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Abstract

Numerous studies find that education and the healthiness of diets are highly correlated. One possible explanation is that the most highly educated consumers are better at understanding and appreciating the health implications of their diet than consumers with less lower education. In this study, we estimate a hedonic model of consumers' valuation of food characteristics that allows nutrients to influence utility both through their perceived effects on health and through their effects on the taste and consumption experience. We find that the most highly educated have the same or lower revealed preferences for health compared to the least educated, and we find that it is differences in taste preferences, not differences in health preferences, that explain why the most highly educated have a healthier diet.

Keywords: Hedonic model, taste, health, food consumption

JEL codes: D12, I12

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1. Introduction and background

An unhealthy diet composition can lead to cancer, cardiovascular disease, diabetes, and osteoporosis as well as obesity (WHO, 2015) and this problem is growing dramatically in many countries (OECD Health Data, 2011). It seems that the pleasures of taste and consumption experience² often encourage the consumption of fatty, salty and sweet foods, whereas health awareness discourages their consumption. Essentially, there seems to be a trade-off between the immediate pleasure of “taste” associated with certain foods and the long-term health consequences they imply. With the growing awareness of health-related issues among consumers, one pressing question is how this trade-off between “taste” and health affects consumers’ valuations of and their demand for different food products. All over the Western world, a social bias is observed in diet-related health problems where population groups with less education (and lower income) have more diet-related lifestyle health problems (Mackenback, 2012; Brønnum-Hansen and Baadsgaard, 2008, 2012; Majer et al., 2011; Hoffmann, 2011, Marmot, 2005, 2012) and a less healthy diet with a larger intake of unhealthy nutrients such as saturated fat and sugar (Hiscock, 2012; Glümer et al., 2014; Kulik et al., 2014; Demarest et al., 2014; Gallo et al., 2014; Pechey et al., 2013; Darmon and Drenowski, 2008; Groth et al., 2014; ; Beenackers et al., 2012). One possible explanation as to why the most highly educated consumers have a healthier diet is that they are better at understanding and appreciating the health implications of their diet than less educated consumers (e.g., Grunert and Wills, 2007; Grunert et al., 2010; Johnston et al., 2015; Pampel et al., 2010). If this is the case, information campaigns designed for and focusing on increasing health awareness among less educated consumers might be effective. However, another possible explanation could be differences in the valuation of the “taste” effects of, e.g. saturated fat or sugar in different foods. If consumers care about the health effects, but still choose an unhealthy diet because they have strong “taste” preferences for unhealthy foods, then information campaigns focusing on health awareness might not be effective. Instead policies focusing on changing the habits and social norms that form “taste” preferences may be more effective.

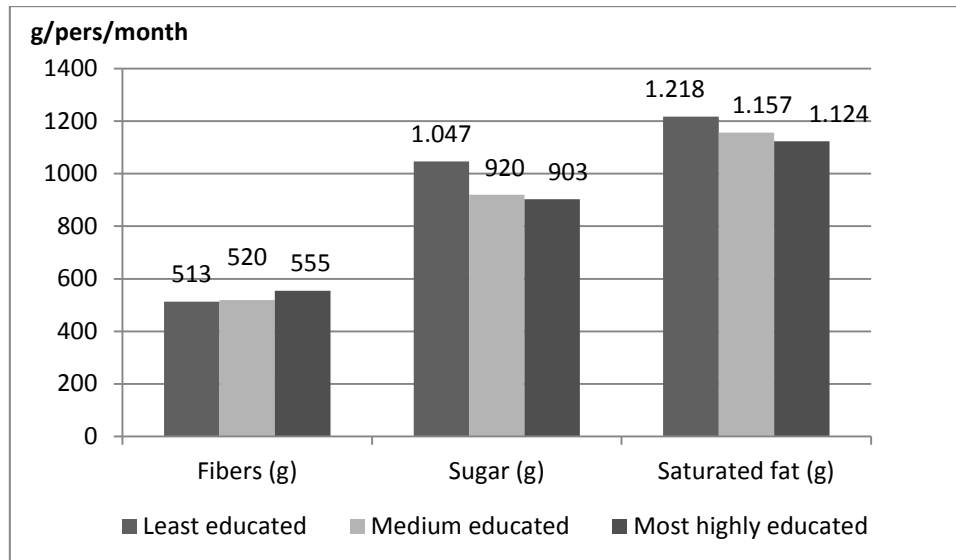
In the following, we investigate this and explain the observed differences in dietary healthiness across consumers with different educational backgrounds³. In our study, we utilize a unique panel dataset with approximately 2500 Danish consumers provided by GfK Panel Services Scandinavia. As in most other studies (see, e.g. Groth et al., 2013, 2014; Darmon and Drenowski, 2008; Pechey et al, 2013), we find that

² In the following, we refer to taste and consumption experience as “taste” for ease of exposition.

³ Least educated (no or vocational education), medium educated (short non-vocational education) and most highly educated (medium or long tertiary education).

the least educated consumers in our panel have a less healthy diet. In figure 1, we compare per capita consumption of fats, added sugar and fibre for consumers categorized according to education level.

Figure 1 Diet composition for selected nutrients by level of education (g/pers./month)



Note: All values differ significantly at the 1% level, except for sugar consumption by medium and most highly educated consumers and fibre consumption by the least and the medium educated consumers (these differ at the 5% level). For the significance level of differences, see table 1 below. Source: Own calculations from the GfK panel.

On average, all groups eat too much sugar and saturated fat and too little fibre compared to the official dietary recommendations, but deviations from the recommended diet are larger for the least educated, while differences between the medium and most highly educated consumers' diet composition are smaller. Our focus is on investigating if these differences are driven by different valuations of health effects of nutrients or by differences in valuations of "taste". What is rather unique about our panel data is that it covers *all* components of each household's diet (including meat, fish, fruits and vegetables, etc.) and that we have a long time dimension. This allows us to disentangle "taste" and health values of a given nutrient under the key identifying assumptions that the health value of a given nutrient in a consumer's diet depends on his total consumption of this nutrient, while the "taste" value of consuming this nutrient in a given food only depends on his consumption of the nutrient contained *in the given type of food*. More specifically, we model health and "taste" valuations of five nutrients (saturated fat, sugar, carbohydrates, fibre and protein) contained in seven aggregate food groups (meat, dairy, fish, fruit and vegetables, fats, the carbohydrate containing group; bread, flour and cereals and finally the group of sugar products; biscuits, cakes, spreadable, and ice cream).⁴

⁴ For a description of how the groups are composed, see appendix A.

Our methodological starting point is the hedonic price model, which has been widely used to assess consumer valuations of the different attributes inherent in a purchased good. The hedonic price model originates from the characteristics model, in which consumers are assumed to derive utility or satisfaction from the characteristics that goods contain rather than from the good itself (Becker, 1965; Lancaster, 1966; Rosen, 1974; Lucas, 1975, Ladd and Suvannunt, 1976, Ladd and Martin, 1976). A key implication of this model is that the price paid by a consumer for a purchased good must equal the sum of his marginal valuations of all the characteristics contained in this product. Based on this, hedonic pricing models have been used to decompose revealed consumer preferences for specific foods into implied valuations of the different characteristics contained in these foods, ranging from search characteristics such as convenience (e.g. Vickner, 2014; Ahmad and Anders, 2012) to credence characteristics such as being organic (e.g. Huang and Lin, 2007; Schulz et al., 2007; Schroeck, 2014) and other attributes such as nutrient content (e.g. Stanley and Tschirhart, 1991; Drecher et al., 2008a, 2008b Richards et al., 2012; Thunström and Rausser, 2008; Thunström, 2007; Shongwe et al., 2007; Ward et al., 2008; Carlucci, 2013). Most of these studies consider only a few related food items simultaneously and estimated valuations of nutrients (such as saturated fat) contained in different foods differ substantially. This is not surprising since nutrients, in addition to having health implications, in many cases also have important effects on the “taste” experience of consuming the food. If the effect of a given nutrient on “taste” varies between goods, then so will its marginal utility values. However, to the best of our knowledge, no studies have attempted to decompose consumer valuations of different nutrients into a marginal valuation that originates from its health effects and a marginal valuation that originates from its “taste” effects. This is our point of departure.

We find that the most highly educated have the same or even lower revealed preferences for health compared to the least educated consumers and that their healthier diet is explained by differences in “taste” valuations. While stronger health preferences may be part of the explanation as to why consumers with a medium education have a healthier diet than the least educated consumers, we find that differences in “taste” valuations again are an important part of the explanation. These results could have important implications for the design and role of information campaigns and labelling schemes that are a key nutrition policy instrument in many countries. The rest of this paper is organized as follows: section 2 presents the theoretical model, section 3 presents the empirical model and identification, and section 4 is devoted to a description of the data. Section 5 presents the results, while section 6 discusses and concludes.

2. A characteristics model of food demand

In the classical characteristics model, utility is derived directly from consumption of characteristics such as nutrients contained in the food that the consumers eat. This implies that a given nutrient in one food is a perfect substitute for the same nutrient contained in another food. This assumption seems reasonable when thinking about the *health* implications of eating nutrients since the health implications of consuming, e.g., unsaturated fats in milk and in spare ribs are equivalent. Since we model consumer choice covering the entire food basket, the assumption may, on the other hand, be problematic when thinking about the “taste” implications of nutrients. It seems obvious that the corresponding implications for “taste” can vary substantially between different foods (e.g. the “taste” of saturated fat may vary considerably between milk and spareribs). Therefore, in the following, we model the effect of the nutrients on these two different parts of the consumer’s utility explicitly, which allows us to apply more reasonable assumptions in both cases.⁵

We consider a household consuming a vector of J (running index j) different foods. Following the traditional characteristics model approach (e.g. used by Ladd and Zober, 1977; Lenz et al., 1994; Shi and Price, 1998; Ranney and McNamara, 2002), we assume that each food consists of a number of nutritional characteristics and a number of non-nutritional characteristics.

The amount of nutrient i contained in one unit of good j is given by a technology matrix \mathbf{A} :

$$(1) \quad A \equiv \text{goods} \left\{ \begin{array}{c} 1 \\ \vdots \\ j \\ \vdots \\ J \end{array} \right. \left(\begin{array}{ccccc} \overbrace{1 \quad \dots \quad i \quad \dots \quad I}^{\text{health characteristics}} \\ a_{11} \quad \dots \quad a_{1i} \quad \dots \quad a_{1I} \\ \vdots \quad \ddots \quad \vdots \quad \ddots \quad \vdots \\ a_{j1} \quad \dots \quad a_{ji} \quad \dots \quad a_{jI} \\ \vdots \quad \ddots \quad \vdots \quad \ddots \quad \vdots \\ a_{J1} \quad \dots \quad a_{Ji} \quad \dots \quad a_{JI} \end{array} \right)$$

In the same way, the amount of non-nutrient characteristic m contained in one unit of good j is given by a similar technology matrix \mathbf{B} .

The total amount of nutritional characteristics (given by vector \mathbf{h} of I nutritional characteristics

$\mathbf{h} = (h_1, \dots, h_i, \dots, h_I)'$) consumed by the household is:

⁵ Note that the perfect substitutability assumption may be reasonable when modelling “taste” implications of nutrients in similar goods (such as different milk variants or different breakfast cereals), which is what most other studies in the literature do.

$$(2) \quad \mathbf{h} = \mathbf{A}'\mathbf{q}$$

where $\mathbf{q} = (q_1, \dots, q_i, \dots, q_J)'$ is a vector of quantities of consumed foods. Similarly, the total amount of non-nutritional characteristics consumed (given by vector \mathbf{g} of M non-nutritional characteristics

$\mathbf{g} = (g_1, \dots, g_m, \dots, g_M)'$) is:

$$(3) \quad \mathbf{g} = \mathbf{B}'\mathbf{q}$$

When a household purchases a vector of foods, it is assumed to derive “taste” utility from its consumption. “Taste” utility is assumed to be produced in a two-step process: in the first step, the characteristics contained in each food j are combined to produce “taste” sub-utility for this food:

$$(4) \quad x_j = k_j(\mathbf{h}_j, \mathbf{g}_j)$$

where $\mathbf{h}_j = \mathbf{a}_j q_j$ is the vector of quantities of nutrients consumed via good j (\mathbf{a}_j is the relevant vector of per-unit nutrient characteristics from the technology matrix \mathbf{A} , i.e. the content of saturated fat, sugar, etc., in good j). In the same way, $\mathbf{g}_j = \mathbf{b}_j q_j$ is the vector of non-nutritional characteristics consumed via good j .

We assume homogeneity of “taste” production, so that $x_j = q_j k_j(\mathbf{a}_j, \mathbf{b}_j)$, which allows us to interpret $k_j(\mathbf{a}_j, \mathbf{b}_j)$ as a quality measure for good j .⁶ Essentially the “taste” quality of a unit of good j depends on its content of nutrient and non-nutrient characteristics. For example, a pound of beef may have a higher “taste” quality when it contains 20% fat than when it contains 10% or 30% fat, and this valuation is not affected by the amount of beef consumed. This seems a natural and intuitive interpretation.

In the second step, utility is produced by combining the good-specific “taste” sub-utilities derived from each good:

$$(5) \quad u(x_1, \dots, x_J)$$

This is a traditional model of consumption where (as we have formulated it) the quality of each good is a function of the different characteristics contained in it.

⁶ Note that this model is analogous to a characteristics model of “taste” production from aggregate goods when homogeneity of the sub-utility production is assumed: see, e.g., Lenz et al. (1994). The difference with Lenz and others is that we allow nutritional characteristics to influence “taste”.

When a household purchases a vector of foods, it is, in addition to deriving “taste” utility, assumed to derive health utility depending on the amount h_i of each nutritional characteristic contained in its diet:

$$(6) \quad v_i(h_i)$$

We assume that the consumers’ total utility is the sum of utility derived from “taste”, the utility derived from different health characteristics and the utility derived from expenditures on a numeraire good representing consumption of non-food goods. Expenditure on the numeraire is equal to income Y minus expenditures on the J different foods, $\sum_{j=1}^J p_j q_j$ where p_j is the market-price of good j . Thus consumer’s utility becomes:

$$(7) \quad U = u(x_1, \dots, x_J) + \sum_{i=1}^I v_i(h_i) + Y - \sum_{j=1}^J p_j q_j$$

Where we assume additive separability of utility from health, from “taste” and from the consumption of other goods. The consumers choose quantities of each good so as to maximize normalized utility:

$$(8) \quad \begin{aligned} \text{Max}_q U &= u(x_1, \dots, x_J) + \sum_{i=1}^I v_i(h_i) + Y - \sum_{j=1}^J p_j q_j \\ \text{where } x_j &= k_j(\mathbf{h}_j, \mathbf{g}_j) \end{aligned}$$

The resulting first-order condition for the optimal choice of quantity of good j (the hedonic pricing equation) is:

$$(9) \quad \begin{aligned} p_j &= \sum_{m=1}^M \frac{dU}{dg_{jm}} b_{ji} + \sum_{i=1}^I \frac{dU}{dh_{ji}} a_{ji} \\ &= u_j \left(\sum_{m=1}^M \frac{dk_j(\mathbf{h}_j, \mathbf{g}_j)}{dg_{jm}} b_{ji} + \sum_{i=1}^I \frac{dk_j(\mathbf{h}_j, \mathbf{g}_j)}{dh_{ji}} a_{ji} \right) + \sum_{i=1}^I v_i(h_j) a_{ji} \end{aligned}$$

Thus the marginal utility value of “taste” derived from good j in general depends on the consumption of other goods in a complicated way (marginal “taste” values of goods, $u_j(x_1, \dots, x_J)$, depend on the consumption of other goods). In contrast, the marginal health utility value of nutrients only depends on the aggregate consumption of these nutrients because of the assumed separability structure. Further, the separability implied by our model of “taste” quality implies that the “taste” quality function only depends

on the characteristics contained in the specific good.⁷ This is what allows identification in the empirical model.

Multiplying (9) by the quantities of each food consumed q_j we get:

$$(10) \quad X_j = u_j \left(\sum_{m=1}^M \frac{dk_j(\mathbf{h}_j, \mathbf{g}_j)}{dg_{jm}} g_{jm} + \sum_{i=1}^I \frac{dk_j(\mathbf{h}_j, \mathbf{g}_j)}{dh_{ji}} h_{ji} \right) + \sum_{i=1}^I v_i(h_j) h_{ji}$$

where X_j is total expenditure on good j and h_{ji} is the total amount of nutrient i in the specific good j . This is the first-order condition that we estimate empirically. We assume “taste” quality is linear in non-nutritional characteristics, i.e:

$$(11) \quad \frac{dk_j(\mathbf{h}_j, \mathbf{g}_j)}{dg_{jm}} = \delta_{jm}$$

Examples of non-nutritional characteristics are amounts of different meat or vegetable types with a clear preference ranking (e.g. a greater proportion of roast beef will, for example, always increase utility). For the nutritional characteristics, we allow for a quadratic form, thereby allowing that, e.g. the utility maximizing beef quality has a certain fat content where the utility value of beef is reduced both when fat content is lower and when it is higher, so that:

$$(12) \quad \frac{dk_j(\mathbf{h}_j, \mathbf{g}_j)}{dh_{ji}} = \alpha_{ji} + \beta_{ji} [h_{ji} / q_j]$$

where the marginal value depends on the per-unit content (concentration) of the nutrient. Note that this satisfies the assumed homogeneity of “taste”. Finally, we allow for the same quadratic form for the health utility of nutrients:

$$(13) \quad v_i(h_i) = \gamma_i + \varepsilon_i [h_i]$$

We allow u_j to vary over time to take account of the vector of consumed food goods changing over time.

However, because of the assumed separability, quality and health utility parameters are constant over

⁷ One could imagine non-separable relationships where one quality of a certain food tastes especially good with specific qualities of other foods (e.g. sweet wine with sweet desserts). These are the types of complex substitutional relationships that we have ruled out.

time. Technically, we do this by including time- and good-specific dummies u_{jt} for each type of household that we model. The regression equations that we estimate, therefore, become:

$$(14) \quad [X_j] = u_{jt} \left(\sum_{m=1}^M \delta_{jm} [g_{jm}] + \sum_{i=1}^I \alpha_{ji} [h_{ji}] + \sum_{i=1}^I \beta_{ji} [h_{ji}^2 / q_j] \right) + \sum_{i=1}^I (\gamma_i [h_{ji}] + \varepsilon_i [h_i h_{ji}])$$

for each good j , where square brackets indicate observed variables in our data set and t indicates time. For each food, the non-nutritional characteristic g_j captures unobserved characteristics contained in this food. We see that second-order “taste” and health effects of nutrients (β_{ji} and ε_i respectively) in (14) are identified through our assumptions about their dependence on nutrients contained in the given food and on the total amount of consumed nutrients, respectively. The separation of first-order “taste” and health effects (α_{ji} and γ_i) is through our assumption that “taste” effects vary over time and between foods while health effects do not.

3. Data and model structure

In the present paper, we use monthly self-reported purchase data from a Danish consumer panel maintained by GfK Panel Services Scandinavia. The panel contains, on average, 2,500 households reporting quantity, price and detailed product characteristics of all food purchases. The diary is filled out by the diary keeper in principle immediately after each shopping trip and is sent to GfK on a weekly basis. Additional to providing the purchase data, the main person responsible for shopping in the household fills out an annual questionnaire concerning a number of background variables which characterize the household. We aggregate the purchase data to monthly observations, covering the entire period of 2003 and 2004. The level of detail on purchases is for many foods close to barcode level. The purchase data are merged with nutrition matrices from the Food Composition Databank provided by the Danish Institute for Food and Veterinary research.⁸ The nutrition database provides detailed information about the content of macronutrients (e.g. protein, fats, carbohydrates and fibre in 1,032 different foods).⁹ As all values are given per 100 g of edible content in the nutrient matrices, it is possible to calculate the total amount of various macronutrients purchased by the households by matching the nutrition matrices with the purchase data. For each type of food, the match is done on the most detailed level possible. It is, for example, possible to separate the purchased quantity of milk into different types of milk (e.g. butter milk, whole milk, semi-skimmed milk, skimmed milk and flavoured milk) and to match each type with a nutrition matrix describing

⁸ For further information on the nutrition database see: http://www.foodcomp.dk/fcdb_default.asp.

⁹ The database covered 1,032 different foods in 2005, but is being continuously improved.

the exact nutrient content of this particular type of milk.¹⁰ This results in a panel dataset at the household level where the nutritional composition of purchases is measured together with prices and expenditure. In table 1 below, we present summary statistics for the dataset after we have normalized for household size and omitted reporting weeks. From table 1, we see the same differences in our Danish panel that have been found in a number of other studies. The most highly educated spend more money on food and consume more fruit and vegetables, less meat and fewer sugar products and fats compared to the less educated households. Looking at nutrients, the most highly educated consume more fibre and less total and saturated fat and less sugar compared to the least educated.

Table 1: Consumption of nutrients and food as well as number of households and observations by educational levels

	Least educated	Medium educated	most highly educated	Test (p-value Student's t-test)		
				$\mu_{le} = \mu_{med}$	$\mu_{med} = \mu_{best}$	$\mu_{le} = \mu_{best}$
Number of households	2355	651	862			
Number of observations	28630	6428	9084			
Average length of panel membership (months)	15.5	12.7	13.9			
Value of food consumed (DKK/pers./month)	865.48	913.49	969.04	0.0052	0.0000	0.0000
Amount of food consumed (kg/pers./month)						
Fish	2.22	2.22	2.25	0.9465	0.2128	0.1928
Fruit and vegetables (fruit/veg)	7.93	9.20	10.60	0.0000	0.0000	0.0000
Dairy	8.73	8.86	9.50	0.0660	0.0000	0.0000
Fats	1.14	0.99	0.92	0.0000	0.0000	0.0000
Bread, flour and cereals (carb.prod.)	8.23	7.91	7.94	0.0000	0.6467	0.0000
Meat	5.61	5.53	5.02	0.0866	0.0000	0.0000
Biscuits, cakes, spreadables and ice cream (sugar.prod.)	3.89	3.64	3.67	0.0000	0.6306	0.0000
Nutrients (g/pers/month)						
Fibre	513	520	555	0.0366	0.0000	0.0000
Carbohydrates	7335	7132	7470	0.0002	0.0000	0.1556
Added sugar	1047	920	903	0.0000	0.2522	0.0000
Unsaturated fat	1569	1496	1462	0.0000	0.0001	0.0000
Saturated fat	1218	1157	1124	0.0000	0.0001	0.0000
Protein	2972	3009	3045	0.0830	0.8906	0.1726

We then follow the approach in Lenz et al. (1994) and construct 31 aggregate food “qualities”. The content of these 31 food qualities differs between households as the qualities are constructed from market purchases.¹¹ Prices and technology matrices depend on how households construct these 31 food qualities and are, hence, a product of k market goods (in principle equal to the number of foods on the Danish

¹⁰ For a detailed description of the merging of purchase data with the nutrition matrices, see Smed (2008).

¹¹ The 31 aggregated food qualities are shown in appendix A together with the 7 final food types we use in the model

market). Not all goods contain all types of nutrients. Table 2 shows the average amount of each of the five nutrients in grams per kilo in each of the j food types (e.g. there are, on average, 54.96 grams of protein in one kilogram of dairy products and on average 2.595 grams of added sugar). A similar table could be constructed for the relationship between the 31 food “qualities” and the seven food types. To facilitate estimation of the model, we exclude nutrients from the model of a specific food category if the contribution from this food category to total consumption of these nutrients is insignificant (less than 2% of total consumption). For example, we only include protein, unsaturated and saturated fat from meat in the model since carbohydrates, fibre and added sugar from meat all account for less than 2% of total consumption of these respective nutrients. An overview is given in table 2, where cells containing values included in the model are shaded.

Table 2: Average content of nutrients in each of the food categories (g/kg)

(The % contribution of the nutrient by each food group to total consumption of the nutrient in question is given in parentheses)

	Dairy	Meat	Fats	Fruit/veg	Sug.prod.	Fish	Carb.prod.
Added sugar (g/kg)	2.82 (2.9%)	2.95 (1.8%)	0.00 (0.0%)	0.00 (0.0%)	212.96 (93.0%)	0.00 (0.0%)	2.49 (2.3%)
Carbohydrates (g/kg)	42.60 (5.9%)	17.11 (1.5%)	5.00 (0.1%)	91.88 (12.5%)	296.60 (17.7%)	104.52 (3.6%)	462.45 (58.7%)
Fibre (g/kg)	0.42 (0.8%)	0.95 (1.1%)	0.00 (0.0%)	19.34 (36.9%)	3.98 (3.3%)	0.70 (0.3%)	32.24 (57.5%)
Protein (g/kg)	54.96 (18.7%)	207.08 (43.3%)	4.88 (0.2%)	11.76 (3.9%)	17.96 (2.6%)	144.62 (12.3%)	61.09 (19.0%)
Saturated fat (g/kg)	25.21 (21.7%)	61.46 (32.5%)	314.48 (32.5%)	1.24 (1.0%)	14.99 (5.5%)	18.02 (3.9%)	3.70 (2.9%)
Unsaturated fat (g/kg)	11.63 (7.8%)	92.51 (37.9%)	388.77 (31.2%)	0.18 (0.1%)	14.90 (4.3%)	75.90 (12.7%)	9.95 (6.1%)

4. Estimation and Results

The model specified in equation (14) is estimated for each of the seven aggregated food types using monthly food purchases per person as the dependent variable. This is performed jointly as a system of seven simultaneous non-linear SUR equations using the NLSUR command in STATA 10. The model is estimated independently for three different educational groups — least educated (no or vocational education), medium (short, non-vocational education) and most highly educated (medium or long tertiary education) — to which households are assigned according to the educational status of the main household member responsible for shopping. We also estimate a pooled model for all consumers. Summary statistics for these models are presented in appendix B. In the pooled regression, we include quadratic nutrient “taste” terms for all nutrients. In the separate regressions for educational groups, we dropped quadratic

nutrient "taste" terms that were insignificant in the pooled estimation, in order to conserve degrees of freedom.

The estimated parameters for the health attributes of nutrients are presented in table 3 below for all four regressions. Many of the parameters are highly significant. Combining the parameters, all nutrients have the expected marginal valuation signs (positive net valuation of fibre, protein and unsaturated fat, and negative net valuation of sugar, saturated fat and carbohydrates) within the value span covered by our data. Also, for nutrients with a net positive health valuation, all quadratic parameters have the expected negative sign (or are insignificant), indicating falling (non-increasing) marginal health utility, while the converse is true for nutrients with a net negative health valuation.

Table 3: Parameter values, the health attribute

		All households		Least educated		Medium educated		most highly educated	
	Nutrient	Coef	Std. err	Coef	Std. err	Coef	Std. err	Coef	Std. err
γ_i	Common health								
	Added sugar	5.76E ⁻⁰⁸	0.0049	-0.0060	-5.11E ⁻⁰⁸	-0.0240	**	0.0099	6.39E ⁻¹¹
	Carbohydrates	-0.0018	0.0031	2.61E ⁻⁰³	2.98E ⁻⁰³	0.0387	***	0.0086	-0.0235
	Fibre	0.1119	***	0.0359	0.1334	***	0.0361	0.4095	***
	Protein	0.1211	***	0.0086	0.0804	***	0.0112	0.0200	0.0200
	Saturated fat	3.34E ⁻⁰⁹	0.0154	2.82E ⁻⁰⁹	2.41E ⁻⁰²	-2.74E ⁻⁰⁹	0.0472	6.12E ⁻¹¹	0.0226
\mathcal{E}_{ij}	Unsaturated fat	0.1862	***	0.0120	0.2027	***	0.0168	0.1461	***
	Common health, quadratic								
	Added sugar	-7.7E ⁻⁰⁸	***	-2.94E ⁻⁰⁸	-2.70E ⁻⁰⁹	-0.0500	-1.11E ⁻⁰⁷	7.30E ⁻⁰⁸	-6.05E ⁻¹¹
	Carbohydrates	-5.04E ⁻⁰⁸	***	-9.29E ⁻⁰⁹	-1.81E ⁻⁰⁷	***	-1.08E ⁻⁰⁸	-5.99E ⁻¹²	3.04E ⁻⁰⁸
	Fibre	-1.9E ⁻⁰⁵	***	-1.20E ⁻⁰⁶	-2.43E ⁻⁰⁸	-1.38E ⁻⁰⁶	-6.64E ⁻⁰⁵	***	4.18E ⁻⁰⁶
	Protein	-1.57E ⁻⁰⁶	***	-6.17E ⁻⁰⁸	-1.48E ⁻⁰⁶	***	-7.60E ⁻⁰⁸	-1.63E ⁻⁰⁶	***
	Saturated fat	-1.81E ⁻⁰⁶	***	-9.42E ⁻⁰⁸	-2.17E ⁻⁰⁶	***	-1.36E ⁻⁰⁷	-5.88E ⁻⁰⁷	***
	Unsaturated fat	-1.81E ⁻⁰⁶	***	-9.42E ⁻⁰⁸	-2.17E ⁻⁰⁶	***	-1.36E ⁻⁰⁷	-5.88E ⁻⁰⁷	***

* Significant at 10% level, **Significant at 5% level, *** significant at 1% level

In table 4, the estimated parameter values for the "taste" attributes of nutrients are shown for each of the educational groups.¹² The (numerous) estimated parameters for non-nutritional attributes are shown in appendix C. Generally, the "taste" of fibre is negatively valued, but mostly so for the least educated. Added sugar is positively valued in dairy products and generally negatively valued in other products, but the most highly educated consistently have the lowest taste valuations of sugar. Saturated fat is positively valued in meat, sugar products and dairy products for the least educated. Saturated fat is negatively valued in fats and bread, flour, and cereals, and no one likes the "taste" of unsaturated fat. All of these results seem plausible.

¹² Protein and carbohydrates are omitted since they do not add to the taste of the products.

Table 4: Estimated parameter values α_{ij} and β_{ij} for "taste" attributes for each educational group¹³

Nutrient i	Food type j	Least educated		Medium educated		Most highly educated	
		Coef.	Std.err	Coef.	Std.err	Coef.	Std.err
Fibre α_{ij}	Fibre						
	Fish						
	Fruit/veg	-0.1814 ***	0.0322	-0.5429 ***	0.0675	-0.0496	0.0621
	Dairy						
	Fats						
	Carb.prod. ¹	-0.0862 **	0.0387	-0.2672 ***	0.0576	-0.0257	0.0680
	Meat						
	Sugar.prod ²	-0.6211 ***	0.0794	-0.4693 ***	0.1105	-0.2441	0.1951
	Fibre squared $\hat{\beta}_{ij}$						
	Fish						
Fibre squared $\hat{\beta}_{ij}$	Fruit/veg	(omitted)				(omitted)	
	Dairy						
	Fats						
	Carb.prod. ¹	-0.9126 ***	0.0964	-1.0673 ***	0.2551	-0.8433 ***	0.0000
	Meat						
	Sugar.prod ²	(omitted)				(omitted)	
	Added sugar α_{ij}						
	Fish						
Added sugar α_{ij}	Fruit/veg						
	Dairy	0.5989 ***	0.0252	0.1540 **	0.0683	0.0165	0.0456
	Fats						
	Carb.prod.	-0.0305 ***	0.0095	0.1105 ***	0.0208	-0.0907 ***	0.0216
	Meat						
	Sugar.prod.	-0.0918 ***	0.0079	-0.0533 ***	0.0120	-0.1260 ***	0.0197
	Added sugar squared, β_{ij}						
	Fish						
	Fruit/veg						
	Dairy	(omitted)		(omitted)		(omitted)	
Added sugar squared, β_{ij}	Fats						
	Carb.prod.	-1.73E ⁻⁰¹ *	0.1054	-0.7696 ***	0.3045	-1.31E ⁻⁰⁹	0.2804
	Meat						
	Sugar.prod.	0.0668 ***	0.0039	0.0895 ***	0.0067	0.0863 ***	0.0121
	Saturated fat α_{ij}						
	Fish	-0.1801 ***	0.0258	-0.2883 ***	0.0586	-0.0919 ***	0.0334
	Fruit/veg						
	Dairy	0.1797 ***	0.0453	-0.4807 ***	0.0562	0.0081	0.0778
Saturated fat α_{ij}	Fats	-0.0968 ***	0.0276	-0.1613 **	0.0747	-0.0536	0.0373
	Carb.prod.	-0.0967 ***	0.0262	-0.2222 ***	0.0523	-0.1322 ***	0.0269
	Meat	0.2224 ***	0.0559	0.1053	0.1330	-0.0661	0.1084
	Sugar.prod.	0.1202 ***	0.0271	0.0502	0.0479	0.1339 ***	0.0404
	Saturated fat squared						
	Fish	(omitted)		(omitted)		(omitted)	
	Fruit/veg						

¹³ Estimated parameter values for the non-nutritional "taste" parameters are shown in appendix C

β_{ij}	Dairy	1.0200 ***	0.0866	3.2306 ***	0.2802	0.6701 ***	0.1276
	Fats	-0.0904 ***	0.0187	-0.0518	0.0741	-0.1200 ***	0.0397
	Carb.prod.	(omitted)		(omitted)		(omitted)	
	Meat	0.1410 *	0.0754	0.6580 ***	0.1366	0.5784 ***	0.1896
	Sugar.prod.	0.2158 ***	0.0404	-0.2011 **	0.0999	-0.0335	0.1481
	Unsaturated fat	-0.0439 **	0.0177	-0.1019 **	0.0418	0.0060	0.0224
α_{ij}	Fish						
	Fruit/veg						
	Dairy	-1.0695 ***	0.0973	0.0876		-0.2505	0.1789
	Fats	-0.1754 ***	0.0170	-0.1015 **	0.0400	0.0001	0.0186
	Carb.prod.	-0.2457 ***	0.0264	0.0162	0.0508	-0.2797 ***	0.0387
	Meat	-0.5269 ***	0.0395	-0.4861 ***	0.0911	-0.1982 ***	0.0723
Unsaturated fat, squared	Sugar.prod.	-0.3190 ***	0.0243	-0.2243 ***	0.0406	-0.2014 ***	0.0441
	Fish	-0.7023 ***	0.0658	-0.2910 **	0.1479	-0.3635 ***	0.1079
	Fruit/veg						
	Dairy	(omitted)		(omitted)		(omitted)	
	Fats	-0.0027 **	0.0011	-0.0326 *	0.0182	-0.0178 ***	0.0055
	Carb.prod.	(omitted)		(omitted)		(omitted)	
β_{ij}	Meat	0.0106	0.0312	-0.1731 ***	0.0614	-0.1764 **	0.0861
	Sugar.prod.	-2.0106 ***	-0.2007	-1.9908 ***	-0.1987	-1.7008 ***	-0.1697

1) Bread, flour and cereals 2) Biscuits, cakes, spreadables and ice cream

5. Discussion of Results

Health preferences

The estimated marginal valuation as a function of per capita nutrient consumption is illustrated for six nutrients in figure 2 below¹⁴. Each function is cut off at the 5th percentile and the 95th percentile of monthly per capita nutrient consumption levels observed in our data period so that the horizontal span of each graph illustrates the observed variation in nutrient consumption in our data.¹⁵ Our regression estimates indicate positive health valuations of unsaturated fat, protein and fibre, and negative health valuations of sugar, saturated fat and carbohydrates. These valuations are well aligned with the official Danish diet recommendations from 2003-2004¹⁶, which indicate that sugar and saturated fat are unhealthy, while fibre,

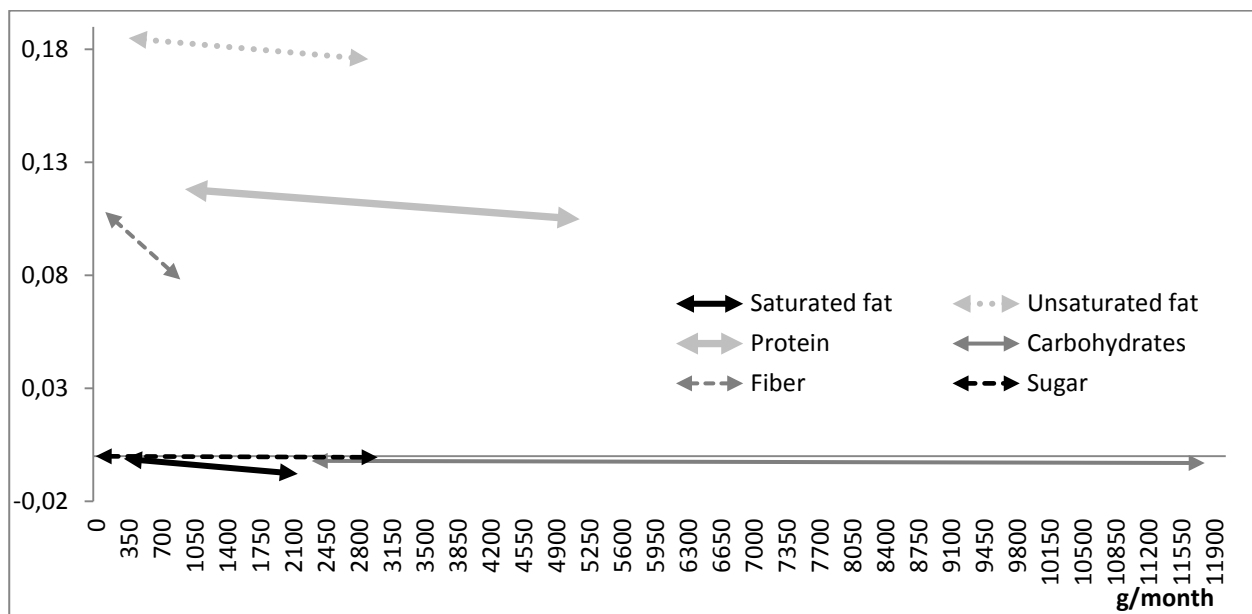
¹⁴ Each functional relationship is calculated by inserting the estimated parameters from the aggregated model (all consumers) into equation (13). We calculate the marginal health valuations of each nutrient as a function of monthly per capita nutrient consumption.

¹⁵ Fibre consumption ranges from 117 to 914 g/person/month, protein from 956 to 5,132 g/person/month, carbohydrates from 2,290 to 11,785 g/person/month, saturated fat from 292 to 2,136 g/person/month, unsaturated fat from 381 to 2,887 g/person/month and sugar from 0 to 317 g/person/month.

¹⁶ The recommendation is for a maximum of 30 % of total energy intake from fat and a maximum of 10 % of total energy intake from saturated fat. (The more refined recommendations suggest minimum requirements from unsaturated fat consumption, namely between 10 – 15 % of total energy intake from monounsaturated fat and 5-10 % of total energy intake from polyunsaturated fat). In addition, 10-15% of energy intake should come from protein, and 55-60% from carbohydrates. Fibre intake should be at least 3 grams per MJ (about 2.4% of total energy intake), fruit

protein, carbohydrates and unsaturated fat are healthy. The only real inconsistency is that consumers appear to have a negative valuation of carbohydrates despite the positive evaluation in the official diet recommendations. This inconsistency might be because the official carbohydrates recommendation was questioned in the popular press and in various popular diets (e.g. the Atkins and South Beach diets) during our data period. In addition, the main focus of the authorities during this period was on communicating warnings about the negative health consequences of saturated fat and the positive health consequences of fibre in the diet and to some extent also the negative health consequences of sugar consumption. It is the health valuations of these three nutrients that we focus on in the comparison between educational groups.

Figure 2: Marginal health valuation of nutrients

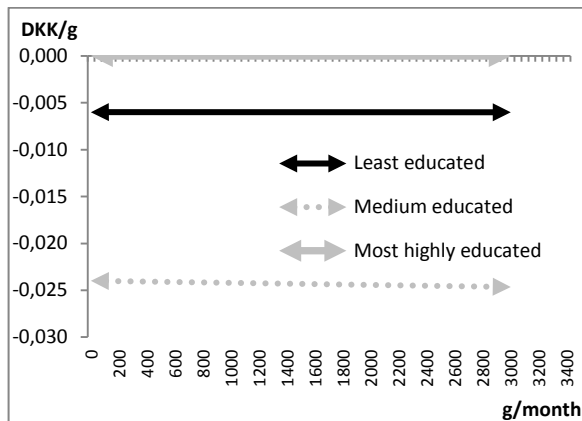


In figure 3, we present the estimated marginal health valuations for sugar (3a), fibre (3b) and saturated fat (3c) for each of the three educational groups. As in figure 2, we present the marginal valuations as a function of per capita nutrient consumption where the horizontal span of each graph illustrates the observed variation in nutrient consumption in our data¹⁷.

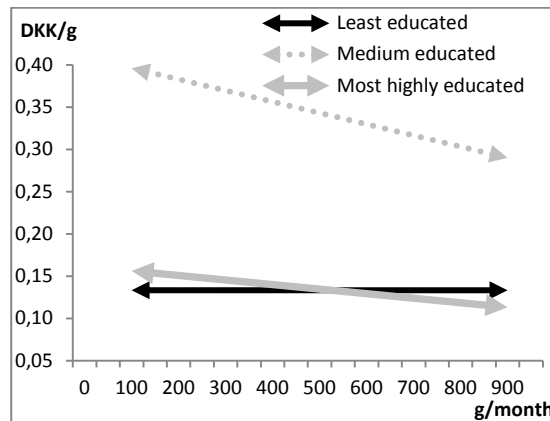
and vegetables intake should be at least 600 grams a day while the fish intake should be 200-300 grams of fish each week (Becker et al., 2008). The recommendations were updated in 2013.

¹⁷ These are again calculated from equation (13) using parameter estimates from each of the three sub-group models. In each figure, functions are cut off at the 5th percentile and the 95th percentile of observation for the indicated education sub-group.

3a) Marginal health valuation of added sugar



3b) Marginal health valuation of fibre



3c) Marginal health valuation of saturated fat

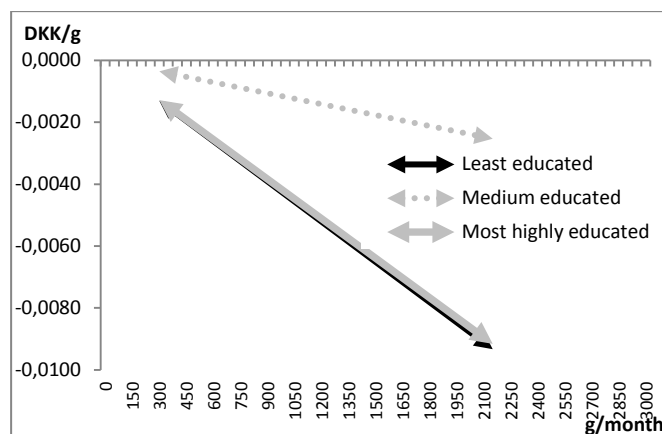


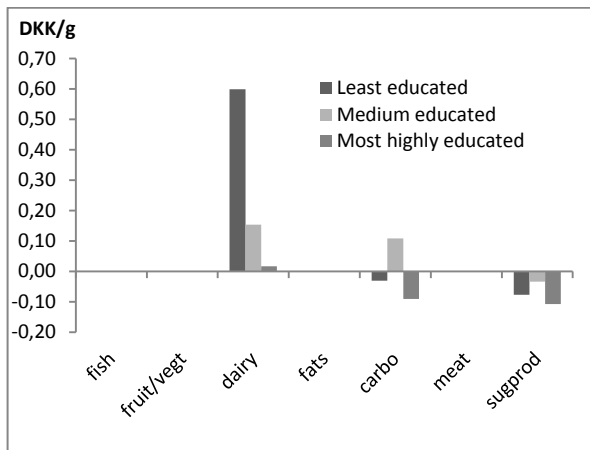
Figure 3a) illustrates the marginal health valuations of added sugar. Marginal health valuations are almost constant for all three groups across the consumption variation indicated by our data. It is also clear that medium educated consumers have a substantially more negative evaluation of sugar than both the least and the most highly educated consumers (these two groups' health valuations do not statistically differ from 0). Figure 3b) shows the marginal health valuations of fibre. All three groups have significant positive valuations, and for the medium educated group (with the highest valuation) the valuation decreases notably with aggregate fibre consumption. Thus it seems that within this group consumers realize not only that fibre is healthy, but also that the marginal benefits decrease with consumption. The medium educated again deviate from the two other groups by having a substantially more positive health valuation across the entire 90% span of values in our data. Figure 3c) presents the marginal health valuations of saturated fat. All three consumer groups have significant negative marginal health valuations that become substantially more negative with aggregated saturated fat consumption. So it seems that consumers in all three groups realize not only that saturated fat is unhealthy, but also that it is more important to reduce consumption if one eats a lot of saturated fat in the first place. However, for saturated fat, we find that the medium

educated are the least concerned about health compared to the least and most highly educated consumers across the entire 90% span of values in our data. In conclusion, it seems that consumers generally understand and appreciate the documented health effects of nutrients, but only appreciate that these effects are closely related to the amount of nutrient consumed in relation to saturated fat. The second noticeable valuation pattern is that the least and most highly educated consumers have very similar marginal health valuations and that the medium educated group stands out by having stronger health preferences for two out of the three nutrients. This contrasts with the differences in healthiness of the three groups' diet composition (figure 1), where the most highly educated group stands out as it has the healthiest diet in all three nutrition dimensions.

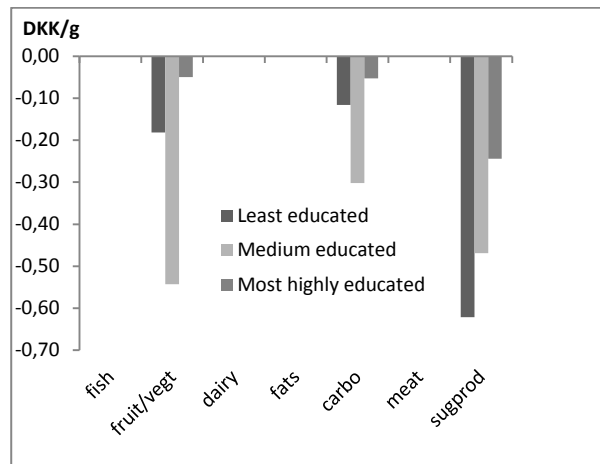
"Taste" preferences

We now turn to consumers' "taste" preferences. In figure 4, we compare the three consumer groups' marginal "taste" valuation of sugar (4a), fibre (4b) and saturated fat (4c). We compare the "taste" valuation of these three nutrients contained in each of the seven aggregated food categories, calculated at the average nutrient content level from table 2. The illustrated valuations indicate the "taste" value that consumers assign having more of the given nutrient in that specific food, and we see, as hypothesized, that the "taste" valuation varies over products for different nutrients. All educational groups like (or are neutral about) the "taste" of sugar in dairy, but dislike (or are neutral about) the "taste" of sugar in sugar products. The most highly educated dislike sugar the most. All groups dislike (or are neutral about) the "taste" of fibre, but the most highly educated dislike it the least. The "taste" valuations of saturated fat are more mixed. All groups dislike (or are neutral about) the "taste" of saturated fat in fish, fats and carbohydrate-containing foods, and like (or are neutral about) the "taste" in sugar products. For the groups contributing most saturated fat to the diet, namely meat and dairy, the results are mixed, with the least educated having positive valuations and the most highly educated having negative valuations.

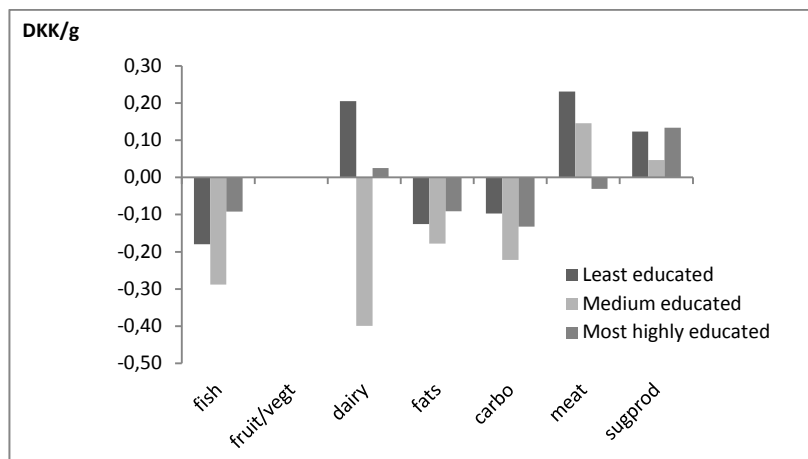
4a) Marginal "taste" valuation of added sugar



4b) Marginal "taste" valuation of fibre

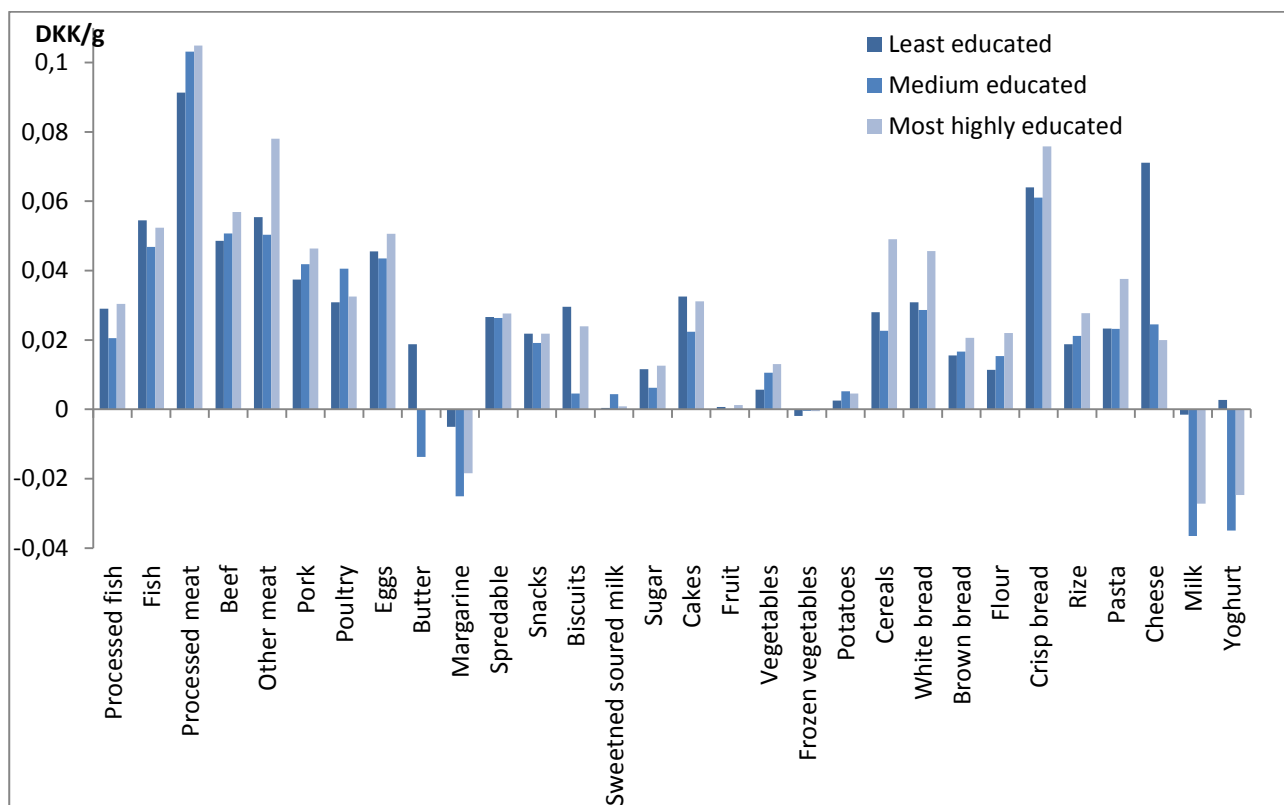


4c) Marginal "taste" valuation of saturated fat



Finally, in table 5 below, the "taste" valuation of non-nutritional characteristics of food are shown, i.e. the valuation of the 32 aggregated quality variants. These reflect "taste" which is not associated with the nutritional content of the products. This could be, for example, the quality of beef, which increases "taste" valuation within the meat category independently of the nutrient content. The least educated place a value of 48.6 DKK per kg on having beef within the meat category. For the medium and most highly educated, the same numbers are 50.7 and 56.9 DKK, indicating that the most highly educated have a stronger taste preference for beef than the least educated.

Figure 5 “Taste” valuation of non-nutritional characteristics



What explains healthier diets?

In table 5a below, we compare the healthiness of diet, health preferences and “taste” preferences for the most highly and least educated consumers. The table entries indicate which consumer group has the healthier diet (first column), health preferences (second column) and “taste” preferences (third column) with respect to the nutrient indicated in the row header. “No difference” indicates that there is no significant difference between the two groups. We see that the most highly educated have a healthier diet with respect to all three nutrients, but that their health preferences either do not differ from those of the least educated or are less healthy. Clearly, what explains the healthier diet is, in all cases, healthier “taste” preferences.

Table 5a: Healthiness of diets, health and “taste” preferences of most highly educated compared to least educated.

	<i>Healthiest Diet</i>	<i>Healthiest Health Preferences</i>	<i>Healthiest “Taste” Preferences</i>
<i>Sugar</i>	Most highly Educated	Least Educated	Most highly Educated
<i>Fibre</i>	Most highly Educated	No difference	Most highly Educated
<i>Saturated fat</i>	Most highly Educated	No difference	Most highly Educated ^{a)}

a) The most highly educated value the “taste” of saturated fat in fish and fats more than the least educated and the “taste” of saturated fat in dairy, meat and carbohydrate-containing foods less. However, as the latter account for 57.1% of the total intake of saturated fat, the most highly educated have healthier “taste” preferences overall.

In table 5b below, we compare the healthiness of diet, health preferences and "taste" preferences for the medium and least educated consumers. As in table 5a, the entries indicate which consumer group has the healthiest diet, health preferences or "taste" preferences with respect to the nutrient indicated in the row header. The medium educated have a healthiest diet with respect to saturated fat and again the explanation is healthier "taste" preferences because the least educated have healthier health preferences. In contrast, health preferences explain the medium educated's healthier diet with respect to sugar since both preference orderings are reversed. For fibre, there is no difference in diet healthiness, which is caused by the significant differences in the healthiness of "taste" and health preferences cancelling each other out. So here, both health and "taste" preference contribute to explaining the difference in diet healthiness.

Table 5b: Healthiness of diets, health and "taste" preferences of medium educated compared to least educated.

	<i>Healthiest Diet</i>	<i>Healthiest Health Preferences</i>	<i>Healthiest "Taste" Preferences</i>
<i>Sugar</i>	Medium Educated	Medium Educated	Least Educated ^{a)}
<i>Fibre</i>	No difference	Medium Educated	Least Educated ^{b)}
<i>Saturated fat</i>	Medium Educated	Least Educated	Medium Educated

^{a)} The medium educated value the "taste" of sugar in dairy less than the least educated, but the "taste" of sugar in carbohydrate-containing products and sugar products more. However, as the latter deliver 93% of all consumed sugar from food, the least educated have healthier "taste" preferences overall.

^{b)} The medium educated value the "taste" of fibre in fruit and vegetables and in carbohydrate-containing products less than the least educated, but the "taste" of fibre in sugar products more. However, as fruit and vegetables and carbohydrate-containing products together account for 94.4 % of all consumed fibre, the least educated have healthier "taste" preferences overall.

6. Conclusion

Most hedonic studies model only a few related food items simultaneously and find that the estimated valuations of nutrients (such as fat or sugar) contained in different foods differ substantially. This is not surprising since these nutrients, in addition to having any health implications, in many cases also have important effects on the "taste" experience when consuming the food. If a given effect of a nutrient on "taste" varies between goods, then likely so will its overall marginal valuation. In this paper, we develop a hedonic model based on the repackaging model of quality, which makes it possible to disentangle the "taste" and health values of a given nutrient under the key identifying assumptions that the health value of a given nutrient in a consumer's diet depends on his total consumption of the nutrient, while the "taste" value of consuming the nutrient in a given food only depends on his consumption of the nutrient contained in the given type of food. Our results suggest that consumers generally understand and appreciate the documented health effects of nutrients, but only appreciate that these effects are closely related to the amount of nutrient consumed in relation to saturated fat. Our results also indicate that the most highly

educated have a healthier diet than the least educated, not because of a greater preference for health, but because of a greater preference for the "taste" of healthy food. In contrast, differences in health preferences may, in part, explain why medium educated consumers have a healthier diet than the least educated.

The results in this paper may have important policy implications. A better understanding of why there are substantial differences in health preferences especially between the medium educated and other consumers could help improve the design of policies aimed at informing and motivating consumers to eat healthier foods. But perhaps more important is the result that the most highly educated eat a healthier diet because they prefer the "taste" of healthy foods. A better understanding of how these "taste" preferences are formed might guide and inspire policies focusing on forming healthier "taste" preferences. As "taste" preferences are often formed in early childhood, this might, for example, be accomplished through school meal programs or policies aimed at motivating parents to help their children appreciate the "taste" of healthy foods.

7. References

- Ahmad, W., and S. Anders. 2012. "The value of brand and convenience attributes in highly processed food products". *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 60(1): 113-133.
- Becker G.S. 1965. "A theory of the allocation of time" *Economic Journal* 75(299): 493- 517
- Becker, W., N.Lyhne, A.N. Pedersen, A. Aro, M. Fogelholm, P. Phórsdóttir, J.Alexander, S.A. Anderssen, H. M. Meltzer, and J.I. Pedersen. "Nordic Nutrition Recommendations2004-integrating nutrition and physical activity." *Food & Nutrition Research* 48(4): 178-187.
- Beenackers, M. A., C.B. Kamphuis, K. Giskes, J. Brug, A.E. Kunst, A. Burdorf, and F. Lenthe F. 2012. "Socioeconomic inequalities in occupational, leisure-time, and transport related physical activity among European adults: a systematic review". *Int J Behav Nutr Phys Act*, 9(1), 116.
- Brønnum-Hansen H., M. Baadsgaard, M. 2008. "Increase in social inequality in health expectancy in Denmark". *Scand J Public Health January 2008*. 36(1): 44-51
- Brønnum-Hansen H., M. Baadsgaard, M. 2012. "Widening social inequality in life expectancy in Denmark. A register-based study on social composition and mortality trends for the Danish population". *BMC Public Health* 12:994-201
- Carlucci, D., A. Stasi, G. Nardone and A. Seccia 2013. "Explaining price variability in the italian yogurt market: a hedonic analysis" *Agribusiness* 29(2): 194-206.
- Darmon, N., and A. Drewnowski 2008. "Does social class predict diet quality?". *The American journal of clinical nutrition*, 87(5), 1107-1117.
- Demarest S., H. Van Oyen, A. Roskam, B. Cox, E. Regidor, J.P. Mackenbach and A.E. Kunst. 2014. "Educational inequalities in leisure-time physical activity in 15 European countries". *European Journal of Public Health*, 24(2): 199-204. doi: 10.1093/eurpub/ckt061
- Drescher L., S. Thiele and C.R. Weiss 2008a. "The taste for variety: A hedonic analysis" *Economic Letters* 101: 66-68.
- Drescher, L. S., J. Roosen, S. Thiele, G.B. Mensink, S. Von Cramon-Taubadel, and J.P. Loy 2008b. "Quantification of a diet's value using hedonic analysis: Integrating a health aspect". *Food Economics-Acta Agriculturae Scandinavica, Section C* 5(3-4): 164-177.
- Gallo V., J.P Mackenbach, M. Ezzati, G. Menvielle, A.E. Kunst, S. Rohrmann, et al. 2012. "Social inequalities and mortality in Europe—results from a large multi-national cohort". *PloS one*, 7(7), e39013.

- Glümer C., B.H. Hansen, A.H. Bender, K.M. Andreasen, I. Robinsom I and A. Andersen 2014." Time trends in absolute and relative social inequality in smoking from 2007 to 2013 in the Capital Region of Denmark" 7th European Public Health Conference 21th of November 2014. *The European Journal of Public Health*
- Groth MV, Christensen LM, Knudsen VK, Sørensen MR, Fagt S, Ege M, Matthiessen J. 2013. *Sociale forskelle. I børns kostvaner, fysiske aktivitet og overvægt og voksens kostvaner*. Fødevareinstituttet. Mørkhøj. Denmark.
- Groth, M.V., M.R. Sørensen, J. Matthiessen, S. Fagt, N. Landvad, and V.K. Knudsen. 2014. "Disparities in dietary habits and physical activity in Denmark and trends from 1995 to 2008." *Scandinavian journal of public health* 42(7): 611-620.
- Grunert, K.G., and J.M. Wills, 2007. " A review of European research on consumer response to nutrition information on food labels". *Journal of Public Health* 15(5): 385-399.
- Grunert, K.G., L. Fernández-Celemín, J.M. Wills, S.S. genannt Bonsmann, and L. Nureeva. 2010. "Use and understanding of nutrition information on food labels in six European countries". *Journal of Public Health* 18(3): 261-277.
- Hiscock R., L. Bauld, A. Amos, J.A. Fidler and M. Munafo 2012. "Socioeconomic status and smoking: a review" *Annals of the New York Academy of Sciences* 1248(1): 107–123
- Hoffmann R. 2011. "Socioeconomic inequalities in old-age mortality: A comparison of Denmark and the USA". *Social science and medicine* 72(12): 1986–1992
- Huang C.L. and B-H. Lin 2007. "A hedonic analysis of fresh tomato prices among regional Markets" *Review of Agricultural Economics* 29(4): 783 - 800
- Johnston DW, Lordan G, Shileds MA, Suziedelyte A. 2015. Education and health knowledge: Evidence from UK compulsory schooling reform. *SAocial science and Medicine*. 17. 92-100
- Kulik M.C., T.A. Eikemo, E. Regidor, G. Menvielle and J.P. Mackenbach. 2014."Does the pattern of educational inequalities in smoking in Western Europe depend on the choice of survey?" *International Journal of Public Health* 59(4): 587-597
- Ladd G.W. and M. Zober 1977. "Model of consumer reaction to product characteristics". *The Journal of Consumer Research* 4(2): 89-101
- Ladd G.W. and V. Suvannunt 1976. "A Model of Consumer Goods Characteristics". *American Journal of Agricultural Economics* 58: 504-510
- Ladd, G.W., and M.B. Martin .(1976). Prices and Demands for Input Characteristics." *Am. J. Agr.*

Econ.58: 21–30.

Lancaster K. 1966. "A new approach to consumer theory" *Journal of Political Economy* 74(2): 132-157

Lenz J.E., R.C. Mittelhammer and H. Shi 1994. "Retail-level hedonics and the valuation of milk components" *American Journal of Agricultural Economics* 76(3): 492-503

Lucas R. 1975. "Hedonic price functions" *Economic Inquiry* 13(2): 157-178

Mackenbach JP 2012. The persistence of health inequalities in modern welfare states: The explanation of a paradox. *Social science and Medicine*. 75(4). 761-769

Majer I.M., W.J. Nusselder, J.P. Mackenbach and A.E. Kunst. 2011. "Socioeconomic inequalities in life and health expectancies around official retirement age in 10 Western-European countries". *J Epidemiol Community Health*. 65:972-979

Marmot M. 2005. "Social determinants of health inequalities". *The Lancet*. 1099–1104

Marmot M., Allan J, Bell R., Bloomer E., Goldblatt P (2015): WHO European review of social determinants of health and the health divide. *The Lancet*. 380(9846). 1011-1029

OECD Health Data (2011).

http://www.oecd.org/document/30/0,3746,en_2649_33929_12968734_1_1_1_1,00.html Accessed March 2012

Pampel FC, Krueger PM, Denney JT 2010: Socioeconomic Disparities in Health Behaviors. *Annu Rev Sociol*. 36. 349-370

Pechey R., S.A. Jebb, M.P. Kelly, E. Almiron-Roig, S. Conde, R. Nakamura, I. Shemilt, M.Suhrcke, and T.M. Marteau. 2013. "Socioeconomic differences in purchases of more vs. less healthy foods and beverages: Analysis of over 25,000 British households in 2010". *Social Science & Medicine* 92: 22-26.

Ranney C.K. and P.E. McNamara 2002. *Do healthier diets cost more?* Paper presented at the American Agricultural Economics Association's Annual meeting, July 28-31 2002, Long Beach, CA

Richards, T.J., L. Mancino, and W. Nganje 2012. "Nutrient Demand in Food Away from Home" *Forum for Health Economics and Policy* 15(2): 1-31

Rosen S. 1974. "Hedonic prices and implicit markets: Product differentiation in pure competition" *Journal of Political Economy* 74(1): 34-55

- Schroeck, R. 2014. "Valuing Country of Origin and Organic Claim: A Hedonic Analysis of Cheese Purchases of German Households" *British Food Journal* 116(7): 1070-1091.
- Schulz, L.L., T.C. Schroeder, T. C., and K.L. White. 2012. "Value of beef steak branding: Hedonic analysis of retail scanner data" *Agricultural and Resource Economics Review* 41(2): 260.
- Shi H. and D.W. Price 1998. "Impact of sociodemographic variables on the implicit values of breakfast cereal characteristics". *Journal of Agricultural and Resource Economics* 23(1):126-139
- Shongwe, M., A. Jooste, A. Hugo, Z.G. Alemu and A. Pelsler. 2007. "Will consumers pay for less fat on beef cuts? The case in Bloemfontein, South Africa" . *Agrekon* 46 (4): 475–493
- Smed S. 2008. *Health, information and consumer behaviour*. Ph.D. dissertation, Phd series no 128-2008 University of Copenhagen, Denmark
- Stanley L.R. and J. Tschirhart (1991). Hedonic Prices for a Nondurable Good: The Case of Breakfast Cereals. *The Review of Economics and Statistics*, 73 (3). 537-541
- Thunström, L. 2007. "The Marginal Willingness-to-Pay for Health Related Food Charactersitics" *Umeå Economic Studies No. 724*
- Thunström, L., and G. Rausser 2008. "The marginal willingness to pay for health-related food characteristics" *Food Economics-Acta Agriculturae Scandinavica, Section C* 5(3-4): 194-206.
- Vickner, S.S. 2014. "Estimating the Implicit Price of Convenience: A Hedonic Analysis of the US Breakfast Sausage Market" *Agribusiness*. DOI: 10.1002/agr.21404
- Ward, C. E., J.L. Lusk, and J.M. Dutton 2008. "Implicit value of retail beef product attributes" *Journal of Agricultural and Resource Economics* 33(3): 364-381.
- WHO, fact sheet 2015: <http://www.who.int/mediacentre/factsheets/fs355/en/>

Appendix A: The aggregation of foods into goods

Original grouping in data	Quality variants of good	Final food types in model	
Processed fish	Processed fish	Fish	
Fish	Fish		
Processed meat for bread	Processed meat	Meat	
Liver pâté			
Brawn and pâté			
Rissole			
Bacon			
Sausages			
Beef			Beef
Other meat			Other meat
Pork	Pork		
Poultry	Poultry		
Eggs	Eggs		
Butter	Butter	Fats	
Margarine	Margarine	Biscuits, cakes, spreads and snacks	
Chocolate (for bread)	Spreadable		
Marmalade	Snacks		
Snacks			
Icecream			
Biscuits	Biscuits		
Sweetened soured milk/desserts	Sweetened soured milk		
Desserts			
Sugar	Sugar		
Cake	Cakes		
Cookies			
Fruit	Fruit	Fruit and vegetables	
Vegetables	Vegetables		
Frozen vegetables	Frozen vegetables		
Potatoes	Potatoes	Flour, bread and cereals	
Cereals	Cereals		
White bread	White bread		
Brown bread	Brown bread		
Flour	Flour		
Crisp bread	Crisp bread		
Rice	Rice		
Pasta	Pasta		
Speciality cheese	Cheese		Dairy
Ordinary cheese			
Milk	Milk		
Yoghurt	Yoghurt		

Appendix B: Results from Feasible Generalized Nonlinear Least Squares (FGNLS) regression

Equation	Obs	No. Parms	RMSE	R-sq
All consumer				
Total expenditure on fish	44142	40	20.50361	0.9732*
Total expenditure on fats	44142	38	56.10426	0.9012*
Total expenditure on dairy	44142	46	76.00578	0.8398*
Total expenditure on fruit/veg	44142	32	98.4687	-5.0540*
Total expenditure on carb.prod.	44142	54	34.05683	0.9239*
Total expenditure on meats	44142	40	152.9373	0.8312*
Total expenditure on sugar.prod.	44142	50	87.01856	0.4906*
Least education				
Total expenditure on fish	28630	40	20.08006	0.9742*
Total expenditure on fats	28630	38	43.54888	0.9237*
Total expenditure on dairy	28630	46	66.49451	0.8631*
Total expenditure on fruit/veg	28630	32	90.75708	-3.9765*
Total expenditure on carb.prod.	28630	54	33.04928	0.9248*
Total expenditure on meats	28630	40	143.5624	0.8455*
Total expenditure on sugar.prod.	28630	50	95.81182	0.3810*
Medium educated				
Total expenditure on fish	6428	39	18.41777	0.9786*
Total expenditure on fats	6428	36	62.74028	0.8924*
Total expenditure on dairy	6428	44	85.06465	0.8019*
Total expenditure on fruit/veg	6428	32	120.3177	-8.5258*
Total expenditure on carb.prod.	6428	52	31.79167	0.9314*
Total expenditure on meats	6428	40	164.9183	0.8166*
Total expenditure on sugar.prod.	6428	48	54.34521	0.7915*
Best educated				
Total expenditure on fish	9084	40	19.8354	0.9749*
Total expenditure on fats	9084	38	74.42616	0.8906*
Total expenditure on dairy	9084	46	86.60007	0.8422*
Total expenditure on fruit/veg	9084	32	89.45695	-4.3682*
Total expenditure on carb.prod.	9084	54	36.55251	0.9253*
Total expenditure on meats	9084	40	145.3408	0.8573*
Total expenditure on sugar.prod.	9084	50	136.2599	-0.1994*

* Uncentered R-squared

Appendix C: Estimated parameter values for non-nutritional characteristics

	Least educated		Medium educated		Best educated	
	Coef.	P>z	Coef.	P>z	Coef.	P>z
Processed fish	0.0290	0.0000	0.0205	0.0000	0.0304	0.0000
Fish	0.0545	0.0000	0.0468	0.0000	0.0524	0.0000
Processed meat and pate	0.0913	0.0000	0.1031	0.0000	0.1050	0.0000
Beef	0.0486	0.0000	0.0507	0.0000	0.0569	0.0000
Other meat	0.0555	0.0000	0.0503	0.0000	0.0780	0.0000
Pork	0.0374	0.0000	0.0418	0.0000	0.0463	0.0000
Poultry	0.0309	0.0000	0.0406	0.0000	0.0326	0.0000
Eggs	0.0456	0.0000	0.0435	0.0000	0.0506	0.0000
Butter	0.0188	0.0000	-0.0137	0.4710	0.0001	0.9960
Margarine	-0.0050	0.0390	-0.0251	0.0230	-0.0184	0.0020
Spreadable	0.0267	0.0000	0.0263	0.0000	0.0276	0.0000
Snacks	0.0218	0.0000	0.0191	0.0000	0.0218	0.0000
Biscuits	0.0296	0.0000	0.0045	0.2240	0.0239	0.0020
Sweetened soured milk	0.0004	0.0800	0.0043	0.0000	0.0009	0.0270
Sugar	0.0116	0.0060	0.0062	0.3110	0.0126	0.2560
Cakes	0.0325	0.0000	0.0223	0.0000	0.0312	0.0000
Fruit	0.0007	0.0000	0.0000	0.8160	0.0012	0.0000
Vegetables	0.0056	0.0000	0.0105	0.0000	0.0131	0.0000
Frozen vegetables	-0.0019	0.0000	-0.0005	0.6400	-0.0005	0.5420
Potatoes	0.0025	0.0000	0.0052	0.0000	0.0045	0.0000
Cereals	0.0280	0.0000	0.0226	0.0000	0.0490	0.0000
White bread	0.0309	0.0000	0.0287	0.0000	0.0457	0.0000
Brown bread	0.0155	0.0000	0.0166	0.0000	0.0206	0.0000
Flour	0.0114	0.0000	0.0154	0.0000	0.0220	0.0000
Crispbread	0.0640	0.0000	0.0611	0.0000	0.0759	0.0000
Rice	0.0187	0.0000	0.0212	0.0000	0.0277	0.0000
Pasta	0.0233	0.0000	0.0232	0.0000	0.0377	0.0000
Cheese	0.0711	0.0000	0.0245	0.0030	0.0200	0.0010
Milk	-0.0015	0.2090	-0.0365	0.0000	-0.0272	0.0000
Yoghurt	0.0027	0.0430	-0.0349	0.0000	-0.0247	0.0000