to the best home-made option. The chilled ready-made meal has the highest value added (£2.01) compared to the frozen (£1.22) and the home-made meal (£0.44). However, from the consumer perspective, the cheapest option is the home-made meal (£1.17) while the chilled ready-made option is most expensive (£2.61). If the meal options are compared on both the life cycle costs and environmental impacts, the home-made meal is the best option overall. These findings can be used to inform both producers and consumers on how their choices influence costs and environmental impacts of food.

1. Introduction

The convenience food sector is growing rapidly, with the global ready-made meals market predicted to grow by 17% by 2016, from $1.11 trillion in 2011 to $1.3 trillion (Key Note, 2013). The majority of the expansion is expected to occur in China, the fastest growing market for ready-made meals in the world (Key Note, 2013). At present, the USA and the UK hold the largest market share in the world, estimated at £7.2 bn (Sheely, 2008) and £2.6 bn (Mintel, 2013), respectively. By comparison, the value of the whole Western European market is equivalent to £3.9 bn (Sheely, 2008), most of which is due to the UK market, which increased by 47% on the value in 2007 (Key Note, 2013). In the UK, chilled meals hold the vast majority of the market share (84%) with the rest belonging to frozen meals (Mintel, 2013). It is expected that the UK market will grow by a further 35% by 2017, reaching an estimated value of £3.5 bn (Mintel, 2013). Currently, a third of the British adult population consumes ready-made meals once a week, while in countries such as France only 15% of adults buy prepared meals. Overall, 8.8 kg of chilled and frozen ready-made meals are consumed in the UK per capita per year (Millstone and Lang, 2008).

The market is affected by many economic factors, including inflation, unemployment and household disposable income (Key Note, 2013). These are particularly apparent during an economic crisis when salaries freeze and employment goes down, while prices of value-added foods such as ready-made meals rise, affecting both consumers and producers. For a further discussion on the topic, see Aguiar and Hurst (2005). In the UK, food prices increased sharply since the onset of the recession in 2007, with the processed food sector being one of the most affected (Downing and Harker, 2012). A survey conducted by the consumer magazine WHICH? (2013) shows that 80% of consumers are worried about food prices and 60% have changed their shopping options because of the constant rise in food prices. As expected, the most affected are the lower-income earners and households with children (Green et al., 2013). As food affordability is a key factor in food poverty (Sustain, 2013), the rise in food prices affects the welfare of the

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population (IGD, 2014). In the UK, the National Health Service (NHS) spends £6 bn a year on food-related illnesses (Scarborough et al., 2011).

Therefore, it is important to analyse the economic costs of food production and consumption, considering costs to both producers and consumers, to help identify hotspots and opportunities for improvement. This can be achieved by taking a life cycle approach and using life cycle costing as a tool to estimate the costs along whole supply chains, from production of ingredients to preparation and consumption of food. Currently, life cycle costs (LCC) of food are poorly understood with few studies available in the literature. For example, Iotti and Bonazzi (2014) considered the LCC of Italian Parma ham, demonstrating the usefulness of life cycle costing for innovation, improving business efficiency and reducing production costs. Krozer (2008) also showed how LCC can be applied to identifying innovative solutions, finding that for the short-cycle products such as food the highest cost-saving opportunities are usually in the agriculture and waste management. Furthermore, de Luca et al. (2014) combined LCC with life cycle assessment (LCA) to help identify sustainable options for a citrus production system, considering conventional, integrated and organic farming. Some other studies also highlighted the need for the integration of LCC and LCA in the food sector (Senthil et al., 2003; Kloepffer (2008); Settanni et al., 2010).

However, as far as the authors are aware, no studies have considered the life cycle costs of ready-made meals which is the focus of this paper. The aim is to estimate the LCC of different ready-made alternatives and compare them to equivalent home-made meal options. In addition to the LCC, value added and costs to the consumer are also considered. Finally, to help identify more sustainable options from both the economic and environmental perspectives, the meal options are also compared for the life cycle environmental impacts, based on the previous work by the authors (Schmidt Rivera et al., 2014).

2. Methodology

The LCC methodology applied in this work follows the approach proposed by Swarr et al. (2011) and Hunkeler et al. (2008) and is congruent with the ISO 14040/44 methodology for LCA (ISO, 2006a, 2006b). This is detailed in the following sections.

2.1. Goal and scope

The main goals of this study are:

- to estimate the LCC of a ready-made meal and compare them to the costs of an equivalent home-made meal, considering different processing, distribution and consumption alternatives;
- to analyse the influence on the LCC of factors such as ingredient sourcing and type of cooking appliances;
- to estimate the value added along the supply chain as well as the costs of the meal to the consumer; and
- to compare the life cycle costs and environmental impacts of ready- and home-made meals to help identify the best options.

As the paper builds on the previous LCA study of ready-made meals by the authors (Schmidt Rivera et al., 2014), the scope, the functional unit and the composition of the meal in both studies are the same, to enable comparisons of different options for both the economic and environmental impacts. Thus, the scope of the study is from 'cradle to grave', considering all life cycle stages from production and processing of ingredients to manufacture, distribution and consumption of the meal, including end-of-life waste management. The functional unit is defined as 'preparation and consumption of a meal for one person'. The meal chosen for consideration represents a typical roast dinner, consisting of chicken meat and three vegetables (potatoes, carrots and peas) served with tomato sauce. The meal weighs 360 g with the recipe details given in Table 1.

2.2. System definition

As outlined in Fig. 1, the life cycle of the ready-made meal involves chicken rearing and cultivation of the vegetables, their processing in a slaughterhouse and at a regional distribution centre (RDC), respectively, preparation of the meal at a factory, its subsequent transport to another RDC, retailer and finally to consumer's home where it is prepared according to manufacturer's instructions. The life cycle of the home-made meal is similar, except that the meal is fully prepared at home, starting from fresh ingredients. For further details, see Schmidt Rivera et al. (2014).

2.3. Calculation of life cycle costs and value added

Total life cycle costs are estimated from 'cradle to grave' (see Fig. 2) according to the following equation:

$$LCC_{Cradle\ to\ grave} = C_{RM} + C_{PP} + C_M + C_P + C_D + C_C + C_W \quad (1)$$

where:

$LCC_{Cradle\ to\ grave}$ total life cycle cost of ready- or home-made meals from 'cradle to grave'
C_{RM} costs of raw materials (meal ingredients)
C_{PP} costs of pre-processing of raw materials
C_M costs of meal manufacturing (ready-made meal only)
C_P costs of packaging
C_D costs of distribution
C_C costs of meal consumption (consumer transport and meal preparation)
C_W costs of post-consumer waste disposal.

In addition to the LCC, value added (VA) is also considered in this work. VA is defined as sales minus the costs of bought-in materials and services (DTI, 2007), in effect representing a profit margin. It therefore provides an insight into the value to manufacturers and to society at large, the latter through the value added tax. For these purposes, the VA of the ready-made meal is estimated from 'cradle to distribution', taking into account all the costs up to and including meal distribution to and storage at retailers (Fig. 2), before being sold to the consumer. For the home-made meal, the system boundary is the same, except that the VA relates to the ingredients, rather than the meal. Therefore, the VA is calculated as follows:

Table 1
Composition of the ready- and home-made meals as served.

Ingredients	Weight (g)	Contribution (%)
Chicken	98	27.22
Potatoes	87.5	24.31
Carrots	35	9.72
Peas	35	9.72
Tomato sauce	94.5	26.25
Tomato paste	*66.2*[a]	*70*
Onions	*28.3*	*30*
Salt	1	0.28
Vegetable oil	9	2.50
Total	**360**	**100**

[a] 43.8 g of tomato paste plus water.

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