

# Supplementary material for

Trolle et al. Carbon Footprint Reduction by Transitioning to a Diet consistent with the Danish Climate-Friendly Dietary Guidelines: A Comparison of Different Carbon Footprint Databases. Foods, 2022.

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**Table S1.** Carbon Footprint (kg CO<sub>2</sub>-eq/kg) from primary production (farming) and processing of foods. When several references are given, the CF is the arithmetic mean of the different source data, unless otherwise indicated.

Food group	Food item	Farm + Processing, kg CO <sub>2</sub> -eq/kg	Reference
Meat and egg	Pork, raw <sup>1</sup>	4.25 <sup>2</sup>	[1,2]
	Beef and veal, raw <sup>1</sup>	12.88	[3] based on [4]
	Chicken, raw	2.84 <sup>3</sup>	[2] <sup>4</sup>
	Lamb, raw	27.91 <sup>5</sup>	[5]
	Processed pork products <sup>6</sup>	5.53	Calculated <sup>7</sup>
	Processed beef products <sup>8</sup>	16.32	Calculated <sup>7</sup>
	Game meat <sup>9</sup>	0	Estimate
	Egg	1.96	[6] <sup>10</sup>
Cereals and bread	Wheat flour	1.01	[6]
	Rye flour	0.98	[6]
	Wheat bread <sup>11</sup>	0.78	[6]
	Rye bread <sup>12</sup>	0.72	[6,7]
	Oats	0.66	[6]
	Pasta, dry	1.23 <sup>13</sup>	[8]
	Rice, dry	2.90	[9]
	Breakfast cereals	2.21	[10]
	Pastries, cakes and cookies	1.06	[11]
Milk, dairy and cheese	Skimmed milk	0.82	[12]
	Semi skimmed milk	0.88	[12]
	Whole milk	1.05	[12]
	Yoghurt	1.16	[12]
	Crème fraîche/cream (9-18% fat)	2.39–2.64	[12]
	Crème fraîche/cream (38% fat)	4.65–5.12	[12]
	Mould cheese	7.95	[12]
	Yellow cheese	8.66–9.47	[12]
	White cheese	6.93	[12]
	Cream cheese	6.11	[12]
	Cottage cheese	3.04	[12]
	Ice cream	3.78	[2]
Vegetables	Potatoes	0.15	[2,13–15]
	Broccoli	0.42	[2,15–18] <sup>14</sup>
	Tomato	0.69 <sup>15</sup>	[19–21]
	Carrot	0.14 <sup>16</sup>	[22]
	Other roots	0.15	[15,16,23–26]
	Spinach	0.20	[18] <sup>14</sup>
	Cucumber	0.47 <sup>17</sup>	[15]
	Salad/lettuce	0.42 <sup>17</sup>	[15,27,28]
	Bell pepper	0.98	[18,29,30] <sup>14</sup>
	Onion <sup>18</sup>	0.14	[22]
	Cabbage and kale <sup>19</sup>	0.18	[15,16,23,24,29]
	Green pea	0.43 <sup>20</sup>	[29,31,32]
	Corn, kernels	0.40 <sup>21</sup>	[33–35]
	Cauliflower	0.30	[2,18,36] <sup>14</sup>
	Leek	0.14	[16]
	Avocado	0.70 <sup>21</sup>	[18,29] <sup>14</sup>
	Olive	0.55	[37–39]
	Green beans	0.40 <sup>21</sup>	[17,24,29,33,36,40]

Fruits	Asparagus (green and white)	1.80 <sup>21</sup>	[18,29,33,41] <sup>14</sup>
	Pumpkin and zucchini	0.15	[24,42]
	Aubergine	1.35	[18,29] <sup>14</sup>
	Artichoke	0.50	[29]
	Jerusalem artichoke	0.30	[23]
	Champignon	2.80	[36,43–45]
	Apple	0.20 <sup>21</sup>	[2,13,15,46,47]
	Pear	0.20 <sup>21</sup>	[2,13,18,48] <sup>14</sup>
	Banana and mango	0.50 <sup>21</sup>	[36,39,49]
	Peach and nectarine	0.20 <sup>21</sup>	[13,29,35,50,51]
	Melon, all	1.00 <sup>21,22</sup>	[18,24,29,30,52] <sup>14</sup>
	Orange	0.20 <sup>21</sup>	[15,29,49,53–56]
	Tangerine	0.30 <sup>21</sup>	[18,29,51,57] <sup>14</sup>
	Lemon and grapefruit	0.25 <sup>21</sup>	[2,25,29,53]
	Grape <sup>23</sup>	0.50 <sup>21,24</sup>	[33,35,47,58–61]
	Pineapple	0.31	[18,36,62–64] <sup>14</sup>
	Kiwi	0.30 <sup>21</sup>	[65–67]
	Plum	0.32	[29]
	Apricot	0.38	[29,68]
Legumes, nuts <sup>28</sup> and seeds <sup>29</sup>	Cherry	0.40 <sup>21,25</sup>	[15,29,69,70]
	Fig	0.25 <sup>21</sup>	[29,33]
	Berries, all	0.70 <sup>21</sup>	[2,15,29,36,47,71–75] <sup>26</sup>
	Jam/marmalade, all types	0.90	Calculated from recipe <sup>27</sup>
	Beans, unspecified, dry <sup>30</sup>	0.24 <sup>31</sup>	[76]
	Soy beans, dry	0.29	[26]
	Chickpeas and lentils	0.25 <sup>21</sup>	[33]
	Split peas	0.35 <sup>21</sup>	[29,31,32] <sup>32</sup>
	Tofu	1.32	[77,78]
	Seeds, all	1.57	As sunflower seeds from [26]
	Peanuts	1.60	[79,80]
	Hazelnut	2.21	[29,80,81]
	Almond	3.45	[82]
	Walnut	2.34	[47,78]
Fish, mollusks and crustaceans <sup>33</sup>	Flatfish (plaice, halibut, flounder), raw	19.31	[2]
	<u>Mackerel</u> , garfish, raw	0.45	[2]
	Mackerel, <u>smoked</u> /in tomato sauce	0.67	Calculated from [2] <sup>34</sup>
	Salmon, farmed, raw	4.13	[2]
	Salmon, smoked	5.27	Calculated from [2] <sup>34</sup>
	Herring, raw	0.62	[2]
	Herring, pickled	1.01 <sup>21</sup>	[2,83]
	Tuna, canned <sup>35</sup>	2.15	[5,84]
	Rainbow trout	4.20	[2]
	Cod, raw	5.77	[2]
	Cod roe	1.28	[2]
	Saithe (Pollock)	3.80	[2]
	Mussel, raw	1.24	[85]
	Shrimp, frozen	11.85	[2]
	Crab claws	7.14	[86]
	Lobster	31.40	[87]

Fats and fat products	Margarines	1.60	[2,88,89]
	Mayonnaise, dressing etc.	2.04	Calculated <sup>36</sup>
	Rapeseed oil <sup>37</sup>	2.12	[26,90,91]
	Olive oil	3.66	[90,91]
	Sunflower oil	3.21	[26,90,91]
	Palm oil	4.23	[26]
	Palm kernel oil	5.65	[26]
	Soybean oil	1.14	[26,90,91]
	Coconut oil	2.73	[90]
	Butter	10.10	[12]
Beverages, discretion- ary foods and other	Butter blends	6.46	[12]
	Sugar	0.60	[26,92]
	Honey	0.92	[93]
	Candy/sweets	2.50	[94]
	Soft drink (soda/carbonated water)	0.18 <sup>21</sup>	[2,95]
	Milk chocolate	5.55	[2]
	Dark chocolate	3.90	[92]
	Coffee beans <sup>38</sup>	3.99	[2]
	Beer	0.18	[2] <sup>39</sup>
	Wine	1.44	[96]
	Spirits	1.00	[96]
	Water, tap	0.001	Estimated
	Juice, orange	1.32	[2]
	Juice, apple	0.53	[2]
	Juice tomato/vegetable	0.69	[97]
	Soy milk	0.47	[79]
	Nut butter with cocoa	1.94	Estimated <sup>40</sup>
	Peanut butter	1.80	Estimated <sup>41</sup>
	Chips, potato	2.48	[2](modified)
	Spices/condiments	0.50 <sup>21</sup>	[29](modified)

<sup>1</sup> All cuts, including edible offal. Edible boneless weight.

<sup>2</sup> CF corresponding to bone free meat. Obtained from 3.4 kg CO<sub>2</sub>-eq/kg carcass (mean between the cited studies) with 1.25 as meat conversion factor from carcass to bone free meat [98]

<sup>3</sup> CF corresponding to carcass weight. 23% unavoidable loss [5] is deducted to obtain edible bone free meat.

<sup>4</sup> Values from Moberg et al., 2019 [2] are adjusted for Danish import.

<sup>5</sup> Global average. System boundary: regional distribution center.

<sup>6</sup> Incl. sausages, ham etc.

<sup>7</sup> Calculated from raw pork and beef, respectively, by adding CF for cooking (0.216 kg CO<sub>2</sub>-eq/kg food) and 20% weight loss from cooking.

<sup>8</sup> Incl. cold cuts of beef.

<sup>9</sup> Incl. pheasant and hare, which are consumed in limited amounts.

<sup>10</sup> Value accessed through SimaPro in 2008.

<sup>11</sup> CF for wheat bread with seeds is estimated assuming 5% of the weight is sunflower seed.

<sup>12</sup> CF for rye bread with seeds is estimated assuming 15% of the weight is sunflower seed.

<sup>13</sup> Estimated as mix between dry and fresh pasta and wheat and durum flour.

<sup>14</sup> Stoessel et al., 2011 [18] and Jungbluth et al., 2016 [41] cited through Potter et al., 2020 [33].

<sup>15</sup> Estimated as 20% imported field grown and 80% greenhouse-grown.

<sup>16</sup> Average between two different storage systems: cold store or under straw matting in field.

<sup>17</sup> Literature values for cucumber and lettuce vary widely depending on production system and heat source assumed for greenhouse-grown products. Estimated as a mix between greenhouse-grown (with high proportion of renewable energy) and field grown.

<sup>18</sup> Spring onion estimated as x5 onion since inputs are similar but output lower due to earlier harvesting.

<sup>19</sup> All cabbages (red, spring) and kale are assigned the value for white cabbage.

<sup>20</sup> CF corresponding to green pea without pod. An estimated 0.125 kg CO<sub>2</sub>-eq/kg for processing has been added for processing (removal of pod), based on Landquist & Woodhouse, 2015 [23] for processing of vegetables (without freezing).

<sup>21</sup> Estimate based on cited references.

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- <sup>22</sup> Represents mix between greenhouse-grown (CF 1.2 -1.5 kg CO<sub>2</sub>-eq/kg) and field grown (0.30 kg CO<sub>2</sub>-eq/kg).
- <sup>23</sup> CF for raisin estimated as 5 x grape based on dry matter content.
- <sup>24</sup> Estimate at the higher end of values found in literature based on Potter et al., 2020 [33] estimate for grapes in Swedish retail and because table grapes are estimated to have higher CF than grapes for wine production.
- <sup>25</sup> Estimated at the higher end of values found in literature since cherries are sometimes transported by air freight [33].
- <sup>26</sup> Literature based on strawberries, blueberries and raspberries.
- <sup>27</sup> Estimated 50% berries and 50% sugar with 0.25 kg CO<sub>2</sub>-eq/kg for processing.
- <sup>28</sup> CF of nuts estimated without shell. Edible fractions are 0.38 for hazel nuts, 0.69 for peanuts and 0.59 for almonds [33,99]. Walnut is assumed without shell in literature.
- <sup>29</sup> Standard CF value 0.05 kg CO<sub>2</sub>-eq/kg is added as estimated processing for all dry legumes, nuts and seeds.
- <sup>30</sup> Incl. brown and white beans.
- <sup>31</sup> CF for dry beans calculated from CF for fresh beans based on dry matter content, assuming that 1.08 kg of fresh beans need to be cultivated for 1 kg of dry beans.
- <sup>32</sup> CF from farming estimated from green peas.
- <sup>33</sup> CF for all fish represents edible part since inedible parts are assumed removed at processing stage.
- <sup>34</sup> Calculated from the raw fish by adding CF for cooking (0.108 kg CO<sub>2</sub>-eq/kg food) and 20% weight loss from cooking.
- <sup>35</sup> Edible part without CF from the packaging material.
- <sup>36</sup> Calculated rapeseed oil 63%, sunflower oil 15% and egg 6%.
- <sup>37</sup> CF for rapeseed oil estimated as rapeseed oil.
- <sup>38</sup> It is estimated that 45 g of coffee beans is needed for 1 litre of coffee ready to drink.
- <sup>39</sup> Based to values in the Danish market: from Moberg 2019 [2] 80% Danish and 20% rest of the world (0.175 kg CO<sub>2</sub>-eq/kg)
- <sup>40</sup> 55% sugar + 13% palm oil + 13% hazelnut + 7% skim milk powder + 7% cocoa powder + 5% other (processing: 0.08 kg CO<sub>2</sub>-eq/kg food)
- <sup>41</sup> As peanut + extra processing.

**Table S2.** CF (kg CO<sub>2</sub>-eq/kg) related to packaging of different foods.

Type of packaging	Food item	CF, kg CO <sub>2</sub> -eq/kg food	Reference
Paper/carton	Flour, grain, sugar	0.030	[100]
Carton + plastic cap	Cream (0.5 liter)	0.030	[12]
Plastic foil	Yellow cheese (800 g)	0.030	[12]
Carton + plastic cap	Milk, yoghurt (1 liter)	0.040	[12]
Plastic bag/paper/ carton	Rice, breakfast cereals, bread, biscuits, vegetables and fruit (fresh)	0.050	[100]
Plastic bag	Pasta, legumes (dried), nuts, seeds, fruit (dried), vegetables and fruit (frozen), candy	0.070	[100]
Paper carton + film	Mould cheese (150 g)	0.080	[12]
Carton + plastic	Mushroom (raw)	0.100	[100]
Plastic bag/ retort pouch	Snacks, potato chips	0.100	[101,102]
Plastic, modified-atmospheric packaging	Frozen fish	0.102	[102]
50% carton/50% plastic	Ice cream	0.121	[100,101]
Retort pouch	Coffee, tea	0.129	[101]
Carton	Eggs	0.145	[102]
Plastic bottle/ cans(steel)/glass bottle	Soft drinks, beer, juice	0.150	[2,96] <sup>1</sup>
Plastic tray + absorption pad + lid	Meat, cold cut, fish, tofu	0.160	[103,104]
Plastic pot	Shrimp in brine	0.211	[101]
Metal can/carton	Vegetables, preserved (tomato)	0.252	[105]
Plastic bag/ glass	Spices, dried tomato	0.260	[100,101,105]
Plastic tub	Cottage cheese, white cheese (200g)	0.320	[12]
Plastic/glass bottle	Oils, dressings, sauces	0.321	[100,106]
Glass jar	Pickled vegetables, marmalade	0.341	[107]
Plastic pot/glass jar	Herring in brine, honey, syrup, chocolate/nut paste	0.355	[101]
Plastic/paper/ aluminium wrap	Butter, butter blends, margarine (250g)	0.380	[12]
Glass bottle/bag-in-box (plastic + carton)	Wine	0.391	[96]
Plastic tub	Cream cheese (200 g)	0.400	[12]
Plastic tub	Crème fraiche (200 g)	0.410	[12]
Metal can	Canned vegetables, fruit and fish	0.451	[105]
Metal can	Milk powder	0.730	[12]
Glass bottle	Spirits	0.770	[96]

<sup>1</sup> Similar to information from Danish Brewers' Association <https://bryggeriforeningen.dk/wp-content/uploads/2020/03/Faktaark-samlet.pdf>

**Table S3.** The CF (kg CO<sub>2</sub>-eq) from cooking 1 kg of raw food.

<b>Food</b>	<b>CF per kg raw food cooked, kg CO<sub>2</sub>-eq/kg food <sup>1</sup></b>
Meat	0.216
Fish and egg	0.108 <sup>2</sup>
Vegetables & fruit	0.109
Potatoes	0.138
Rice, quinoa, bulgur	0.243
Pasta	0.364
Flour, all	0.134 <sup>3</sup>
Coffee/tea (1 l water)	0.055
Legumes (dried beans and chickpeas) <sup>4</sup>	0.219
Legumes (lentils, split peas) <sup>5</sup>	0.121

<sup>1</sup> Unavoidable waste (bones, peel etc.) assumed not cooked.

<sup>2</sup> Cooking time is estimated to be half of that for meat.

<sup>3</sup> All flours are given cooking value corresponding to "baking a cake"

<sup>4</sup> Boiling time 45-60 minutes

<sup>5</sup> Boiling time 15-20 minutes

**Table S4.** Estimated CF (kg CO<sub>2</sub>-eq/kg) related to storage in supermarket and home.

Type of storage in super-market and home	GHG emissions, kg CO <sub>2</sub> -eq/kg food <sup>1)</sup>	Type of storage used per food group
100% dry	0.033	Coffee, sugar, rice, pasta, legumes, canned products, sweets, spices, condiments
80% dry and 20% cold	0.037	Fresh vegetables and fruit, potatoes, soft drink, alcohol
100% cold	0.055	Dairy products, eggs
80% dry and 20% frozen	0.079	Bread, bakery
80% cold and 20% frozen	0.097	Fresh meat and fish
100% frozen	0.263	Dessert (mainly ice cream), fish, vegetables etc.

1) Sum of CF from storage in supermarket and home



**Table S5.** Total carbon footprint (CF) of the current diet among adults (18-64 year), per person per day and per 10 MJ, respectively\*, calculated using three different CF data sets at household level.

	CF, AU-DTU data			CF, BCD excl. iLUC			CF, BCD incl. iLUC		
	Average N=2492	Men N=1202	Women N=1290	Average N=2492	Men N=1202	Women N=1209	Average N=2492	Men N=1202	Women N=1290
<b>CF kg CO<sub>2</sub>-eq/pers/day</b>									
Mean	4.62 <sup>a</sup>	5.29	4.00***	5.11 <sup>b</sup>	6.04	4.26***	5.84 <sup>c</sup>	6.91	4.83***
(SD)	(1.54)	(1.57)	(1.20)	(2.29)	(2.44)	(1.75)	(2.71)	(2.89)	(2.07)
Median	4.40	5.15	3.87	4.65	5.59	3.95	5.28	6.37	4.49
(P10;P90)	(2.95; 6.57)	(3.52; 7.21)	(2.67; 5.36)	(2.75; 8.10)	(3.42; 9.17)	(2.47; 6.28)	(3.06; 9.34)	(3.80; 10.60)	(2.76; 7.21)
<b>CF kg CO<sub>2</sub>-eq/10 MJ</b>									
Mean	4.78 <sup>a</sup>	4.78	4.78	5.29 <sup>b</sup>	5.49	5.11***	6.04 <sup>c</sup>	6.29	5.81***
(SD)	(0.96)	(0.91)	(1.01)	(1.98)	(1.97)	(1.97)	(2.38)	(2.37)	(2.37)
Median	4.62	4.65	4.61	4.89	5.08	4.72	5.56	5.80	5.32
(P10;P90)	(3.72; 6.06)	(3.76; 5.93)	(3.69; 6.11)	(3.35; 7.69)	(3.46; 8.05)	(3.25; 7.31)	(3.71; 8.87)	(3.87; 9.38)	(3.61; 8.47)

\*) Average energy intake per day for the entire adult population 18-64 years is 9.81 MJ (3.12 MJ), and 11.24 MJ (3.24 MJ) and 8.49 MJ (2.32 MJ) for men and women, respectively (SD, standard deviation, in brackets). Significant difference between results of the total population in the same row is indicated with different letters a, b, c (p<0.01). Significant difference between gender is indicated: \*\*\*=p<0.001.

The current food intake: The Danish National Survey on Dietary habits and physical Activity (DANSDA) 2011-2013, adults 18-64 years. The AU-DTU data are compiled by researchers from Aarhus University and DTU (Technical University of Denmark) described in methodological section 2.3 of the present study. The BCD (the Big Climate Database): published by the Danish green think tank CONCITO. iLUC: indirect land use change.

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