Designing a healthy and sustainable diet

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Abstract

Many Western countries such as Scotland face the challenge of reducing carbon emissions associated with food systems (Garnett 2011) while also improving dietary nutritional intake (Scottish Government 2016). Both measures together with affordability represent a sustainable diet. The purpose of this paper is to estimate a healthy and sustainable diet for the major demographic groups in Scotland through producing a list of food products which would help create such a diet. The data for the analysis were sourced from the National Diet and Nutrition Survey (NDNS) for the purposes of estimating Scottish food consumption categories and their respective nutrients. The datasets were augmented with prices obtained from 2014 Kantar Worldpanel data in addition to carbon footprint data (cradle to grave). The diet was designed using a linear programming model, which minimised the monetary cost of the diet subject to 22 nutritional constraints based on UK and Scottish dietary recommendations plus a greenhouse gas emission constraint. The results suggest that a sustainable and healthy diet is possible for all the demographic groups. All 22 nutrient constraints were satisfied in the modelling of the healthy and sustainable diet and the cost of the seven-day diet was estimated to be the most expensive for the Female 11-14 group at £18.20. However, the diets are virtually vegetarian based and some quantities of food products are unrealistic, which may pose issues for consumer acceptability.

Keywords [Food Consumption, Linear Programming, Nutrition, Sustainability]

JEL code [D120, C020, I100, Q560]
1. Introduction

Many Western countries such as Scotland face the challenge of reducing carbon emissions (i.e. greenhouse gas GHG emissions) associated with food systems (Garnett 2011) while also improving dietary nutritional intake (Scottish Government 2016). Therefore, designing a diet which fulfils the aforementioned issues is crucial with regards to the issue of sustainability.

The definition of a sustainable diet as agreed at the 2010 Food and Agriculture Organization (FAO) International Scientific Symposium on Biodiversity and Sustainable Diets is: “diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources.” (FAO 2012). A recent systematic literature review found that out of 113 peer reviewed papers studying sustainable diets, 71 papers measured GHG emissions whilst only 13 papers measured the associated monetary cost of such a diet (Jones et al. 2016). Therefore, the area of monetary cost of a sustainable diet is often ignored in favour of mainly GHG emissions.

This study will model a sustainable diet (referred to as a healthy and sustainable diet) based on the following three components: low in greenhouse gas emissions (GHG), fulfils the various government dietary recommended values (DRVs) and has a low monetary cost for consumers. This study estimates a healthy and sustainable diet for the major demographic groups in Scotland and produces a list of the relevant food products in order to achieve such a diet.

Many studies in agricultural economics such as Edjabou and Smed (2013), Caillavet et al (2016) and Kehlbacher et al (2016) have estimated the effects of price based policies on nutrient intake and carbon emissions through the fiscal measures of consumption taxes. However, these studies often lack detail on the exact quantities of food products which would form a healthy sustainable diet and understanding this would likely improve research in this area. The issue surrounding recent studies using linear programming (LP) are the lack of nutrient constraints in addition to failing to incorporate both price and GHG emissions into the model (Macdiarmid et al. 2012). Or only a small set of possible food products being used in the LP (Wilson et al. 2013).
The structure of the paper is as follows: The literature review highlights recent studies using LP. The Data section presents a description of the data required for the estimation of the LP. The methods section details how the LP was estimated along with the seven-day diet. The Results and Discussions section details the estimates of the LP.

2. Literature review
Macdiarmid et al (2011) used a linear programme with the objective function of minimising carbon emissions subject to the various dietary constraints for estimating a diet called “Livewell 2020” through the use of upper and lower limits of certain food products. The study found that the UK diet contained 7.14 kgCO2e/adult/day and estimated that the emissions associated with the “livewell” diet were 4.32 kgCO2e/woman/day (Macdiarmid et al. 2011). Macdiarmid et al (2011) estimated a weekly list of food products which could then be turned into recipes for different meals. The paper also estimated the monetary costs of this “Livewell 2020 diet” at £28.40 per person per week, which the authors attribute to helping with “consumer acceptability” (Macdiarmid et al. 2011).

More recent UK based sustainable diets were estimated by Macdiarmid et al (2012) which used 13 nutrient constraints in addition to some food constraints. The dietary constraints of a female aged 19-50 were based on Department of Health’s Committee on Medical Aspects (COMA) 1991 report. This report does provide a more comprehensive list of dietary reference values (DRVs) for the UK (COMA 1991) than just the 13 constraints. The results suggest that a 36 percent reduction in GHG emissions (relative to 1990 baseline diet) for a female diet is possible with acceptability constraints and an even larger reduction of 90 percent is possible though the resulting diet is unlikely to be acceptable to consumers (Macdiarmid et al. 2012). Macdiarmid et al (2012) estimated the lowest possible GHG emissions diet of 2.43 kg CO2e/day with the GHG emission data being adjusted by the authors to partially account for some of the consumer stages e.g. hydration of rice involved in cooking.

Macdiarmid et al (2012) estimated the lowest possible GHG emissions diet through LP modelling with “acceptability” constraints. The acceptability constraints involved placing upper and lower constraints which were formed from food products which were consumed from at least 50 percent of the NDNS sample (Macdiarmid et al. 2012). This is an improvement relative to the other studies though it does mean that the list of total food products entered into
the LP is likely reduced. It may be the case that some demographic groups have particular preferences, which would be ignored through this method.

While acceptability is an important area, it does seem that understanding the underlying consumer preferences would provide for an idea of food substitutes for which these authors do not include. The study included the use of inserting milk as a minimum requirement in order to have cereal and milk (in addition to add to hot drinks) as the LP returned cereal without milk (Macdiarmid et al. 2012). Macdiarmid et al (2012) explain that reducing milk below certain levels would pose a problem with the cereal component of the diet. However, some milk products do have a relatively low carbon footprint and it is possible that the study’s use of attaching a carbon footprint to the food groups instead of individual products may have masked this potential result.

Wilson et al (2013) used LP in order to model different scenarios involving both cost and emissions with regards to New Zealand through modelling DRVs of males only. Wilson et al (2013) used data covering 76 food items and GHG emissions data which from the description likely covers cradle to regional distribution centre. The price data were obtained from the New Zealand Food Price Index (FPI) and online supermarkets (Wilson et al. 2013). The study involved four scenarios whereby cost was minimised, four scenarios where emissions were minimised and finally Asian and Mediterranean diets. The results suggest all the scenarios would result in more nutritious diets (relative to NZ existing diets) and were less costly than the existing NZ diet (Wilson et al. 2013). However, this study includes a limited range of food items and the use of separate cost and emission scenarios appears to limit the ability of the diet to be both low monetary cost and low emissions. There is also little attempt to extend the resulting diet to a weekly basis such as in Macdiarmid et al (2012).

Horgan et al (2016) used linear programming in order to understand how individual diets from the National Diet and Nutrition Survey (NDNS) sample could be changed in order to create a healthier and lower GHG diet. The paper found that diverse changes in diet could result in a healthy and sustainable diet. Horgan et al (2016) used four different steps in order to increase their sample (from the NDNS) which adheres to a sustainable and healthy diet based on four different steps: “1. No change to the foods being eaten, only the quantity”, “2. Changes to the amount of any food already being eaten and addition of new foods”, “3. Greater reduction in the amount of any food already eaten and new foods added” and “4. Removal of any food from
the current diet”. This is particularly interesting result which demonstrates the challenge of healthy diets (not even sustainable) is that only one person out of the 1,491 sample met all the constraints. Horgan et al (2016) did not consider the cost of this healthy and sustainable diet.

3. Empirical work
3.1 Data
The data consisted of using the National Diet and Nutrition Survey (NDNS) for the purposes of estimating the available food products and their respective nutrient content. Median unit prices of food products were obtained from the Scottish section of the 2014 Kantar Worldpanel data and matched to the NDNS data. Cradle to grave carbon footprint data were matched to the NDNS data. The constraints consisted of 22 dietary reference values (DRVs) which were obtained from the Department of Health’s Committee on Medical Aspects report in addition to the updated Scottish Dietary Goals (Scottish Government 2016).

National Diet and Nutrition Survey (NDNS)
The NDNS “year 4 databank” (covering 2008 to 2012) was used for this study as it contains nutrient data for a variety of food products (NatCen Social Research, MRC Human Nutrition Research & University College London 2015). This dataset contains 4,379 records on food, drink and supplements. However, as products such as baby foods, alcohol and supplements were not required the dataset was reduced to 4,405 records. There were also cases where products in the NDNS dataset could not be found in the Kantar dataset such for specific branded products or particular food products.

Dietary recommended values
The DRVs are based mainly on the reference nutrient intakes (RNI) and revised Scottish dietary goals (SDG). The RNI is the amount of nutrient which satisfies the requirement of at least 97 percent of a group (Eastwood 1997). The Scottish Dietary Goals (SDG) cover additional nutrients relative to the RNIs (Scottish Government 2016). This study focusses on the nutrients listed in Table 1 which form the constraints for the linear programme. One of the recent revisions made to the SDG is that dietary fibre intake should increase for adults to 30g/day (Scottish Government 2016). It is important to highlight the NDNS dataset records Englyst

1 Referred to as reference nutrient intake (RNI)
(NSP) fibre which is different from the AOAC fibre of SDG. Lockyer et al (2016) provide the conversion factor for the different fibres.
Table 1 Dietary recommended values for the different demographic groups

<table>
<thead>
<tr>
<th></th>
<th>Child 7-10</th>
<th>Female 11-14</th>
<th>Male 11-14</th>
<th>Female 15-18</th>
<th>Male 15-18</th>
<th>Female 19-50</th>
<th>Male 19-50</th>
<th>Female 50 Plus</th>
<th>50</th>
<th>Male 50 Plus</th>
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<tr>
<td>Energy (Kj)</td>
<td>7362.5</td>
<td>9100</td>
<td>9850</td>
<td>10175</td>
<td>12575</td>
<td>8950</td>
<td>11225</td>
<td>8300</td>
<td>10250</td>
<td></td>
</tr>
<tr>
<td>Protein (g)</td>
<td>28.3</td>
<td>41.2</td>
<td>42.1</td>
<td>45</td>
<td>55.2</td>
<td>45</td>
<td>55.5</td>
<td>46.50</td>
<td>53.3</td>
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<tr>
<td>Sodium (mg)</td>
<td>1200</td>
<td>1600</td>
<td>1600</td>
<td>1600</td>
<td>1600</td>
<td>1600</td>
<td>1600</td>
<td>1600</td>
<td>1600</td>
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</tr>
<tr>
<td>Calcium (mg)</td>
<td>550</td>
<td>800</td>
<td>1000</td>
<td>800</td>
<td>1000</td>
<td>700</td>
<td>700</td>
<td>700</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>200</td>
<td>280</td>
<td>280</td>
<td>300</td>
<td>300</td>
<td>270</td>
<td>300</td>
<td>270</td>
<td>300</td>
<td></td>
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<tr>
<td>Iron (mg)</td>
<td>8.7</td>
<td>14.8</td>
<td>11.3</td>
<td>14.8</td>
<td>11.3</td>
<td>14.8</td>
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<tr>
<td>Copper (mg)</td>
<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
<td>1</td>
<td>1</td>
<td>1.2</td>
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<td>1.2</td>
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<tr>
<td>Zinc (mg)</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>7</td>
<td>9.5</td>
<td>7</td>
<td>9.5</td>
<td>7</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>Vitamin A (µg)</td>
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<td>600</td>
<td>700</td>
<td>600</td>
<td>700</td>
<td>600</td>
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<td>600</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>0.7</td>
<td>0.7</td>
<td>1.1</td>
<td>0.8</td>
<td>1.1</td>
<td>0.8</td>
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<td>0.80</td>
<td>0.9</td>
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<tr>
<td>Riboflavin (mg)</td>
<td>1</td>
<td>1.1</td>
<td>0.9</td>
<td>1.1</td>
<td>1.3</td>
<td>1.1</td>
<td>1.3</td>
<td>1.1</td>
<td>1.3</td>
<td></td>
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<tr>
<td>Niacin (mg)</td>
<td>12</td>
<td>12</td>
<td>15</td>
<td>14</td>
<td>18</td>
<td>13</td>
<td>17</td>
<td>12</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Vitamin B6 (mg)</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
<td>1.2</td>
<td>1.5</td>
<td>1.2</td>
<td>1.4</td>
<td>1.2</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Vitamin B12 (µg)</td>
<td>1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>150</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>30</td>
<td>35</td>
<td>35</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Iodine (µg)</td>
<td>110</td>
<td>130</td>
<td>130</td>
<td>140</td>
<td>140</td>
<td>140</td>
<td>140</td>
<td>140</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>Selenium (µg)</td>
<td>30</td>
<td>45</td>
<td>45</td>
<td>60</td>
<td>70</td>
<td>60</td>
<td>75</td>
<td>60</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Sugar (g)</td>
<td>20</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>30</td>
<td>30.00</td>
<td>30</td>
<td>30</td>
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<td></td>
</tr>
<tr>
<td>Fat (g)*</td>
<td>65.96</td>
<td>67.39</td>
<td>73.13</td>
<td>61.16</td>
<td>90.61</td>
<td>59.13</td>
<td>87.92</td>
<td>54.66</td>
<td>81.06</td>
<td></td>
</tr>
<tr>
<td>Saturated Fat (g)*</td>
<td>20</td>
<td>20</td>
<td>22.98</td>
<td>19.22</td>
<td>28.48</td>
<td>18.58</td>
<td>27.63</td>
<td>17.18</td>
<td>25.48</td>
<td></td>
</tr>
<tr>
<td>Fibre (g)</td>
<td>14.80</td>
<td>15.70</td>
<td>15.70</td>
<td>18.50</td>
<td>18.50</td>
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<td>18.50</td>
<td>18.50</td>
<td></td>
</tr>
</tbody>
</table>

Source: Based on reference nutrient intakes (RNI) and revised Scottish dietary goals (SDG)

Notes: * indicates that the absolute values for total fat and saturated fat presented were estimated using the Scottish Dietary Goals (Scottish Government 2016) relative fat intake guidelines. These were estimated using NDNS “Person level dietary data”.
Kantar Worldpanel data
In order to obtain unit prices paid by households it was necessary to use the Scottish section of Kantar Worldpanel data. Kantar Worldpanel provided different food groups. 589 of these food groups were individually matched to the NDNS food products with homemade food products being matched to the most similar products in the Kantar database. The median unit price for each category were estimated (adjusted on per 100 gram basis) in order for a more representative price which is not skewed by either low cost or luxury products (e.g. coffee) within a particular category.

Cradle to grave carbon footprint data
Some studies such as Macdiarmid et al (2012) have estimated diets based on cradle to regional distribution centre (at food group level and not individual products) and then adjusted the values to partially incorporate the end sections of the chain. However, this study has used cradle to grave carbon footprint data in order to estimate a diet which considers the waste stage etc. of the food chain. Most of the carbon footprint (CF) values (main exceptions being tap water and hot beverages) follow the British Standards Institute PAS 2050 cradle to grave method (BSI 2008) in order to ensure greater consistency. In total 116 carbon footprint values were matched to the 4,405 NDNS products.

3.2 Method
Figure 1 shows how the three main datasets are combined for the purposes of estimating the linear programme. The estimation follows an iterative process in the sense that after the first diet is obtained (i.e. Day one), any food product within the diet were removed from the aforementioned dataset. This process was repeated until a seven-day diet was formed and ensures that different food products would be contained within each diet. Diets for the main demographic groups were estimated in order to obtain a resulting diet which closely matches the specific group DRVs.
Before estimating the linear programme, a restriction was placed on the NDNS data whereby products which contained zero energy were excluded in order to avoid the resulting diets containing unrealistically large quantities of products such as tea or water. A further restriction included excluding all alcoholic beverages as these are not listed in either the COMA or SDG.

The linear programme (LP) were estimated\(^2\) using the objective function to minimise the monetary cost of diet. With regards to equation 1 the objective function (minimise unit costs i.e. price) is made up of: \(c_i\) which is the contribution of food item \(i\) to unit cost, \(x_i\) is quantity of food and subscript \(n\) represents the food groups. Inequality and equality constraints are shown in 2 to 4 and feature \(r_j\) which represents the carbon or nutritional constraints formed from these groups and \(a_{jn}\) is the weight of the food group to theses dietary constraints.

\[
\min \sum_{i=1}^{n} c_i x_i \\
\text{s.t.}
\]

2 represents the minimum carbon emissions of the diet. The carbon footprint constraints were estimated from running the LP with the objective function minimising the carbon footprint

\(^2\) The LP was estimated using R package “Rglpk” (Theussl et al. 2016)
(removing price) and the resulting emissions were then set as a minimum level constraint of emissions for the diet. The reason that this constraint is set at a minimum level is because initial estimations found that the dietary recommended values required adjustment if the emissions were set as a maximum level and this therefore distorts the purpose of the sustainable healthy diet.

\[
\sum_{j=1}^{19} q_j x_j \geq r_j
\]  
(2)

3 represents 19 of the DRVs which ensures the resulting diet equates to the exact DRV.

\[
\sum_{j=1}^{19} q_j x_j = r_j
\]  
(3)

4 represents total fat and saturated fat constraints.

\[
\sum_{j=1}^{2} q_j x_j \leq r_j
\]  
(4)

It is important to note that each run of the LP was checked for the condition of it being an optimal solution.

4. Results and Discussion

The results suggest that a sustainable and healthy diet is possible for all the demographic groups. All 22 nutrient constraints (in addition to the GHG constraint) were satisfied in the modelling of the healthy sustainable diet. Table 2 shows the resulting carbon emissions associated with the diet and the resulting cost. It should be noted that as some of the quantities modelled, such as herbs are small quantities and a unit price represents these products (given that a jar of herbs could last an individual many weeks). Due to space constraints only day seven diets are listed in the appendix though the full seven-day diets are available from the author.

The GHG emissions of the seven day diets in Table 2 shows a variation from the lowest value of 12.66 Kg CO₂e for children aged 7 to 11 to the highest value of 24.75 Kg CO₂e for males aged 15 to 18. Using Audsley et al (2009) “Annual emissions per capita in regions” it is possible to estimate an approximate reduction in emissions of each Scottish diet. Audsley et al (2009) do emphasise the uncertainties with their data and the following results should be treated with some caution as it is similar but not identical to the carbon footprint data of this study. All the diets would reduce GHG emissions by a large percentage with the children aged 7-11
experiencing the largest reduction of 83.5 percent. The large reduction appears logical given the composition of such diets which will be discussed in the next two paragraphs.

The day one and day seven diets in Table 3 to Table 20 (in the appendix) show a varied list of food products along with the quantity (grams). For some of these diets, food products are listed in very small quantities and this does pose an issue for a realistic diet. However, unlike Macdiarmid et al (2012), milk products feature in many of the days which could be used as a drink or with cereal (for day 7 milk products do not feature to the same extent as previous days). As the only constraints were excluding alcohol and zero energy products then this is an interesting finding which has likely arisen through using more detailed carbon emissions and price data. Unfortunately, it is difficult to estimate an average Scottish NDNS diet at the same level of disaggregation as this study which makes estimating a baseline diet for purposes of nutrient intake and carbon emissions unreliable.

The existence of meat and cheese which are both considered to have high carbon footprints and in most cases high in saturated fat (excluding white meats) made up very low shares of the seven-day diet for each demographic group (as shown in Table 2). All of the diets for the individual demographic groups are virtually meat and cheese free. This does raise the question of consumers adapting to a vegetarian diet. In many of the day one diets “energy drink mix powder maltodextrin based” existed which then limited other sugar based food products (all diets fulfilled their sugar constraint). This product may not be acceptable to many consumer preferences.

The most expensive seven day diet would be for the Female 11-14 group of £18.20 (using 2014 Kantar Worldpanel prices). This is an approximate figure given the earlier explanation with regards to jars of herbs. However, this value is lower than the 2014 UK average weekly food expenditure of £29.57 (nominal expenditure) (Defra 2015). Whilst Macdiarmid et al (2012) created full menus (which this study did not do) which could affect the overall cost to the consumer (likely to increase the cost) and their study found that the resulting diet would cost approximately £29 (in 2010 prices). As Macdiarmid et al (2012) did not use price in the objective function then it does make a direct comparison difficult. As this is one of the first studies to include both GHG emissions and price (sourced from Kantar Worldpanel data) then it seems that healthy sustainable diets are not as expensive as previously modelled.
Table 2: Carbon emissions and costs associated with seven day diet

<table>
<thead>
<tr>
<th></th>
<th>Carbon emissions (Kg CO2e)</th>
<th>Reduction in emissions (%)</th>
<th>Cost (£)</th>
<th>Share of meat and cheese (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 7-10</td>
<td>12.66</td>
<td>83.5</td>
<td>6.98</td>
<td>0.03</td>
</tr>
<tr>
<td>Female 11-14</td>
<td>18.64</td>
<td>75.6</td>
<td>18.20</td>
<td>0.04</td>
</tr>
<tr>
<td>Male 11-14</td>
<td>18.08</td>
<td>76.4</td>
<td>12.63</td>
<td>0.02</td>
</tr>
<tr>
<td>Female 15-18</td>
<td>23.32</td>
<td>69.5</td>
<td>16.60</td>
<td>0</td>
</tr>
<tr>
<td>Male 15-18</td>
<td>24.75</td>
<td>67.7</td>
<td>15.69</td>
<td>0.01</td>
</tr>
<tr>
<td>Female 19-50</td>
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<td>75.4</td>
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<tr>
<td>Male 19-50</td>
<td>24.47</td>
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<td>Female 50 plus</td>
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<tr>
<td>Male 50 Plus</td>
<td>22.13</td>
<td>71.1</td>
<td>12.19</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Source: Own elaborations

Incorporating consumer acceptability which is based on microeconomic theory would likely improve these results as a healthy and sustainable diet must be a realistic diet from a consumer’s preferences in order to increase the likelihood of the actual diet being consumed. The time scale could be adjusted from a seven-day diet to a 14-day diet in order to create a more varied diet. However, this could result in an unrealistic diet in the sense that the resulting food products may be unappetising or the quantities are very small.

5. Conclusions

Designing a healthy and sustainable for Scottish individuals would be possible and could also cost the consumer less than the average UK weekly food expenditure. This highlights how a healthy sustainable diet may also be less expensive for the consumer which is likely because of the lack of meat. The inclusion of 589 prices (in the form of unit price) and 116 carbon footprint values marks an improvement over the previous literature which used food groups rather than individual level matching. Also the inclusion of price and carbon footprint values in the linear programme (LP) allow for improved dietary modelling. This study also modelled the DRVs of the individual groups rather than one demographic DRVs to represent all demographic groups.

However, there are issues with using LP such as the failure to account for consumer acceptability through the incorporation of microeconomic theory. The unrealistic quantities of some food products is also an issue. The main contribution of this study is the improved use of data and linear programming. This study recommends the use of similar disaggregated food data for future work on modelling sustainable diets instead of food group level data.
6. References

Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C. & Williams, A. 2009, *How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050*, WWF-UK.


Garnett, T. 2011, "Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)?", *Food Policy*, vol. 36, pp. S23-S32.


Appendix

The following tables show the quantities (Grams) of food products (FOODNAME) which would satisfy the nutritional and GHG emission constraints of the specific demographic groups. The FOODNAME is derived from the NDNS dataset. Due to space constraints it was not possible to show the seven day diet for each demographic group thus only day one and seven diets are shown.

Table 3 Child aged 7 to 10- Day one food list

<table>
<thead>
<tr>
<th>Grams</th>
<th>FOODNAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>98.14</td>
<td>GARI (CASSAVA FLOUR)</td>
</tr>
<tr>
<td>62.77</td>
<td>SR FLOUR AFTER BAKING</td>
</tr>
<tr>
<td>55.89</td>
<td>PITTA BREAD, WHOLEMEAL, TOASTED</td>
</tr>
<tr>
<td>47.78</td>
<td>MILK SKIMMED WITH ADDED VIT UHT</td>
</tr>
<tr>
<td>46.38</td>
<td>MAPLE SYRUP</td>
</tr>
<tr>
<td>30.24</td>
<td>EGG, WHOLE, FRIED IN SUNFLOWER OIL</td>
</tr>
<tr>
<td>25.41</td>
<td>REDUCED FAT SPREAD (41-62% FAT) NOT POLYUNSATURATED, WITH OLIVE OIL</td>
</tr>
<tr>
<td>24.10</td>
<td>POTATO CAKES (SCONES) PURCHASED</td>
</tr>
<tr>
<td>23.52</td>
<td>HALO REDUCED CALORIE AND FAT CHOCOLATE BAR</td>
</tr>
<tr>
<td>20.22</td>
<td>OAT BRAN</td>
</tr>
<tr>
<td>19.43</td>
<td>BLENDED VEGETABLE OIL</td>
</tr>
<tr>
<td>14.45</td>
<td>WHITE CHOCOLATE BUTTONS MICE</td>
</tr>
<tr>
<td>10.91</td>
<td>BANANA COOKED</td>
</tr>
<tr>
<td>10.89</td>
<td>COCONUT DESICCATED UNSWEETENED</td>
</tr>
<tr>
<td>10.18</td>
<td>NUT &amp; SUGAR SWEETS</td>
</tr>
<tr>
<td>9.84</td>
<td>BREAD ROLLS, WHITE WITH ADDED WHEATGERM</td>
</tr>
<tr>
<td>9.56</td>
<td>FLORA PRO ACTIV LIGHT SPREAD ONLY</td>
</tr>
<tr>
<td>4.91</td>
<td>GREEN BANANA FRIED RED PALM OIL</td>
</tr>
<tr>
<td>3.97</td>
<td>CARROTS FRIED IN PUFA OIL</td>
</tr>
<tr>
<td>2.67</td>
<td>WHOLEMEAL FLOUR WITH LOSSES</td>
</tr>
<tr>
<td>1.33</td>
<td>CHICKEN TIKKA MASALA WITH RICE, LOW FAT</td>
</tr>
<tr>
<td>0.68</td>
<td>LIQUORICE SHAPES</td>
</tr>
<tr>
<td>Grams</td>
<td>FOODNAME</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>133.69</td>
<td>PRUNES CANNED IN SYRUP FRUIT &amp; SYRUP</td>
</tr>
<tr>
<td>129.56</td>
<td>RICE WHITE LONG GRAIN POLISHED DRIED</td>
</tr>
<tr>
<td>121.84</td>
<td>GREEK YOGURT SHEEP</td>
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<td>88.50</td>
<td>CASSAVA-FRESH RAW</td>
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<td>TORTILLA CHIPS IN SUNSEED OR HIGH OLEIC SUNFLOWER OIL, EG DORITOS</td>
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<td>37.06</td>
<td>PANCAKES MADE WITH GLUTEN FREE FLOUR</td>
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<td>LIGHT SPREADABLE BUTTER (60% FAT)</td>
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<td>16.90</td>
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<tr>
<td>15.43</td>
<td>FLOUR WHITE SELF RAISING</td>
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<tr>
<td>12.64</td>
<td>CORN MEAL UNSIFTED DRIED</td>
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<tr>
<td>12.21</td>
<td>REDUCED FAT SPREAD (41-62% FAT) POLYUNSATURATED</td>
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<td>11.32</td>
<td>UNFORTIFIED MARGARINE (MANUFACTURED PRODUCTS ONLY)- DO NOT USE, SUPPORTS</td>
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<td>PARSNIPS BOILED</td>
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<td>MOUSSE, CHOCOLATE, LOW FAT</td>
</tr>
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<td>INSTANT HOT OAT CEREAL, NOT FLAVOURED, DRY WEIGHT, NOT FORTIFIED W.G</td>
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<td>3.88</td>
<td>BISTO SAUCE GRANULES</td>
</tr>
<tr>
<td>3.08</td>
<td>FLORA PRO ACTIV EXTRA LIGHT ONLY</td>
</tr>
<tr>
<td>1.80</td>
<td>OATS, ROLLED, PLAIN, DRY WEIGHT, NOT QUAKER, READY BREK/ INSTANT OATS</td>
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<td>CLUSTER/GUARE BEANS RAW</td>
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<td>POPPY SEEDS</td>
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<td>THYME DRIED</td>
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Table 5 Female 11 to 14 - Day one food list

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<td>ENERGY DRINK MIX POWDER MALTODEXTRIN BASED</td>
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<td>120.29</td>
<td>OATMEAL WITH COOKING LOSSES</td>
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<tr>
<td>100.84</td>
<td>MILK WHOLE STERILISED</td>
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<tr>
<td>80.41</td>
<td>EGG, WHOLE, FRIED IN SUNFLOWER OIL</td>
</tr>
<tr>
<td>58.63</td>
<td>BREAD ROLLS, WHITE WITH ADDED WHEATGERM</td>
</tr>
<tr>
<td>56.16</td>
<td>MAPLE SYRUP</td>
</tr>
<tr>
<td>30.69</td>
<td>LENTILS CANNED IN TOMATO SAUCE</td>
</tr>
<tr>
<td>29.56</td>
<td>BROCCOLI-SPROUTING RAW</td>
</tr>
<tr>
<td>20.96</td>
<td>CHILLI PICKLE OILY</td>
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<td>20.83</td>
<td>COCONUT DESICCATED UNSWEETENED</td>
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<tr>
<td>16.65</td>
<td>REDUCED FAT SPREAD (41-62% FAT) NOT POLYUNSATURATED, WITH OLIVE OIL</td>
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<td>10.49</td>
<td>BLACK TREACLE</td>
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<tr>
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<td>8.54</td>
<td>FLORA PRO ACTIV LIGHT SPREAD ONLY</td>
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<tr>
<td>6.03</td>
<td>CARROTS, YOUNG, FRESH, RAW</td>
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<td>5.93</td>
<td>NUT &amp; SUGAR SWEETS</td>
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<td>Grams</td>
<td>FOODNAME</td>
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<td>POPCORN SALTED E.G. MICROWAVE OR PURCHASED</td>
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<td>LETTUCE-ICEBERG RAW</td>
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<td>CHERRIES CANNED IN SYRUP WITH OR WITHOUT STONES FRUIT &amp; SYRU</td>
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<tr>
<td>6.83</td>
<td>ORGANO DRIED</td>
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<tr>
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</tr>
<tr>
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<td>0.37</td>
<td>FRENCH DRESSING</td>
</tr>
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<td>93.69</td>
<td>MILK SKIMMED WITH ADDED VIT UHT</td>
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<tr>
<td>67.25</td>
<td>OATMEAL WITH COOKING LOSSES</td>
</tr>
<tr>
<td>65.64</td>
<td>EGG, WHOLE, FRIED IN SUNFLOWER OIL</td>
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<tr>
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<td>BLENDED VEGETABLE OIL</td>
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<td>GARI (CASSAVA FLOUR)</td>
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<td>CHILLI PICKLE OILY</td>
</tr>
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<td>19.93</td>
<td>OAT BRAN</td>
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<td>SR FLOUR AFTER BAKING</td>
</tr>
<tr>
<td>17.87</td>
<td>GREEN BANANA FRIED RED PALM OIL</td>
</tr>
<tr>
<td>16.06</td>
<td>WHITE CHOCOLATE BUTTONS MICE</td>
</tr>
<tr>
<td>14.63</td>
<td>CARROTS FRIED IN PUFA OIL</td>
</tr>
<tr>
<td>10.16</td>
<td>WHEATGERM</td>
</tr>
<tr>
<td>9.17</td>
<td>FLORA PRO ACTIV LIGHT SPREAD ONLY</td>
</tr>
<tr>
<td>6.54</td>
<td>ACAI BERRY JUICE DRINK WITH VITAMIN B6</td>
</tr>
<tr>
<td>3.18</td>
<td>TAHINI:SESAME SEED PASTE</td>
</tr>
<tr>
<td>1.84</td>
<td>BRAZIL NUTS KERNEL ONLY</td>
</tr>
<tr>
<td>1.53</td>
<td>LIQUORICE SHAPES</td>
</tr>
<tr>
<td>1.43</td>
<td>CHICKEN TIKKA MASALA WITH RICE, LOW FAT</td>
</tr>
<tr>
<td>1.07</td>
<td>SINGLE STRENGTH HIGH JUICE CONC, LOW SUGAR, BLACKCURRANT</td>
</tr>
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<td>Grams</td>
<td>FOODNAME</td>
</tr>
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<td>-------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td>432.68</td>
<td>FRUIT JUICE DRINK RTD NAS WITH VITAMINS A,C,E, AND CALCIUM</td>
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<td>TORTILLA CHIPS</td>
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<td>OAT CREAM (NON-DAIRY ALTERNATIVE)</td>
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<td>CORNFLAKES UNFORTIFIED, INCLUDING ORGANIC BRANDS</td>
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<td>TRifle, FRUIT PURCHASEd WITH FRESH CREAM</td>
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<td>MULLER VITALITY PROBIOTIC DRINK</td>
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<td>YOGURT, VIRTUALLY FAT FREE, NATURAL, UNSWEETENED</td>
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<tr>
<td>28.92</td>
<td>POTATO CRISPS VERY LOW FAT WITH ARTIFICIAL SWEETENER</td>
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<td>BENECOL LIGHT SPREAD</td>
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<tr>
<td>25.70</td>
<td>BEETROOT UNCOOKED</td>
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<td>PASTA SAUCE, CARBONARA TYPE</td>
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<td>23.27</td>
<td>MARROW PARWAL BOILED Instant Hot Oat Cereal, Not Flavoured, Dry Weight, Not Fortified WM</td>
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<td>OATSO SIMPLE</td>
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<tr>
<td>15.51</td>
<td>QUORN SAUSAGE</td>
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<tr>
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<td>THAI FRAGRANT RICE - RAW</td>
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<tr>
<td>5.35</td>
<td>FLORA LIGHTER THAN LIGHT</td>
</tr>
<tr>
<td>3.72</td>
<td>EGG YOLK RAW</td>
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<td>1.27</td>
<td>THYME DRIED</td>
</tr>
<tr>
<td>0.91</td>
<td>OYSTERS RAW</td>
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### Table 9 Female 15 to 18 - Day one food list

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<th>Grams</th>
<th>FOODNAME</th>
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<tr>
<td>305.28</td>
<td>ENERGY DRINK MIX POWDER MALTODEXTRIN BASED</td>
</tr>
<tr>
<td>116.17</td>
<td>EGG, WHOLE, FRIED IN SUNFLOWER OIL</td>
</tr>
<tr>
<td>110.54</td>
<td>MILK WHOLE STERILISED</td>
</tr>
<tr>
<td>56.59</td>
<td>BREAD ROLLS, WHITE WITH ADDED WHEATGERM</td>
</tr>
<tr>
<td>49.08</td>
<td>OATMEAL WITH COOKING LOSSES</td>
</tr>
<tr>
<td>36.18</td>
<td>GREEN BANANA FRIED RED PALM OIL</td>
</tr>
<tr>
<td>24.93</td>
<td>CHILLI PICKLE OILY</td>
</tr>
<tr>
<td>22.50</td>
<td>ORANGE PEEL</td>
</tr>
<tr>
<td>20.93</td>
<td>BROWN LENTILS BOILED IN SALTED WATER</td>
</tr>
<tr>
<td>19.05</td>
<td>MILK SEMI-SKIMMED PASTEURIZED WITH SMP AND VITS A &amp; D</td>
</tr>
<tr>
<td>17.03</td>
<td>GARI (CASSAVA FLOUR)</td>
</tr>
<tr>
<td>16.43</td>
<td>OAT BRAN</td>
</tr>
<tr>
<td>15.11</td>
<td>MAPLE SYRUP</td>
</tr>
<tr>
<td>14.18</td>
<td>LIQUORICE SHAPES</td>
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<tr>
<td>13.27</td>
<td>BROAD BEANS DRIED RAW</td>
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<td>COCONUT DESICCATED UNSWEETENED</td>
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<td>9.10</td>
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<td>6.06</td>
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<tr>
<td>5.68</td>
<td>GREEN BANANA FRIED IN BLENDED OIL</td>
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<tr>
<td>4.70</td>
<td>BLACK TRECACLE</td>
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Table 10 Female 15 to 18 - Day seven food list

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<td>333.07</td>
<td>RICE WHITE LONG POLISHED BOILED</td>
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<tr>
<td>215.32</td>
<td>MULLER VITALITY PROBIOTIC DRINK</td>
</tr>
<tr>
<td>166.24</td>
<td>PEARs EATING RAW FLESH &amp; SKIN ONLY NO CORE</td>
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<tr>
<td>100.98</td>
<td>CORN BASED SNACKS EG MONSTER MUNCH, WOTSITS, TRANSFORM-A-SNACK</td>
</tr>
<tr>
<td>98.40</td>
<td>WHITE BASMATI RICE DRY</td>
</tr>
<tr>
<td>77.55</td>
<td>TORTILLA CHIPS</td>
</tr>
<tr>
<td>75.77</td>
<td>BEEFTROOT BOILED (SALTED WATER)</td>
</tr>
<tr>
<td>61.21</td>
<td>CHERRIES CANNED IN SYRUP FRUIT ONLY</td>
</tr>
<tr>
<td>49.19</td>
<td>ARROWROOT POWDER</td>
</tr>
<tr>
<td>44.92</td>
<td>APPLES COOKING BAKED WITHOUT SUGAR FLESH &amp; SKIN ONLY</td>
</tr>
<tr>
<td>35.89</td>
<td>SWEETCORN, BABY COB, CANNED DRAINED NO ADDED SALT OR SUGAR</td>
</tr>
<tr>
<td>34.12</td>
<td>FLORA PRO ACTIV SKIMMED MILK</td>
</tr>
<tr>
<td>33.53</td>
<td>CARROTS-FROZEN BOILED</td>
</tr>
<tr>
<td>14.23</td>
<td>BANANA CHIPS WITH ADDED FAT DRIED WEIGHT</td>
</tr>
<tr>
<td>10.87</td>
<td>INSTANT HOT OAT CEREAL, NOT FLAVOURED, DRY WEIGHT, NOT FORTIFIED WG</td>
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<tr>
<td>10.18</td>
<td>HADDOCK STEAMED NO BUTTER</td>
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<tr>
<td>9.53</td>
<td>BANANA DRIED NO ADDED FAT OR SUGAR</td>
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<td>7.63</td>
<td>CAVIAR</td>
</tr>
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<td>DRIED MIXED HERBS</td>
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<td>EGG YOLK FRIED IN BUTTER</td>
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Table 11 Male 15 to 18 - Day one food list

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<td>SR FLOUR AFTER BAKING</td>
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<tr>
<td>99.59</td>
<td>EGG, WHOLE, FRIED IN SUNFLOWER OIL</td>
</tr>
<tr>
<td>84.02</td>
<td>MILK SKIMMED WITH ADDED VIT UHT</td>
</tr>
<tr>
<td>48.66</td>
<td>GREEN BANANA FRIED RED PALM OIL</td>
</tr>
<tr>
<td>41.73</td>
<td>RICE WITH LOSSES</td>
</tr>
<tr>
<td>37.74</td>
<td>OAT BRAN</td>
</tr>
<tr>
<td>37.22</td>
<td>BREAD ROLLS, WHITE WITH ADDED WHEATGERM</td>
</tr>
<tr>
<td>33.08</td>
<td>MAPLE SYRUP</td>
</tr>
<tr>
<td>31.58</td>
<td>OATMEAL WITH COOKING LOSSES</td>
</tr>
<tr>
<td>30.65</td>
<td>WHITE CHOCOLATE BUTTONS MICE</td>
</tr>
<tr>
<td>30.19</td>
<td>BLENDED VEGETABLE OIL</td>
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<tr>
<td>13.29</td>
<td>CHILLI PICKLE OILY</td>
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<tr>
<td>10.40</td>
<td>REDUCED FAT SPREAD (41-62% FAT) NOT POLYUNSATURATED, WITH OLIVE OIL</td>
</tr>
<tr>
<td>7.77</td>
<td>COCONUT DESICCATED UNSWEETENED</td>
</tr>
<tr>
<td>6.70</td>
<td>FLORA PRO ACTIV LIGHT SPREAD ONLY</td>
</tr>
<tr>
<td>5.46</td>
<td>BRAZIL NUTS KERNEL ONLY</td>
</tr>
<tr>
<td>2.98</td>
<td>SOYA PROTEIN POWDER</td>
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<tr>
<td>1.48</td>
<td>CHICKEN TIKKA MASALA WITH RICE, LOW FAT</td>
</tr>
<tr>
<td>1.08</td>
<td>ACAI BERRY JUICE DRINK WITH VITAMIN B6</td>
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<tr>
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<td>CARROTS FRIED IN PUFA OIL</td>
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### Table 12 Male 15 to 18 - Day seven food list

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<tr>
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<td>CORNMEAL PORRIDGE MADE WITH WATER</td>
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<tr>
<td>226.43</td>
<td>CELERY FRESH BOILED</td>
</tr>
<tr>
<td>220.44</td>
<td>MULLER VITALITY PROBIOTIC DRINK</td>
</tr>
<tr>
<td>112.55</td>
<td>PASTA NOODLES EGG BOILED</td>
</tr>
<tr>
<td>112.44</td>
<td>PUDDING RICE - RAW</td>
</tr>
<tr>
<td>111.58</td>
<td>RICE WHITE WITH PUFA OIL</td>
</tr>
<tr>
<td>96.86</td>
<td>ACTIMEL PROBIOTIC DRINKING YOGURT</td>
</tr>
<tr>
<td>89.90</td>
<td>SWEETCORN, BABY COB, CANNED DRAINED NO ADDED SALT OR SUGAR</td>
</tr>
<tr>
<td>86.72</td>
<td>WHITE RICE EASY COOK BOILED</td>
</tr>
<tr>
<td>63.47</td>
<td>MARROW PARWAL BOILED</td>
</tr>
<tr>
<td>56.63</td>
<td>COLESLAW PURCHASED NOT LOW CALORIE</td>
</tr>
<tr>
<td>51.92</td>
<td>RICE WHITE PURCHASED IN LARD</td>
</tr>
<tr>
<td>41.82</td>
<td>CARROTS-FROZEN BOILED</td>
</tr>
<tr>
<td>41.53</td>
<td>BANANA CHIPS WITH ADDED FAT DRIED WEIGHT</td>
</tr>
<tr>
<td>40.86</td>
<td>QUAVERS</td>
</tr>
<tr>
<td>28.44</td>
<td>THAI FRAGRANT RICE - RAW</td>
</tr>
<tr>
<td>19.44</td>
<td>BISTO SAUCE GRANULES</td>
</tr>
<tr>
<td>16.99</td>
<td>GREEN BANANA BOILED</td>
</tr>
<tr>
<td>16.39</td>
<td>PURE SOYA SOFT AND CREAMY DAIRY FREE SPREAD</td>
</tr>
<tr>
<td>16.03</td>
<td>BETEL NUT KERNEL ONLY</td>
</tr>
<tr>
<td>9.32</td>
<td>MUSSELS BOILED WEIGHED WITH SHELL</td>
</tr>
<tr>
<td>7.00</td>
<td>HORLICKS ORIGINAL POWDER</td>
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Table 13 Female 19 to 50 - Day one food list

<table>
<thead>
<tr>
<th>Grams</th>
<th>FOODNAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>239.00</td>
<td>ENERGY DRINK MIX POWDER MALTODEXTRIN BASED</td>
</tr>
<tr>
<td>98.68</td>
<td>MILK SKIMMED WITH ADDED VIT UHT</td>
</tr>
<tr>
<td>82.05</td>
<td>EGG, WHOLE, FRIED IN SUNFLOWER OIL</td>
</tr>
<tr>
<td>53.03</td>
<td>GARI (CASSAVA FLOUR)</td>
</tr>
<tr>
<td>50.66</td>
<td>BREAD ROLLS, WHITE WITH ADDED WHEATGERM</td>
</tr>
<tr>
<td>38.51</td>
<td>GREEN LENTILS, CANNED, DRAINED</td>
</tr>
<tr>
<td>30.79</td>
<td>OAT BRAN</td>
</tr>
<tr>
<td>25.92</td>
<td>REDUCED FAT SPREAD (41-62% FAT) NOT POLYUNSATURATED, WITH OLIVE OIL</td>
</tr>
<tr>
<td>20.83</td>
<td>CHILLI PICKLE OILY</td>
</tr>
<tr>
<td>19.86</td>
<td>BROAD BEANS DRIED RAW</td>
</tr>
<tr>
<td>17.78</td>
<td>LIQUORICE SHAPES</td>
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<tr>
<td>13.12</td>
<td>COCONUT DESICCATED UNSWEETENED</td>
</tr>
<tr>
<td>12.82</td>
<td>GREEN BANANA FRIED RED PALM OIL</td>
</tr>
<tr>
<td>11.32</td>
<td>HALO REDUCED CALORIE AND FAT CHOCOLATE BAR</td>
</tr>
<tr>
<td>9.60</td>
<td>SOYA PROTEIN POWDER</td>
</tr>
<tr>
<td>8.77</td>
<td>FLORA PRO ACTIV LIGHT SPREAD ONLY</td>
</tr>
<tr>
<td>4.50</td>
<td>BLENDED VEGETABLE OIL</td>
</tr>
<tr>
<td>4.46</td>
<td>CHOCOLATES FILLED WITH CARAMEL/CREME NOT TRUFFLES</td>
</tr>
<tr>
<td>3.29</td>
<td>GLUTEN FREE FLOUR MIX</td>
</tr>
<tr>
<td>1.85</td>
<td>ORANGE PEEL</td>
</tr>
<tr>
<td>1.22</td>
<td>OYSTERS RAW</td>
</tr>
<tr>
<td>0.72</td>
<td>CHICKEN TIKKA MASALA WITH RICE, LOW FAT</td>
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### Table 14 Female 19 to 50 - Day seven food list

<table>
<thead>
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<th>Grams</th>
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<tbody>
<tr>
<td>239.36</td>
<td>CARBONATED DRINK &lt;50% JUICE LOW CAL CANNED</td>
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<tr>
<td>166.61</td>
<td>RICE PUDDING CANNED</td>
</tr>
<tr>
<td>128.43</td>
<td>RICE DREAM ALTERNATIVE TO MILK, WITH ADDED CALCIUM</td>
</tr>
<tr>
<td>112.09</td>
<td>CHIPS NEW POTS FRESH TAKEAWAY FRIED COMM VEG OIL</td>
</tr>
<tr>
<td>105.95</td>
<td>CORNMEAL SIFTED DRY</td>
</tr>
<tr>
<td>80.83</td>
<td>WHITE BASMATI RICE DRY</td>
</tr>
<tr>
<td>68.11</td>
<td>FLOUR RICE</td>
</tr>
<tr>
<td>62.59</td>
<td>WORCESTER SAUCE</td>
</tr>
<tr>
<td>49.95</td>
<td>COLESLAW PURCHASED NOT LOW CALORIE</td>
</tr>
<tr>
<td>45.96</td>
<td>CABBAGE FROZEN BOILED</td>
</tr>
<tr>
<td>39.32</td>
<td>MOUSSE, CHOCOLATE, LOW FAT</td>
</tr>
<tr>
<td>34.71</td>
<td>MILK WHOLE CHANNEL ISLAND PASTERIZED WINTER</td>
</tr>
<tr>
<td>33.89</td>
<td>TORTILLA CHIPS IN SUNSEED OR HIGH OLEIC SUNFLOWER OIL, EG DORITOS</td>
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<tr>
<td>28.89</td>
<td>BEETROOT BOILED (SALTED WATER)</td>
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<tr>
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<td>SWEET POTATO ROAST/BAKED</td>
</tr>
<tr>
<td>20.78</td>
<td>CORN CAKES (100% CORN)</td>
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<tr>
<td>18.14</td>
<td>HALF FAT BUTTER, SALTED, WITH VITAMIN A AND D</td>
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<tr>
<td>16.36</td>
<td>POPCORN SWEET</td>
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<tr>
<td>12.42</td>
<td>CHERRIES CANNED IN SYRUP FRUIT ONLY</td>
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<tr>
<td>12.17</td>
<td>EGG YOLK FRIED IN BUTTER</td>
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<td>MAYONNAISE LOW CALORIE (RETAIL)</td>
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<td>BENECOL LIGHT SPREAD</td>
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<td>Grams</td>
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</tr>
<tr>
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<td>RICE WITH LOSSES</td>
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<td>EGG WHITE FRIED IN VEGETABLE OIL</td>
</tr>
<tr>
<td>90.49</td>
<td>MILK SKIMMED WITH ADDED VIT UHT</td>
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<tr>
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<td>SR FLOUR AFTER BAKING</td>
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</tr>
<tr>
<td>38.87</td>
<td>BREAD ROLLS, WHITE WITH ADDED WHEATGERM</td>
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<td>GREEN BANANA FRIED RED PALM OIL</td>
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<tr>
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<td>ASDA POTATO SCONES FRIED IN VEGETABLE OIL</td>
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<td>COCONUT DESICCATED UNSWEETENED</td>
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<tr>
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<td>CHOCOLATES FILLED WITH CARAMEL/CREME NOT TRUFFLES</td>
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<tr>
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<tr>
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<tr>
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<td>CHOCOLATES FANCY AND FILLED</td>
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<td>BRAZIL NUTS KERNEL ONLY</td>
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<td>EGG, WHOLE, FRIED IN SUNFLOWER OIL</td>
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<tr>
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<td>PASTA SPAGHETTI BOILED WHITE</td>
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<td>RICE PUDDING UHT PURCHASED NOT CANNED NOT FRUIT</td>
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<td>RICE PUDDING MADE W 1/2 SS MILK 1/2 WATER NO SUGAR</td>
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<td>CORN BASED SNACKS EG MONSTER MUNCH, WOTSITS, TRANSFORM-A-SNACK</td>
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<td>QUORN SLICED MEATS, ALL VARIETIES</td>
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<td>FLOUR RICE</td>
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<td>FOODNAME</td>
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<td>ENERGY DRINK MIX POWDER MALTODEXTRIN BASED</td>
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<td>57.53</td>
<td>BREAD ROLLS, WHITE WITH ADDED WHEATGERM</td>
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<tr>
<td>45.84</td>
<td>EGG, WHOLE, FRIED IN SUNFLOWER OIL</td>
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<td>BROAD BEANS DRIED RAW</td>
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<td>GREEN BANANA FRIED RED PALM OIL</td>
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<td>24.57</td>
<td>HALO REDUCED CALORIE AND FAT CHOCOLATE BAR</td>
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<td>EGG WHITE FRIED IN VEGETABLE OIL</td>
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<tr>
<td>19.68</td>
<td>REDUCED FAT SPREAD (41-62% FAT) NOT POLYUNSATURATED, WITH OLIVE OIL</td>
</tr>
<tr>
<td>18.79</td>
<td>OAT BRAN</td>
</tr>
<tr>
<td>18.14</td>
<td>CHILLI PICKLE OILY</td>
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<tr>
<td>10.78</td>
<td>BRAZIL NUTS KERNEL ONLY</td>
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<tr>
<td>10.22</td>
<td>CHOCOLATES FANCY AND FILLED</td>
</tr>
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<td>FLORA PRO ACTIV LIGHT SPREAD ONLY</td>
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<td>8.48</td>
<td>COCONUT DESICCATED UNSWEETENED</td>
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<td>SOYA BEAN THREAD - FOO JUK</td>
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<td>5.42</td>
<td>GREEN BANANA FRIED IN BLENDED OIL</td>
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<tr>
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<td>JELLY LOW IN SUGAR NOT MADE UP</td>
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<td>RICE PUDDING MADE W 1/2 SS MILK 1/2 WATER NO SUGAR</td>
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<tr>
<td>89.33</td>
<td>CHOCOLATE SOYA DESSERT, FORTIFIED</td>
</tr>
<tr>
<td>81.68</td>
<td>CASSAVA-FRESH RAW</td>
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<tr>
<td>67.29</td>
<td>CELERY-CANNED DRAINED</td>
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<td>49.99</td>
<td>PRAWN CRACKERS</td>
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<tr>
<td>48.51</td>
<td>STRONG BREAD FLOUR WITH COOKING LOSSES</td>
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<tr>
<td>46.04</td>
<td>VERY LOW FAT CRÉME FRAICHE</td>
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<td>PASTA NOODLES EGG BOILED</td>
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<tr>
<td>45.04</td>
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<tr>
<td>42.48</td>
<td>SEMOLINA PACKET MIX E.G. BIRDS. DRY WEIGHT</td>
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<td>BEETROOT UNCOOKED</td>
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<td>SWEET POTATOES-BOILED</td>
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<tr>
<td>37.19</td>
<td>HUMMUS/HOUMOS, LOW/REDUCED FAT</td>
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<td>31.84</td>
<td>TARKA OR TADKA DAHL PURCHASED OR TAKEAWAY</td>
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<tr>
<td>28.70</td>
<td>RICE WHITE LONG POLISHED BOILED</td>
</tr>
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<td>27.13</td>
<td>CRISPBREAD RYE</td>
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<td>21.16</td>
<td>MILLET DRY</td>
</tr>
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<td>20.42</td>
<td>COLESLAW, PURCHASED, VALUE TYPE PRODUCTS ONLY</td>
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<td>11.57</td>
<td>RICE DREAM ALTERNATIVE TO MILK, WITH ADDED CALCIUM</td>
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<tr>
<td>10.75</td>
<td>MUSSELS BOILED WEIGHED WITH SHELL</td>
</tr>
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<td>6.47</td>
<td>LOW FAT SPREAD (26-39% FAT) POLYUNSATURATED, FORTIFIED WITH B6, B12,</td>
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<td>FOLIC ACID</td>
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Table 19 Male 50 Plus - Day one food list

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<tr>
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<td>135.51</td>
<td>RICE WITH LOSSES</td>
</tr>
<tr>
<td>89.63</td>
<td>MILK SKIMMED WITH ADDED VIT UHT</td>
</tr>
<tr>
<td>74.48</td>
<td>EGG WHITE FRIED IN VEGETABLE OIL</td>
</tr>
<tr>
<td>66.45</td>
<td>BREAD ROLLS, WHITE WITH ADDED WHEATGERM</td>
</tr>
<tr>
<td>44.55</td>
<td>OAT BRAN</td>
</tr>
<tr>
<td>42.92</td>
<td>REDUCED FAT SPREAD (41-62% FAT) NOT POLYUNSATURATED, WITH OLIVE OIL</td>
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<tr>
<td>23.31</td>
<td>GREEN BANANA FRIED RED PALM OIL</td>
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<td>CHOCOLATES FANCY AND FILLED</td>
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<tr>
<td>15.76</td>
<td>CHILLI PICKLE OILY</td>
</tr>
<tr>
<td>14.67</td>
<td>COCONUT DESICCATED UNSWEETENED</td>
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<tr>
<td>14.26</td>
<td>EGG, WHOLE, FRIED IN SUNFLOWER OIL</td>
</tr>
<tr>
<td>13.08</td>
<td>BROAD BEANS DRIED RAW</td>
</tr>
<tr>
<td>12.95</td>
<td>WHITE CHOCOLATE BUTTONS MICE</td>
</tr>
<tr>
<td>11.41</td>
<td>FLORA PRO ACTIV LIGHT SPREAD ONLY</td>
</tr>
<tr>
<td>9.10</td>
<td>SOYA PROTEIN POWDER</td>
</tr>
<tr>
<td>7.08</td>
<td>POTATO CAKES (SCONES) PURCHASED</td>
</tr>
<tr>
<td>7.05</td>
<td>BRAZIL NUTS KERNEL ONLY</td>
</tr>
<tr>
<td>6.59</td>
<td>BLENDED VEGETABLE OIL</td>
</tr>
<tr>
<td>4.67</td>
<td>ACAI BERRY JUICE DRINK WITH VITAMIN B6</td>
</tr>
<tr>
<td>3.66</td>
<td>CHICKEN TIKKA MASALA WITH RICE, LOW FAT</td>
</tr>
<tr>
<td>0.58</td>
<td>JELLY LOW IN SUGAR NOT MADE UP</td>
</tr>
</tbody>
</table>
### Table 20 Male 50 Plus - Day seven food list

<table>
<thead>
<tr>
<th>Grams</th>
<th>FOODNAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>245.60</td>
<td>RICE PUDDING MADE W 1/2 SS MILK 1/2 WATER NO SUGAR</td>
</tr>
<tr>
<td>186.72</td>
<td>RICE PUDDING UHT PURCHASED NOT CANNED NOT FRUIT</td>
</tr>
<tr>
<td>101.24</td>
<td>PASTA SPAGHETTI BOILED WHITE</td>
</tr>
<tr>
<td>94.82</td>
<td>CASSAVA-FRESH RAW</td>
</tr>
<tr>
<td>73.41</td>
<td>COLESLAW PURCHASED NOT LOW CALORIE</td>
</tr>
<tr>
<td>72.73</td>
<td>POPCORN SALTED E.G. MICROWAVE PURCHASED NOT LARGE CALORIE</td>
</tr>
<tr>
<td>70.39</td>
<td>CORN MEAL UNSIFTED DRIED</td>
</tr>
<tr>
<td>69.54</td>
<td>RICOTTA</td>
</tr>
<tr>
<td>56.99</td>
<td>CHRISTMAS PUDDING PURCHASED</td>
</tr>
<tr>
<td>52.31</td>
<td>MILK PUDDING RICE SAGO SEMOLINA CANNED LOW CAL</td>
</tr>
<tr>
<td>48.17</td>
<td>RICE WHITE FRIED BLENDED OIL</td>
</tr>
<tr>
<td>43.10</td>
<td>RICE WHITE LONG POLISHED BOILED</td>
</tr>
<tr>
<td>40.17</td>
<td>CHIPS NEW POTATOES FRESH FRIED IN POLYUNSATURATED OIL OR MAR</td>
</tr>
<tr>
<td>27.24</td>
<td>CORN BASED SNACKS EG MONSTER MUNCH, WOTSITS, TRANSFORM-A-SNACK</td>
</tr>
<tr>
<td>26.29</td>
<td>CARROTS-FROZEN BOILED</td>
</tr>
<tr>
<td>24.46</td>
<td>OATMEAL RAW</td>
</tr>
<tr>
<td>13.13</td>
<td>BEETROOT BOILED (SALTED WATER)</td>
</tr>
<tr>
<td>8.38</td>
<td>FLORA LIGHTER THAN LIGHT</td>
</tr>
<tr>
<td>2.11</td>
<td>CRAB BOILED</td>
</tr>
<tr>
<td>1.28</td>
<td>PARSNIPS BOILED</td>
</tr>
<tr>
<td>0.51</td>
<td>MIXED NUTS SHELLS NOT WEIGHED</td>
</tr>
</tbody>
</table>

### Acknowledgements

This work was funded by the Scottish Government’s Rural and Environment Science and Analytical Services Division (RESAS) Theme 3 programme (Food, Health and Wellbeing). The authors would also like to thank Graham Horgan (from BioSS) for his advice on modelling with R and Leone Craig (from the University of Aberdeen) for her advice on nutrition.