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Specific food preferences of older adults with a poor appetite: a forced-choice test conducted in various care settings

Barbara S. van der Meij

Hanneke A.H. Wijnhoven

Graham S. Finlayson

Babette S.H. Oosten

Marjolein Visser

Department of Health Sciences, VU University Amsterdam (BM, HW, BO, MV)

Institute of Psychological Sciences, Faculty of Medicine and Health, University of Leeds, Leeds, United Kingdom (GF)

Department of Epidemiology and Biostatistics, VU University Medical Center, Amsterdam (MV)

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Author responsible for correspondence about the manuscript

Barbara van der Meij

bs.vandermeij@ctral.org

Center for Translational Research in Aging & Longevity

Department of Health & Kinesiology, Texas A&M University

Research Park Building #2, Suite 210.

1700 Research Parkway

College Station, TX 77843-4253, U.S.A

Phone nr: +1-979 - 450 -9905

Fax nr: +1-979-862-3244

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Food preferences of older persons

Abbreviations

BMI	Body Mass Index
GLM	General linear model
SNAQ65+	Short Nutritional Assessment Questionnaire 65+

Clinical trial registry

Not applicable

Abstract

A poor appetite in older adults is an important determinant of reduced food intake and undernutrition. Food preferences may influence food intake. The aim of this study was to investigate food preferences of older adults receiving a poor appetite and compare these with preferences of older adults with a good appetite. Older adults (n=349, aged 65-101 y) in nursing/residential care homes, hospitals or at home receiving home care participated in a computer-based forced-choice food preference assessment. Self-reported appetite in the past week was classified as 'good' or 'poor' using a validated instrument. Food preferences were determined by counting the relative frequency of choices for food images according to 11 dichotomous categories: high/low 1) protein; 2) fat; 3) carbohydrates; 4) fibre; 5) variation; and 6) animal/vegetarian proteins; 7) sweet/savoury taste; 8) solid/liquid texture; 9) dairy/non-dairy; with/without 10) sauce or 11) colour variation. Specific food preferences in participants with a poor appetite were identified by one-sample t-tests comparing frequencies to 48. Preference differences between those with a good and a poor appetite were analysed using GLM adjusting for confounders. The results showed that older adults with a poor appetite (n= 113; 32.4%) preferred variation (51.6 vs. 48, P<0.001), colour variation (55.9 vs. 48, P<0.01), non-dairy (53.0 vs. 48, P<0.001), high-fibre (51.8 vs. 48, P<0.05), and solid texture (53.5 vs. 48, P<0.05). Participants with a poor appetite had a higher frequency score for variation than participants with a good appetite (51.6 vs. 48.5, P<0.001). In conclusion, older adults with a poor appetite may have specific food preferences. Their preference for variation differs from those with a good appetite. These results may be used to develop meals that are preferred by older adults with poor appetite in order to increase food intake and prevent undernutrition.

Introduction

Protein-energy undernutrition is increasingly recognised as a serious health issue affecting a large and growing population of older adults. Although there is much debate on a gold standard assessment tool, it can be described by 'a state of energy and protein deficiency that can cause measurable adverse effects of the body' (1). Based on a body mass index (BMI) < 20 kg/m^2 and/or unintended weight loss of 5% or more in the past 6 months, prevalence rates of undernutrition among older adults are estimated at 7% in the general community, 12-16% in community-dwelling older adults receiving home care, 18-21% in nursing homes and 18-33% in hospitals (2, 3). Undernutrition is related to bone and muscle weakness, immune deficiencies, prolonged hospitalization, diminished quality of life, an elevated mortality risk, and more health care expenditures (4-9). Causes of undernutrition are multifactorial and include a number of biological and psychosocial factors, such as disease, trauma and depression (10-15); likely often underpinned by a poor appetite status (12, 13, 16).

A poor appetite is experienced by 11-66% of the older population (13, 17-19) and is an important risk factor for the development of undernutrition (13, 16, 20), evidently because it leads to suboptimal food intake (11, 21). Interventions that increase appetite or increase food intake despite a poor appetite, would therefore contribute significantly to the prevention of undernutrition. Up to now, there are only a limited number of interventions available to address this issue. Orexigenic drugs have been found to increase appetite and food intake. However, their use is accompanied by serious unwanted side effects and is therefore only recommended for severe cases of undernutrition (22). Oral nutritional supplements are used to increase protein-energy intake and short-term studies show a small but significant effect of these supplements on weight gain (23). However long-term compliance rates are generally low

(24, 25) and oral nutritional supplements may reduce the intake of regular meals and snacks, thereby reducing the overall effect (23, 25, 26).

So far, little research has been conducted on the specific food preferences of older adults with a poor appetite. Expert opinions suggest that persons with a poor appetite prefer small volumes and liquid foods (27) and dislike meat, stodgy foods and fats (28, 29). In addition, dietary variety is often limited in older persons (18), while more dietary variety has been shown to increase food consumption in older adults (30-32).

These previous studies suggest that older adults with a poor appetite may have specific food preferences. This knowledge may be useful for the development of new strategies to increase food intake in older adults with a poor appetite, and lower their risk of undernutrition. Therefore, the purpose of this study was to examine the specific food preferences of older adults with a poor appetite, and to identify potential differences in food preferences between older adults with a good and a poor appetite.

Subjects and Methods

Study participants and recruitment

Study participants were men and women aged 65 years and older. Recruitment took place in nursing homes, residential care homes, hospitals, and at home through home care organisations, retirement villages and/or meal services. Inclusion criteria were: Dutch language proficiency; able to consume a normal diet consisting of both solid and liquid foods; visual ability sufficient for completing a computer test; able to understand and participate in a task for at least 30 minutes. Exclusion criteria were: poor cognitive functioning (according to the

nursing staff or family members); radio- and/or chemotherapy in the previous month; being in a fasting condition for medical examination; or receiving tube feeding or parenteral nutrition. The procedures followed were in accordance with the ethical standards of the responsible institutional committee on human experimentation, in accordance with the Helsinki Declaration of 1975 as revised in 1983. The medical-ethical committee of the VU University Medical Center Amsterdam approved this study and all participants gave oral informed consent. Participants were visited at home or in their institution to perform the test.

General characteristics

Prior to the forced-choice food preference test, data on sex, age, educational level, type of setting (nursing/residential care home; hospital; at home with home care), smoking status, BMI, diet and nutritional status were obtained during a short interview. The time of testing was recorded and classified into morning or afternoon. BMI was calculated by dividing self-reported body weight (kg) by self-reported height (m) squared. When necessary, body weight or height information was retrieved from staff members or medical records. Nutritional status was assessed by the Short Nutritional Assessment Questionnaire 65+ (SNAQ65+), which is a validated, nutritional screening instrument that can be used to assess undernutrition among older adults and can be easily applied by health care professionals (33).

Appetite was assessed by the following question: “Did you experience a reduced appetite in the previous week? (yes/no)”. Participants answering “yes” were defined as having a poor appetite. At the start of the computer test, current appetite status was assessed using a 9-point Likert scale that varied from “very poor” (1) to “very good” (9).

Forced-choice food preference test

Food preferences were assessed using a behavioural 'forced-choice' methodology to identify relative food preferences. This method is well-suited to situations where overall desire to eat is low (34). A previously validated computerised procedure, developed by Finlayson and colleagues (Leeds Food Preference Questionnaire, Leeds University, U.K.) (35), was adapted for the current study. During the study, participants were randomly allocated to at least one of six tests, each test consisting of 96 pairs of 16 food images presented on a computer screen in high-resolution digital colour. Participants were asked to "select the food they most want to eat", by pressing the corresponding computer button. All choices were recorded as count frequency scores in E-prime (v 1.2, Psychology Software Tools, ND). To assure good understanding and execution of the test, participants were first given a practice run of at least four paired food images. For this study, pre-validated images of foods that are usually consumed by Dutch older adults were used and standardized to regular portion sizes. All images were validated in a separate pilot study, after which photographs of unfamiliar or misidentified foods were replaced.

Block randomization was performed to equally distribute the six tests among participants with a good or poor appetite, while stratifying for sex and type of setting. Participants could perform a maximum of three different tests on a voluntary basis if showing no signs of fatigue or tiredness. To control for differences in hunger level, testing was carried out at least two hours after consumption of a meal and at least half an hour after consumption of any beverages.

Food categories examined

The categories under examination were selected on the basis of the literature on food preferences in older adults, as well as information on differences in food patterns between older adults with various appetite levels (36-39).

Food preferences were examined according to 11 separate, dichotomous categories: 1) high or low protein; 2) high or low fat; 3) high or low carbohydrates; 4) high or low fibre; 5) variation or no variation; 6) animal or vegetarian proteins; 7) sweet or savoury taste; 8) solid or liquid texture; 9) dairy or non-dairy; 10) with or without sauce; and 11) with or without colour variation.

High-protein foods contained a minimum of 14 g of protein per 100 g, low-protein foods contained a maximum of 8 g/100 g. High-fat foods were defined as containing a minimum of 30 % of energy from fat and low-fat foods contained a maximum of 9 % of energy from fat. High-carbohydrate foods contained a minimum of 10 g/100 g of carbohydrates; low-carbohydrate foods contained around 4.5 g/100 g. High fibre foods contained a minimum of 2 g fibre per 100 g, whereas low fibre contained a maximum of 1.5 g/100 g. High- and low-fibre foods were presented with or without the addition of sauce. The category ‘animal protein’ contained meat, poultry and fish products, in contrast to products which only contained vegetarian proteins (e.g. eggs or peanuts). ‘Variation’ was defined as presenting two or three different types of the same food product with similar colour on one plate (i.e. broccoli, green beans, peas) when compared to a single type of food (i.e. broccoli only). ‘Colour variation’ was defined as the same type of foods containing at least 2 colours and flavours (e.g. chocolate, strawberry and vanilla ice-cream), compared to foods in a single colour and flavour.

Food preferences procedure

Each of the six tests comprised a pre-selected array of food images that formed categories within two independent, dichotomous factors. The factors in each food image array, i.e. *protein* and *variation*, were combined into four specific categories: high protein with variation, low protein with variation, high protein with no variation and low protein with no variation (**Table 1**). For each category, four exemplar food images were used (**Table 2**). During each test, the food images were paired so that every image from each of the four specific categories was compared to every other category over 96 trials (food pairs). For each trial, participants were instructed to indicate the food they wanted to eat the most at that time ("Which food do you most want to eat now?"). The recorded count frequency scores indicated the relative food preference for a particular category (range 0-24). Besides the preferences for specific categories, preferences for each generic factor were also assessed. For example: the counts of all high-protein foods (with or without variation) were compared against all low-protein foods (range 0-48).

Statistical analysis

All data were analysed using SPSS 20.0 for Windows. General characteristics of participants with a poor and good appetite were compared using independent t-tests and chi-square tests, as appropriate. In participants with a poor appetite, general food preferences for a specific food factor were identified by comparing count frequency scores to the expected values '48' and '24'. For generic factors (e.g. 'high-fat' or 'variation'), the expected value was '48', and for

combination factors (e.g. high-fat sweet or high-protein with variation), the expected value was '24'. A multivariate general linear model (GLM), suitable for multiple dependent variables, was used for comparing the four categories per test between appetite groups. Count frequency scores of the four categories were entered to the model as dependent variables and appetite (good vs. poor) was entered as independent variable. Univariate GLM was used for comparing the generic factors of each test between appetite groups. In addition, potential confounders (i.e. sex, care setting, education level, smoking status, diet and time of testing) were added to the model when causing a >10% change of the regression coefficient of appetite. Differences in preferences observed by the count frequency scores between participants with a good or a poor appetite were considered significant when p-values were < 0.05. For each test, outliers of the good and poor appetite groups (values that exceeded 1.5 x IQR) were excluded from data analyses.

Results

General characteristics

In total 349 older adults participated in this study and performed one or more forced-choice food preference tests. Participants were randomly allocated to one of the 6 different tests, which resulted in 94 to 103 participants per test. Baseline characteristics of the study sample are presented in **Table 3**. The average age of the included participants was 81 years (SD 8) and 63% (*n*=219) was female. Approximately one third (*n*=113) of the included participants reported a poor appetite in the previous week. Participants with a poor appetite were more often undernourished (44.2%) than participants with a good appetite (27.5%, P<0.001). The

prevalence of poor appetite was higher within the hospital setting (55.8%, P<0.001) compared to the nursing/residential home (28.3%) and at home with home care (15.9%).

General food preferences in older adults with poor appetite

In the poor appetite group, specific food preferences were observed when the count frequency score was compared to the expected values of 48 (generic factors) or 24 (combination factors), respectively (**Table 4**). Older adults with a poor appetite had statistically significantly higher count scores for the generic factors variation (51.6 vs. 48, P<0.001), colour variation (55.9 vs. 48, P<0.01), non-dairy (53.0 vs. 48, P<0.001), high-fibre (51.8 vs. 48, P<0.05), and solid texture (53.5 vs. 48, P<0.05). Other generic factors, like for example fat, protein, and carbohydrate content, showed inconsistent outcomes or showed equivocal preference scores. With respect to the combination of factors, older adults with a poor appetite had statistically significantly higher count scores for the combination of high protein with variation (27.4 vs. 24, P<0.05), colour variation with non-dairy (29.0 vs. 24, P<0.01), high fibre with sauce (27.1, vs. 24, P<0.001), and solid texture with high carbohydrate content (27.6 vs. 24, P<0.05).

Differences in food preferences between older adults with good or poor appetite

Compared to participants with a good appetite, participants with a poor appetite had higher frequency score for the general factor variation (51.6 vs. 48.5, P=0.008) and for the combination of variation with high-protein (28.6 vs. 24.0, P=0.004). No other (consistent) food preference differences were observed (Table 4).

Discussion

By means of a computer-based forced-choice food test, this study showed that older adults with a poor appetite had specific identifiable food preferences. They preferred variation, colour variation, non-dairy high-fibre, and solid texture. Some combinations were also preferred: high protein with variation, colour variation with non-dairy, high fibre with sauce, and solid texture with high carbohydrate content. Participants with a poor appetite had a higher preference for variation in food products compared to participants with a good appetite.

Although previous studies examined the food choices and taste preferences in older adults (38, 40-43), this is the first study to apply a forced-choice methodology to investigate relative food preferences in older adults with a poor appetite. Several specific food preferences were observed. One is the preference for color variation by older adults with both a poor appetite and a good appetite. Studies in healthy subjects suggest that colour variation can enhance food intake (44). To our knowledge, the impact of food colour variation on the appreciation and consumption of foods has not yet been investigated in older adults at risk of undernutrition.

We also observed a preference for non-dairy (high-fibre) foods above dairy foods. This was consistent for older adults with a poor and a good appetite, but slightly more pronounced in the poor appetite group (not statistically significant). Food consumption studies among older persons in the Netherlands and the United States report a lower consumption of dairy foods than is recommended (45-47). For instance in the Netherlands, the median consumption of dairy products among community dwelling older adults (> 70 years) is around 300 grams a day instead of the recommended 650 grams a day (46, 48). Data from the United States also show a

suboptimal intake of dairy products, with over 90% of persons of age >71 who do not meet the recommended 3 servings a day (45, 47, 49). As dairy foods are an important source of protein, calcium and B-vitamins, the finding that these products are not preferred by older adults with a poor appetite is of concern. One practical consequence is that the offering of dairy snacks in institutions may be an ineffective way to improve energy and nutrient intake in older persons with a poor appetite, as these do not meet patients' preferences. Another consequence is that the necessary protein and calcium should be consumed through other food products. The preference for non-dairy foods with a high fibre content may help to increase dietary fibre intake, which is also known to be inadequate in older adults (46, 50, 51).

With regard to the structure of foods, we expected that a liquid texture would be preferred by older adults because liquids require less chewing, are easier to swallow and are less satiating than solid foods (27, 52). Our results suggest a preference for solid texture in both older adults with a good and a poor appetite, in particular for solid foods with a high carbohydrate content. This could be explained by the exclusion of subjects who had difficulties with chewing and/or swallowing. Chewing and swallowing difficulties are generally highly prevalent in older institutionalized persons (53), so this is probably a limitation of the generalizability of our findings to this specific population.

We found a strong preference for variation, especially variation of high protein foods, in older adults with a poor appetite, but not in older adults with a good appetite ($P<0.01$). Interestingly, studies have shown that increasing variety by offering more types of foods is an effective strategy to increase short term food intake in older adults (30-32), older adults in general (30-32) and older adults at risk of undernutrition (30-32). Experiments in healthy adults showed that after an imposed protein deficit, food intake and food preferences appeared to change

244 towards savoury, high protein foods in order to compensate for the protein shortage (54). The
245 observed preference for foods with variation and a high protein content in older adults with a
246 poor appetite of whom 44% was considered undernourished and probably had a protein deficit
247 supports these findings. Offering a large variety of high protein foods may therefore be a novel
248 way to increase protein intake and therefore enhance nutritional status in this vulnerable
249 group. At the same time, consumption of protein-rich products by older adults could be
250 hampered by an increased experience of satiety, chewing/swallowing problems and/or
251 financial problems (55-58). This can be overcome by replacing meat by less expensive or easier
252 to chew high-quality protein sources like eggs, seafood, and poultry (56, 59). As we did not
253 observe a preference for animal protein, vegetarian protein sources such as legumes or soy
254 products are also an option.

255
256 Although this study provides novel information regarding specific food preferences among
257 older adults with a poor appetite, some study limitations need to be addressed. Due to our
258 exclusion criteria, e.g. poor cognitive functioning, our study results may not be entirely
259 generalizable to the older population in the three used settings. Another limitation inherent to
260 our study design, is that forced-choice methodology is designed to measure relative food
261 preferences and may not reflect the actual ability to consume the presented foods, as food
262 choices may differ from actual food consumption decisions (60). Experimental studies using
263 similar forced-choice food preference methodology in young healthy adults have consistently
264 shown frequency scores for specific food categories to predict actual selection and intake of
265 those foods under controlled conditions (61, 62).

266 Nevertheless, future studies should be conducted to confirm the identified food preferences in
267 older adults with a poor appetite using actual food intake data.

In conclusion, this study shows that older adults with a poor appetite have specific food preferences that differ from those with a good appetite. These results enable the development of relevant strategies to increase food intake and thus prevent undernutrition in older adults with a poor appetite. The provision of adapted meals and snacks with high variation and color variation could help stimulate their food intake.

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Authors' contributions to manuscript

MV, HAW designed the study; BSM and BO conducted research and analyzed data, BSM performed statistical analysis; BSM, BO, GSF, MV and HAW wrote the paper; GSF shared knowledge and developed the forced choice tests. MV had primary responsibility for the final content. All authors read and approved the final manuscript.

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Table 1 Overview of the six forced-choice experiments.

Factor	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Combination						
1.	High fat / sweet	High protein / variation	High fat / animal protein	Dairy / colour variation	High fibre / sauce	High carbohydrates / solid texture
2.	Low fat / sweet	Low protein / variation	Low fat / animal protein	Non-dairy / colour variation	Low fibre / sauce	Low carbohydrates / solid texture
3.	High fat/ savoury	High protein / no variation	High fat / vegetarian protein	Dairy / no colour variation	High fibre / no sauce	High carbohydrates / liquid texture
4.	Low fat / savoury	Low protein / no variation	Low fat / vegetarian protein	Non-dairy / no colour variation	Low fibre / no sauce	Low carbohydrates / liquid texture

Factor	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Generic						
1.	High fat	High protein	High fat	Dairy	High Fibre	High carbohydrates
2.	Low fat	Low protein	Low fat	Non-dairy	Low fibre	Low carbohydrates
3.	Sweet	Variation	Animal protein	Colour variation	Sauce	Solid texture
4.	Savoury	No variation	Vegetarian protein	No colour variation	No sauce	Liquid texture

Table 2 Overview of food products used per test within each category

Test 1	**High fat / savoury**	**High fat / sweet**	**Low fat / savoury**	**Low fat / sweet**
	Salted peanuts	Apple pie with cream	Red wine	Dutch spiced cake
	Natural crisps	Cake	Cucumber	Grapes
	Beef croquette	Milk chocolate	Salty sticks	Banana
	Fried egg	Puff pastry with cream	Vegetable soup	Sponge cookie
Test 2	**High protein / variation**	**High protein / no variation**	**Low protein /variation**	**Low protein / no variation**
	Bread with types of cheese	Meatball	Mashed, baked and fried	Spaghetti with tomato sauce
	Types of sliced sausages	Chicken breast	Orange, mandarin and	Fried potatoes
	Shrimps, herring, smoked eel	Fish fillet	Broccoli, French beans, peas	Slices of apple
	Types of fried meat	Cheese cubes	Types of salted snacks	French beans
Test 3	**High fat / animal protein**	**High fat / vegetarian protein**	**Low fat / animal protein**	**Low fat / vegetarian protein**
	Fried Salmon	Salted peanuts	Steamed white fish	Kale hotchpot
	Sausage	Fried egg	Chicken Fillet	Pancake
	Chicken drumstick	Vegetarian pizza slice	Pork Fillet	Salty sticks
	Sausage with bacon	French cheese	Roast beef	Sliced cucumber
Test 4	**Dairy / colour variation**	**Dairy / no colour variation**	**Non-dairy / colour variation**	**Non-dairy / no colour**
	Cream pie with fruits	Cracker with 'brie' cheese	Natural and paprika crisps	Croissant
	Coloured ice cream	Plain yoghurt	Coloured cocktail nuts	Snack sausage
	Two coloured custard	Vanilla ice cream	Coloured donuts	Almond cake
	Cheesecake with strawberries	Custard	Coloured chocolate cookies	Natural crisps
Test 5	**High fibre / sauce**	**High fibre/ no sauce**	**Low fibre / sauce**	**Low fibre / no sauce**
	Chilli con carne	Dried fruit mix	Spaghetti with sauce	Boiled egg
	Brown rice with satay sauce	Rye bread with Gouda cheese	Nassi with satay sauce	Nassi
	Cream cheese on rye bread	Peanuts	Boiled potatoes with gravy	Vanilla ice-cream
	Dutch spiced cake with butter	Currant bun	Vanilla ice cream with	Fried salmon trout

Test 6	High carbs / solid texture	High carbs / liquid texture	Low carbs / solid texture	Low carbs / liquid texture
	Milk chocolate	Orange juice	Fried salmon trout	Semi-skimmed milk
	Dutch spiced cake	Cassis	Gouda cheese	Vegetable soup
	Pancake	Custard	Snack sausage	Tomato soup
	French fries	Forest fruit pudding	Stuffed egg	Coffee

Table 3 General characteristics of the study sample, stratified by appetite status.

	Appetite status in previous week		
	Poor	**Good**	**P-value**
n	113	236	
Female (%)	68.1	60.2	0.149[1]
Age (mean ± SD)	80.8 (8.1)	81.6 (8.2)	0.353[2]
Setting (%)			<0.001[1*]
Hospital	55.8	30.5	
Nursing/residential home	28.3	44.9	
Home care	15.9	24.6	
Appetite status at start of test (Likert scale,	5.2 (1.3)	7.4 (1.1)	<0.001[2*]
BMI (mean ± SD)	25.9 (4.9)	26.4 (4.9)	0.391[2]
Unintended weight loss ≥ 4 kg previous	35.4	20.3	0.002 [1*]
Undernutrition (%)[3]			<0.001[1*]
No	30.1	72.5	
At risk	25.7	0.0	
Yes	44.2	27.5	
Diet (%)			0.779[1]
None	88.5	88.1	
Diabetic	6.2	4.7	
Sodium	5.3	6.8	
Unknown	0.0	0.4	
Time of testing (%)			0.512[1]
Morning	71.7	68.2	
Afternoon	28.3	31.8	
Education (%)			0.148[1]
Primary	47.8	39.8	
Secondary	25.7	36.0	
Tertiary	19.5	20.3	
Unknown	7.1	3.8	
Smoking (%)			0.964[1]
Never	38.9	38.6	
Former	48.7	47.0	
Current	9.7	11.4	
Unknown	2.7	3.0	

P-values indicate statistical differences between good and poor appetite; * P-values < 0.05

[1] analysed by chi-square tests

[2] analysed by independent t-tests

[3] assessed by the Short Nutritional Assessment Questionnaire 65+ (SNAQ65+) (33)

Table 4 General food preferences in older adults and stratified by appetite status: mean count frequency scores of the generic factors and combination factors and differences between poor and good appetite groups

FORCED-CHOICE EXPERIMENT		**Total**	**Poor appetite**	**Good appetite**	**Poor vs. Good appetite Difference[3] (SE[4])**	
***n* Poor appetite / *n* Total [1]**	**Generic factors (2) Combination factors (4)**	**Mean (SE)[2]**	**Mean (SE)[2]**	**Mean (SE)[2]**	**Crude**	**Adjusted**
Test 1	High Fat vs. Low Fat	46.1 (1.03)	42.1 (1.77)**	47.4 (1.20)	5.4 (2.32)*	-4.2 (2.29)*
21 / 84	Sweet vs. Savoury	46.7 (1.22)	47.7 (2.85)	46.3 (1.33)	-1.4 (2.83)	-0.3 (3.19)
	Low Fat / Sweet	26.1 (0.77)**	27.6 (1.45)*	25.7 (0.91)	2.0 (1.78)	2.1 (1.91)
	Low Fat / Savoury	23.8 (0.93)	26.3 (1.66)	22.9 (1.10)	3.4 (2.13)	2.6 (2.21)
	High Fat / Savoury	22.9 (0.89)	21.4 (2.00)	23.4 (0.98)	-2.0 (2.05)	-1.7 (2.18)
	High Fat / Sweet	23.2 (1.02)	20.7 (2.38)	24.0 (1.10)	-3.4 (2.35)	-3.0 (2.55)

Test 2	High protein vs. Low protein	50.3 (1.11)*	51.3 (2.27)	49.8 (1.20)	1.4 (2.33)	4.2 (2.43)
32 / 93	Variation vs. No variation	49.6 (0.67)*	51.6 (0.89)***	48.5 (0.89)	3.1 (1.38)*	3.8 (1.40)**
	High protein / Variation	25.6 (0.72)*	27.4 (1.25)*	24.6 (0.87)	2.9 (1.50)	4.6 (1.56)**
	Low protein / Variation	24.0 (0.71)	24.2 (1.29)	23.9 (0.85)	0.2 (1.50)	-0.5 (1.57)
	High protein / No variation	24.8 (0.69)	23.8 (1.50)	25.3 (0.72)	-1.4 (1.46)	-0.9 (1.52)
	Low protein / No variation	21.7 (0.77)**	20.6 (1.33)*	22.2 (0.94)	-1.7 (1.62)	-3.2 (1.74)
Test 3	Animal protein vs.	46.1 (0.77)*	47.4 (1.20)	45.6 (0.98)*	1.8 (1.65)	2.8 (1.76)
30 / 95	vegetarian protein					
	High fat vs. Low Fat	50.8 (1.41)	52.5 (2.45)	50.0 (1.73)	2.6 (3.05)	3.2 (3.19)
	High fat / vegetarian protein	26.8 (0.99)**	27.3 (1.91)	26.6 (1.18)*	0.7 (2.16)	0.3 (2.30)
	High fat / Vegetarian protein	23.9 (0.79)	25.2 (1.11)	23.3 (1.03)	1.9 (1.70)	2.8 (1.86)
	Low fat / Vegetarian protein	23.0 (0.99)	21.3 (1.73)	23.8 (1.20)	-2.5 (2.13)	-2.9 (2.22)

	Low fat / Animal protein	22.2 (0.91)	22.2 (1.53)	22.2 (1.14)	-0.1 (1.97)	-0.2 (2.15)
Test 4	Colour / No colour variation	56.1 (1.23)***	55.9 (2.48)**	56.2 (1.38)***	-0.4 (2.61)	-1.1 (2.66)
30 / 88	Non-dairy / Dairy	51.4 (0.82)***	53.0 (1.02)***	50.6 (1.11)*	2.4 (1.72)	1.9 (1.72)
	Colour variation/Dairy	28.1 (0.90)***	26.8 (1.62)	28.7 (1.08)***	-1.9 (1.90)	-1.9 (1.90)
	No colour variation /Dairy	16.5 (0.94)***	16.1 (1.64)***	16.7 (1.16)***	-0.6 (1.99)	-0.1 (1.93)
	Colour variation/Non-dairy	28.0 (0.83)***	29.0 (1.31)**	27.5 (1.07)**	-1.5 (1.76)	1.4 (1.81)
	No colour variation/Non-dairy	23.4 (0.87)	24.0 (1.58)	23.1 (1.05)	0.9 (1.85)	0.6 (1.82)
Test 5	No sauce vs. Sauce	44.0 (1.05)***	44.6 (1.75)	43.6 (1.28)**	1.0 (2.29)	1.8 (2.18)
27 / 92	High fibre vs. Low fibre	51.8 (0.87)***	51.8 (1.68)*	51.7 (1.02)**	-0.1 (1.99)	-0.3 (1.96)

	High fibre / No sauce	24.4 (0.91)	24.8 (1.85)	24.2 (1.06)	0.6 (2.05)	-0.0 (2.05)
	High fibre / Sauce	27.4 (0.64)***	27.1 (0.87)***	27.6 (0.83)**	-0.5 (1.44)	0.2 (1.55)
	Low fibre / No sauce	19.6 (0.58)***	20.8 (0.92)**	19.2 (0.72)***	1.7 (1.29)	1.2 (1.36)
	Low fibre / Sauce	24.6 (0.87)	23.3 (1.48)	25.0 (1.06)	-1.8 (1.93)	-1.4 (1.99)
Test 6	High carb vs. Low carb	48.3 (0.98)	48.8 (1.17)	48.0 (1.39)	1.0 (2.05)	1.6 (2.25)
34 / 93	Solid vs. Liquid texture	54.1 (0.98)***	53.5 (2.18)*	54.4 (0.92)***	0.9 (2.05)	-0.5 (2.12)
	High carb / Liquid texture	19.7 (0.83)***	21.4 (1.60)	18.7 (0.91)***	2.6 (1.71)	1.8 (1.90)
	High carb / Solid texture	28.6 (0.79)***	27.6 (1.37)*	29.3 (0.96)***	-1.7 (1.64)	0.0 (1.75)
	Low carb / Liquid texture	22.2 (0.69)*	21.1 (1.25)*	22.8 (0.81)	-1.7 (1.42)	-2.4 (1.50)
	Low carb / Solid texture	25.5 (0.90)*	25.9 (1.52)	25.2 (1.13)	0.7 (1.88)	0.6 (2.05)

* P < 0.05; ** P < 0.01; *** P < 0.001

[1] Outliers excluded: test 1 n=4, test 2 n=8, test 3 n=3, test 4 n=3, test 5 n=3, test 6 n=7

[2] P-value of one-sample t-tests of count frequency scores vs. equivocal preference score (24 or 48)

[3] P-values of differences between good and poor appetite, analysed by univariate GLM (generic factors) or multivariate GLM (combination factors), corrected for confounders when applicable (sex, education, setting, smoking, diet, weight loss and/or time of testing)

[4] SE, standard error of the mean difference between poor and good appetite