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1 **The nutritional challenge and health implications of takeaway and fast food**

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11 **Abstract**

12 Consumption of takeaway and fast food is growing in popularity among Western  
13 societies, and is particularly widespread among adolescents. As it is well known that food  
14 plays an important role in the development and prevention of many diseases there is no doubt  
15 that observed changes in dietary patterns affect the quality of the diet as well as public health.  
16 This review examines the nutritional characteristics of takeaway and fast food including  
17 energy density, total fat, saturated and trans fatty acid content. It also reports the association  
18 between the consumption of such foods and health outcomes. Findings on the effect of  
19 takeaway and fast food consumption on health complications are limited. Therefore, more  
20 studies should be directed at better understanding of the nutrition and health consequences of  
21 eating takeaway and fast food and to find the best strategy to reduce the negative impact of  
22 their consumption on public health.

23 **Key words:** takeaway foods, fast foods, dietary intake, chronic disease

24

25

## 1 **Introduction**

2 Lifestyle changes which have taken place in many countries worldwide over the last  
3 few decades have been shown to impact food consumption patterns.<sup>1-4</sup> One of the most  
4 prominent trends is a growing prevalence of meals eaten away from home.<sup>4-6</sup> In addition,  
5 even meals consumed at home are often purchased from catering outlets which offer  
6 takeaway or home delivery service.<sup>5,7</sup> The traditional regular family dinner has been replaced  
7 by eating 'on the run' at various locations throughout the day.<sup>1</sup> An average US woman and  
8 man spend 0.79 h and 0.32 h per day carrying out food preparation and cleaning up,  
9 respectively. Moreover, 59% of men and 32% of women spend no time on daily food  
10 preparation.<sup>8</sup>

11 Food eaten out of the home is becoming an important and a regular component of the  
12 Western diet.<sup>9,10</sup> A number of studies have shown an increased frequency of takeaway and  
13 fast food consumption worldwide, especially in Europe, the USA and Australia.<sup>9-15</sup> About  
14 22% of Britons were found to purchase foods from takeaway outlets at least once a week and  
15 58% a few times a month.<sup>11</sup> A similar frequency of consumption of takeaway or fast food is  
16 observed in other countries as well, about 27% of Australians<sup>12</sup> ate takeaway meals at least  
17 twice a week and 37% of Americans<sup>13</sup> reported eating fast food at least once over two non-  
18 consecutive days. Fast food is particularly popular among adolescents, with 75% of USA  
19 teenagers between the age of 11 and 18 years eat at fast food outlets at least once a week<sup>14</sup>  
20 and 70% of Brazilian students (9 – 18 years old) consumed fast food four times or more per  
21 week.<sup>15</sup> Guthrie et al.<sup>10</sup> reported that consumption of fast food among children has increased  
22 from 2% of total energy in 1970s to 10% of energy in the 1990s.<sup>10</sup>

23 It is well known that food plays an important role in the development and prevention  
24 of many diseases.<sup>16</sup> There is also no doubt that observed changes in dietary patterns affect the  
25 quality of the diet as well as public health. Eating of takeaway and fast food has been shown

1 to have adverse health effects, and the majority of studies on this subject have focused on the  
2 relationship between fast food consumption and weight gain.<sup>17-19</sup> However, an increased risk  
3 of insulin resistance, type 2 diabetes, elevated total cholesterol and low density lipoprotein  
4 cholesterol (LDL-C) levels and decreased high density lipoprotein cholesterol (HDL-C)  
5 concentrations has also been observed with increasing frequency of eating away from home.  
6<sup>17,20,21</sup> Takeaway or fast food consumers are characterised by higher intakes of energy, fat,  
7 saturated fatty acids, trans fatty acids, added sugar and sodium, and lower intakes of fibre,  
8 macronutrients and vitamins in comparison to those who do not eat food prepared outside the  
9 home.<sup>13,18,22,23</sup> Additionally, takeaway and fast food consumption has been linked to poor  
10 dietary patterns including higher intakes of carbonated soft drinks and sweets and lower  
11 consumption of fruits, vegetables, wholegrain and dairy products.<sup>12,13,18,23</sup>

12 This review focus on energy and fat content in takeaway and fast food and their health  
13 implications. However, it should be pointed out that other components of takeaway and fast  
14 foods (for example salt) are also important.

### 15 ***Method of a search strategy***

16 Searches were performed in the following electronic databases: Medline (PubMed),  
17 ScienceDirect and ISI Web of Science. Key words included fast food, takeaway food,  
18 nutrient content, lifestyle, health, obesity, cardiovascular disease, blood lipids, fat, saturated  
19 fatty acids, trans fatty acids, energy density, food consumption patterns, diet quality. In  
20 addition, the reference list in each the identified original and review articles where searched  
21 for additional references. Searches were restricted to English language manuscripts and  
22 included all available data until March 2011. Articles were limited to human participants  
23 only.

### 24 ***Energy and energy density***

1 Humans possess a weak initial ability to recognize the energy density of consumed  
2 food and to appropriately regulate the bulk of food eaten to maintain energy balance, thus  
3 generally people tend to consume a similar amount of food every day regardless of the  
4 variations in energy density.<sup>24-26</sup> The tendency to consume a constant amount of food was  
5 confirmed by Seagle et al.<sup>27</sup> who analysed four day food records of normal weight adults.  
6 Daily variations in the weight of consumed food were significantly smaller than either  
7 variations in the intake of energy or fat.<sup>27</sup> Similarly, a retrospective investigation of three  
8 community studies (the Cambridge Family Food Survey (N=195), the MRC National Survey  
9 of Health and Development (NSHD (N=343)) and the Leeds Nutritional Survey (N=2086))  
10 based in the UK showed that the weight of food remained relatively constant over a seven  
11 day period.<sup>28</sup> When eating food with a low energy density, a greater amount of food needs to  
12 be consumed for a given level of energy intake in comparison to food with a high energy  
13 density. Therefore, increasing the energy density of the diet may result in a passive increase  
14 in energy intake because people are generally habituated to eat a relatively constant weight of  
15 food.

16 Bell et al.<sup>29</sup> conducted a study of normal weight women (n = 18) who consumed all of  
17 their meals in the laboratory over three 2-day periods. During lunch, dinner and an evening  
18 snack, participants consumed *ad libitum* main entrees, which were similar in macronutrient  
19 composition, but varying in energy density. The women consumed a similar amount of food  
20 independent of energy density of the served diets. Thus, the energy intake was about 25%  
21 less in the low energy dense diet in comparison with the diet of the high energy density.  
22 Moreover, no differences in hunger or fullness before meals, after meals, or over the day  
23 across the conditions were observed.<sup>29</sup> These findings were confirmed by several other  
24 studies which have tested the effect of variations in the fat content of the diet while  
25 maintaining a constant energy density.<sup>30,31</sup> Stubbs et al.<sup>30</sup> in a 14 day interventions study

1 reported that men who were offered a diet varying in fat content (20, 40 and 60% of total  
2 energy) but maintained a constant energy density, ate a constant weight of food; therefore,  
3 showing similar energy intakes despite different proportions of fat content in the diet.  
4 Similarly, a randomised crossover study carried out by Saltzman et al.<sup>31</sup> among 7 pairs of  
5 male twins who were provided *ad libitum* with a low or a high fat diet matched for energy  
6 density (20% or 40% of total energy) during an 11 day period had similar daily energy  
7 intakes (10.3 and 10.7 MJ/d, respectively) regardless of the condition of the diet. These  
8 findings support the hypothesis that energy density of consumed food is a crucial determinant  
9 of energy intake. Therefore the weight or volume of food consumed, and thus the energy  
10 density, may increase or decrease energy intake independently of macronutrient content of  
11 the diet.

#### 12 ***Takeaway and fast foods and obesity***

13 The relationship between fast food or takeaway consumption and increased body  
14 mass index (BMI) and obesity has been reported in many epidemiological studies.<sup>17-19,32</sup>  
15 Schroder et al. In a study among Spanish (N=3054) population found that the consumption of  
16 fast food more than once a week increased the risk of being obese by 129%. These results are  
17 consistent with findings of Kjøllestad et al.<sup>34</sup> who reported in a group of 8943 working Oslo  
18 citizens that the likelihood of being obese increased significantly with frequent eating in staff  
19 canteens, after taking into account demographic and socioeconomic variables. Furthermore,  
20 consumption of fast foods twice a week or more was independently associated with a 31%  
21 higher prevalence of moderate abdominal obesity in men and a 25% higher prevalence in  
22 women.<sup>18</sup> According to a theoretical model, an energy increase of 17 kcal/day for men and 19  
23 kcal/day for women would lead to a weight increase of 1 kg per year independent of baseline  
24 body weight.<sup>35</sup> On average, regular consumption of fast food meals was related to an  
25 increased energy intake of 56 kcal/day<sup>36</sup> and 187 kcal/day<sup>18</sup> among adults and children,

1 respectively. Thus, a higher frequency of fast food consumption was associated with a weight  
2 gain of 0.72 kg over 3 years<sup>36</sup> and of 4.5 kg over a 15 year period<sup>17</sup> above the average weight  
3 gain. Moreover, women who reported eating takeaway food once a week were 15% less  
4 likely to be weight maintainers than those who rarely (once a month or less) or never ate  
5 takeaway food.<sup>37</sup>

### 6 ***Takeaway and fast foods – energy content and intake***

7 It has been shown that a typical meal purchased from fast food chains tends to be  
8 energy dense and contains ~ 236 kcal/100 g, which is twice as high as the recommended  
9 energy density of a healthy diet.<sup>38</sup> Considering the large portion sizes of food eaten out of the  
10 home, one meal can provide even more than 1400 kcal.<sup>39</sup> Mancino et al.<sup>40</sup> based on the  
11 dietary recall (two non-consecutive days) data from the 2003–2004 National Health and  
12 Nutrition Examination Survey (NHANES) and the 1994–1996 Continuing Survey of Food  
13 Intakes by Individuals (CSFII) and with the use of a first-difference estimator found that each  
14 meal eaten away from home added on average 130 kcal to total daily energy intake, with  
15 lunch and dinner having the greatest effect on total daily energy. French et al.<sup>14</sup> in a study  
16 conducted among 4746 American teenagers (11 – 18 years old) reported that energy intake  
17 was 40% higher among males and 37% higher among female adolescents who reported  
18 eating fast food three times or more during the studied week in comparison with those who  
19 had not eaten fast foods. Additionally, a dose-response pattern was observed with energy  
20 intake directly increasing with increased frequency of fast food consumption.<sup>14</sup> Similarly, a  
21 follow-up study including 44072 African American women aged 30 – 69 years indicated that  
22 compared to women who have never eaten Chinese food, women who reported eating such  
23 kinds of food at least once a week had daily energy intakes of 26% higher.<sup>20</sup> Furthermore, a  
24 study by Bowman et al.<sup>18</sup> including 9872 adults aged 20 years and older has shown a positive  
25 relationship between the energy density of the diet and fast food consumption. An evaluation

1 of the quality of the diet of American adults showed the increase of the energy density of the  
2 diet from 89 and 98 kcal/100 g among men and women who did not eat fast food to 95 and  
3 102 kcal/100 g among those who reported eating fast food, respectively.<sup>18</sup>

#### 4 ***Total Fat and Saturated Fatty Acids***

5 High fat intake associated with takeaway or fast food consumption may be a factor  
6 leading to obesity development independently of total energy intake. Findings of a study  
7 carried out among 150 British adults by Alfieri et al.<sup>41</sup> found a strong positive correlation  
8 between BMI and total fat consumption but no association with energy intake. These results  
9 were in line with findings of a cross-sectional study of 15,266 men (55–79 years) by Satia-  
10 Abouta et al.<sup>42</sup> who reported that fat intake has a higher adipogenic effect than total energy  
11 intake. In a multivariate linear regression model after adjustment for demographic and health  
12 related characteristic, BMI increased by 0.14 and 0.53 kg/m<sup>2</sup> for every 500 kcal of total  
13 energy intake and 500 kcal energy derived from fat, respectively. Moreover, only energy  
14 provided from fat, but not energy from other macronutrients (carbohydrate and protein),  
15 increased linearly with increasing BMI. Contrary, Larson et al.<sup>43</sup> suggested that dietary fat  
16 plays a very minor role in increasing adiposity, and explained only 2% of variation in body  
17 fat after controlling for other obesity risk factors.

18 There are several possible explanations why dietary fat intake may be associated with  
19 body weight gain. A number of studies have shown that fat possess a less satiating effect than  
20 either carbohydrate or protein. Cotton et al.<sup>44</sup> found that a carbohydrate supplemented  
21 breakfast (173.4 g of carbohydrate, 11.2 g of fat, 12.7 g of protein and 803 kcal of total  
22 energy) suppressed intake of food with the next meal, in contrast to the breakfast  
23 supplemented by fat (77.8 g of carbohydrate, 50.9 g of fat, 12.7 g of protein and 803 kcal  
24 total energy) which produced no detectable effect on the expression of the appetite.  
25 Furthermore, fat is utilized with very high energy efficiency, thus the diet induced



1 thermogenesis following fat consumption is much lower than after protein or carbohydrate  
2 intakes. Also, a high fat meal does not enhance lipid oxidation, thus may promote dietary fat  
3 accumulation in adipose tissue. In a study by Bennett et al.<sup>45</sup> the addition of 50 g of fat to a  
4 standard breakfast (55% energy from carbohydrate, 30% from fat and 15% from protein) did  
5 not increase fat oxidation or energy expenditure either during the immediate 6 hours  
6 postprandial period or over the following 18 hours. Similarly, Horton et al.<sup>46</sup> found in a group  
7 of 16 men, who were offered for 14 days isoenergetic overfeeding (50% above energy  
8 recruitment) of fat and carbohydrate, that fat overfeeding did not produce an increase in fat  
9 oxidation and total energy expenditure leading to storage of 90-95% of excess energy. In  
10 contrast carbohydrate overfeeding was associated with increased carbohydrate oxidation and  
11 total energy expenditure and resulted in 75-85% of excess energy being stored.<sup>46</sup>  
12 Furthermore, Raben et al.<sup>47</sup> in a study among 19 healthy participants who were provided with  
13 meals with similar energy density but rich in protein, fat, carbohydrate or alcohol observed  
14 that postprandial lipid oxidation was suppressed after protein, carbohydrate and alcohol rich  
15 meals and was almost unchanged after the fat rich meal. Griffiths et al.<sup>48</sup> reported that lipid  
16 oxidation was higher after a high fat meal (80 g of carbohydrate, 80 g of fat and 18 g of  
17 protein) than after a low fat meal (80 g of carbohydrate, 0.8 g of fat and 18 g of protein), but  
18 the difference in oxidation level reached 10 g only (20.7 vs 10.6 g,  $p < 0.01$ ) despite that the  
19 high fat meal provided 79.2 g more fat than the low fat meal. It should also be mentioned that  
20 fat is more effectively absorbed from the gastrointestinal tract in comparison to carbohydrate.  
21 Lammet et al.<sup>49</sup> showed that a high fat diet produced significantly lower faecal loss of energy  
22 than a high carbohydrate diet. In addition, fat improves the taste and texture of many food  
23 products which may also promote active overconsumption associated with an enhanced  
24 appetite due to sensory stimulation.<sup>50</sup> The increased food intake with increased food  
25 palatability has been observed in many previous studies.<sup>51-54</sup> However, other studies which

1 investigated sensory properties of food involved in sensory specific satiety found that  
2 increased sensory stimulation may reduce food consumption.<sup>55</sup>

3 A diet high in fat, particularly rich in saturated fatty acids (SFAs), may not only lead  
4 to a higher risk of obesity development but may also have other adverse health effects.  
5 Generally, SFAs increase total and HDL-C levels, although not all SFAs affect plasma lipid  
6 and lipoprotein concentrations in the same manner.<sup>56</sup> Stearic acid in comparison with other  
7 saturated fatty acids has little effect on plasma lipids, which has been proposed to be a result  
8 of the rapid conversion of stearic acid in the body to oleic acid.<sup>57</sup> On the other hand, SFAs  
9 with 12–16 carbon atoms are considered to be hypercholesterolaemic, and lauric acid (C12:0)  
10 appears to be more potent than myristic acid (C14:0) or palmitic acid (C16:0).<sup>57</sup> However, it  
11 has been found that despite C12:0, C14:0 and C16:0 acids increasing serum total and LDL-C  
12 levels they also increase the concentration of HDL-C, as a results they do not increase the  
13 ratio of total to HDL-C.<sup>58</sup> Whether a diet high in SFAs is associated with the increased risk of  
14 coronary heart disease is still controversial.<sup>58,59</sup> Numbers of epidemiological and dietary  
15 intervention studies have found that a diet rich in SFAs is associated with a higher risk of  
16 impaired glucose tolerance, insulin resistance and type 2 diabetes<sup>60-62</sup>but there is no evidence  
17 of a direct causal relationship with CVD.<sup>72</sup> Thanopoulou et al.<sup>61</sup> in a multinational survey  
18 found that participants with recently diagnosed and undiagnosed type 2 diabetes had a higher  
19 intakes of SFAs compared with healthy controls. These findings were similar to those of  
20 Wang et al.<sup>62</sup> who in a 9 year follow up study of 2909 American participants (45 – 64 years of  
21 age) showed the positive association between diabetes incidence and the proportion of total  
22 SFAs in plasma cholesterol esters and phospholipids, which reflects dietary intake of fatty  
23 acids. In addition, higher intake of SFAs may increase the risk of several cancers. Kurahashi  
24 et al.<sup>64</sup> in a 7.5 years follow up study among 43435 Japanese men aged 45 – 74 years found  
25 that myristic and palmitic acids increased the risk of prostate cancer in a dose dependent

1 manner. Multivariable relative risk on comparison of the highest with the lowest quartiles of  
2 myristic acid and palmitic acid intake were 1.62 (1.15-2.29) and 1.53 (1.07-2.20),  
3 respectively. There is also evidence suggesting a possible relationship between SFAs intake  
4 and a modest increase in breast cancer risk.<sup>65</sup>

5         The main source of SFAs in takeaway or fast food is palm oil which is widely use as a  
6 frying medium due to excellent frying performance together with production of a highly  
7 desirable fried food flavour.<sup>57</sup> Palm oil is suggested as an acceptable alternative to partially  
8 hydrogenated vegetable oil in the deep fat frying process, but unhydrogenated vegetable oils  
9 are recommended as they produce a much more favourable plasma/serum lipid profile than  
10 either palm oil or partially hydrogenated oils.<sup>57,66</sup> In a dietary intervention study by Vega-  
11 López et al.<sup>66</sup> 15 participants were provided for 5 weeks with food varying in the type of fat  
12 (partially hydrogenated soybean oil, soybean oil, palm oil, or canola oil; at two-thirds of total  
13 fat, or 20% of energy). It was found that both partially hydrogenated soybean and palm oil  
14 resulted in higher LDL-C concentrations than other investigated fats. No significant  
15 differences in total to HDL-C ratio were observed between the diets enriched with palm,  
16 canola, and soybean oils. Vessby et al.<sup>67</sup> in the KANWU study included 162 healthy  
17 participants who received an isoenergetic diet for 3 months containing either a high  
18 proportion of saturated or monounsaturated fatty acids, and found that replacement of SFAs  
19 with monounsaturated was associated with improvement of insulin sensitivity.

20         On average, food eaten out of the home is characterised by high total fat and SFAs  
21 content. Stender et al.<sup>68</sup> after analysing meals containing chips and fried chicken (nuggets or  
22 hot wings) bought from McDonald's and KFC outlets in 35 countries worldwide, found that  
23 total fat content varied from 41 to 74 g depending on country of origin. These results were in  
24 agreement with findings of Dunford et al.<sup>69</sup> who reported that food (burgers, chicken

1 products, sides or pizzas) purchased from fast food chains contained between 10 and 13 g of  
2 total fat and between 3.9 and 4.9 g of SFAs per 100 g.

3 The intake of fat and SFAs increases with higher frequency of out of home  
4 eating.<sup>13,18,20</sup> A study involving a large sample (N=44072) of adult African American women  
5 showed that total fat intake was significantly higher among women who reported eating out  
6 of the home at least once a week, regardless of the type of meals they consumed (burgers,  
7 fried chicken, fried fish, Chinese food, pizzas or Mexican food) when compared to those who  
8 had never eaten food prepared outside the home.<sup>20</sup> This is consistent with previous findings  
9 of Paeratakul et al.<sup>13</sup> who reported among 9063 adults and 8307 children and adolescents that  
10 on the day when fast food was eaten the intake of total fat, SFAs and percentage of energy  
11 provided by fat was higher compared to the day without fast food consumption.

### 12 *Trans fatty acids*

13 Trans fatty acids (TFAs) are formed during the commercial partial hydrogenation of  
14 unsaturated fats. Small amounts of TFAs are also produced by ruminants during the  
15 biohydrogenation of unsaturated fatty acids from feed by hydrogen produced during  
16 oxidation of substrates with bacterial enzymes in the rumen. These two sources of TFAs  
17 contain similar species of TFAs isomers, but in different amounts and proportions, thus their  
18 consumption may have different biological effects.<sup>70</sup> The concentration of TFAs in partially  
19 hydrogenated oils (PHVO) may be as high as 30 - 50%, compared with only around 5% in  
20 dairy and ruminant meat products.<sup>70</sup> Ruminant and industrially produced TFAs have been  
21 shown to have detrimental effect on blood lipids when consumed in high doses. However,  
22 moderate intake of ruminant TFAs, such as those seen with normal dietary consumption, have  
23 neutral effects on plasma lipids and other risk factors for cardiovascular disease.<sup>71</sup> Hulshof et  
24 al.<sup>72</sup> reported that TFAs intake from ruminant products was under 2 g/day (<1% of total

1 energy intake) in all Western Europe countries investigated in the TRANSFAIR study, and  
2 the main source of TFAs in the diet was PHVO.

3 TFAs due to their physiological effects are undesirable components of the diet. A  
4 growing body of evidence has demonstrated numerous adverse effects associated with TFAs  
5 consumption, including systemic inflammation, diabetes, insulin resistance, endothelial  
6 dysfunction, obesity, decreased LDL particle size, decreased HDL-C and apolipoprotein A1  
7 (ApoA1) concentrations and increased total cholesterol, lipoprotein (a) and apolipoprotein B  
8 (ApoB) levels.<sup>73,74</sup> Recent meta-analysis of the effects of TFAs consumption on blood lipids  
9 and lipoproteins showed that each 1% energy replacement of TFAs with SFAs,  
10 monounsaturated fatty acids or polyunsaturated fatty acids, respectively, decreased total  
11 cholesterol/HDL-C ratio by 0.31, 0.54 and 0.67; ApoB/ApoA1 ratio by 0.007, 0.010 and  
12 0.011; and Lp(a) concentration by 3.76, 1.39 and 1.11 mg/l.<sup>75</sup> Esmailzadeh et al.<sup>76</sup> in a cross-  
13 sectional study among 486 apparently healthy women aged 40 – 60 years found that greater  
14 consumption of PHVO was associated with increased circulating concentrations of several  
15 markers of endothelial dysfunction and systematic inflammation. CRP, IL-6 and sTNFR-2  
16 levels were, respectively, 73, 17 and 5% higher among women in the highest quintile of TFAs  
17 intake, compared with the lowest quintile.<sup>77</sup> Nearly all studies conducted in different  
18 countries which investigated an association between habitual intakes of TFAs or TFAs  
19 exposure, assessed using tissue biomarkers (for example: erythrocyte membrane TFAs  
20 concentrations, serum phospholipids and adipose tissue fatty acid composition) have  
21 demonstrated a significantly increased risk of coronary heart disease (CHD) among  
22 individuals with greater TFAs consumption or exposure. Contrarily, no other studies have  
23 reported a positive association between ruminant TFAs consumption and CHD.<sup>78</sup>  
24 Furthermore, TFAs consumption may be associated with weight gain and visceral fat  
25 accumulation. A large prospective study conducted among 16587 men after controlling for

1 potential confounders found that substitution of each 2% of energy intake from TFAs by  
2 energy from PUFA was independently associated with a 2.7 cm increase in waist  
3 circumference over 9 years.<sup>79</sup> It should also be mentioned that TFAs are transferred from the  
4 mother to the foetus across the placenta and are presented in breast milk.<sup>71</sup> As humans do not  
5 synthesize TFAs isomers their concentration in human milk is directly related to the type of  
6 maternal diet. The content of TFAs in human milk varies between countries, from 0.5% in  
7 Africa, through 1.40 – 2.80% in Poland to 6 – 7% of total fatty acids in Canada.<sup>80</sup> A recent  
8 cross-sectional study found that infants of mothers who consumed 4.5 g or more of TFAs  
9 daily while breastfeeding were over two times more likely to have body fat higher than 24%  
10 in comparison to those consuming less.<sup>81</sup>

11 Takeaway and fast food, particularly chips and deep fried meats may contain a large  
12 amount of TFAs from PHVO which are used for deep frying. It has been reported that the  
13 single meal of chips (171 g) and fried chicken (160 g) purchased from fast food outlets  
14 provided from 0.3 to 24 g of TFAs.<sup>68</sup> Similarly, Wagner et al.<sup>82</sup> found that TFAs content may  
15 vary in burgers from 0.1 to 1.05 g per 100 g and in chips from 0.1 to 1.6 g per 100 g. It has  
16 been assessed that individuals who frequently consume fast food meals could intake between 6  
17 and 12 % of dietary energy from TFAs<sup>83</sup> and a single meal of fried chicken with chips may  
18 deliver four times more TFAs than daily recommended allowance in the UK (no more than  
19 2% of total recommended daily energy intake).<sup>84</sup> However, it should be pointed out that none  
20 of accessible studies regarding TFAs level in fast foods or other takeaway fried meal options  
21 distinguish between naturally occurred TFAs in food products and TFAs from PHVO or  
22 evaluated the level of specific species of TFAs isomers.

## 23 **Conclusion**

24 In summary, a growing body of evidence suggests that the nutrient profile of  
25 takeaway and fast foods may contribute to a variety of negative health outcomes, including

1 cardiovascular disease, insulin resistance, type 2 diabetes and obesity.<sup>12,17-21</sup> Simultaneously,  
2 food prepared out of the home is making up an increasing component of the Western diet and  
3 there is no expectation that this will stop expanding. However, most of the previous studies  
4 have only investigated the nutritional quality of fast foods and there is still a lack of data  
5 regarding the nutrient content in takeaway meals from small independent outlets (e.g. ethnic  
6 cuisines, fish & chips shops, pizza shops and others). Furthermore, there is a lack of good  
7 quality data on the consumption of different takeaway food options. To the best of our  
8 knowledge, there are no studies which differentiate between the frequency of consumption of  
9 fast foods and other type of takeaway meals, the majority of previous studies have  
10 concentrated on fast food from big chains (e.g. McDonald's, KFC) or have investigated  
11 altogether the different kinds of foods that were eaten out of the home. However, results from  
12 our recent study indicate that there are significant differences in the nutrient composition  
13 between different types of takeaway meals (Indian, Chinese, English, Pizzas, Kebabs)<sup>85</sup> as  
14 well as between takeaway meals and similar style ready meal options.<sup>86</sup> There is only one  
15 study which has examined the differences between the frequency of consumption of specific  
16 types of meals eaten out of the home (burgers, pizzas, fried chicken, fried fish, Chinese food  
17 and Mexican food) and incidence of type 2 diabetes, but this was limited to restaurant food  
18 only.<sup>20</sup> Furthermore, most studies have investigated only frequency of eating out of the home  
19 but have not taken into account the amount of food consumed, the overall diet quality and  
20 lifestyle factors. Therefore, more studies should be directed at better understanding of the  
21 nutrition and health consequences of eating takeaway and fast food and to find the best  
22 strategy to reduce the negative impact of their consumption on public health. The co-  
23 operation between food technologists, nutritionists and chefs from takeaway outlets is needed  
24 to alter the food preparation process in order to improve the nutritional quality of prepared  
25 meals. However, this may not be an easy approach as chefs may be reluctant to change their

1 recipes, especially due to concerns about adverse effects on palatability, which can  
2 potentially affect their profits. Also, voluntary guidelines do not always result in adequate  
3 changes of nutritional quality of takeaway foods thus some government regulations may be  
4 considered as a powerful method. In Finland, legislation on food labelling, such as the  
5 mandatory warning “high salt product” if the salt concentration exceeds set limits has been  
6 shown to be a useful tool to reduce salt intake in the population.<sup>87</sup> Similarly, in Denmark the  
7 restriction of industrially produced TFAs levels of all food products to a maximum of 2% of  
8 the total fat content showed that it is possible to reduce or remove TFAs content from food  
9 products.<sup>88</sup>

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