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OPTIMIZING SENSORY QUALITY AND VARIETY: AN EFFECTIVE STRATEGY FOR INCREASING MEAL ENJOYMENT AND FOOD INTAKE IN OLDER NURSING HOME RESIDENTS

Virginie Van Wymelbeke[1,2], Claire Sulmont-Rossé[2], Valérie Feyen[2], Sylvie Issanchou[2], Patrick Manckoundia[1], Isabelle Maître[3]

[1] Pôle Personnes Âgées 1824, CHU Dijon Bourgogne, F-21000 Dijon, France

[2] Centre des Sciences du Goût et de l'Alimentation, AgroSup Dijon, CNRS, INRAE, Université Bourgogne Franche-Comté, F-21000 Dijon, France

[3] Groupe ESA, UPSP GRAPPE, SFR QUASAV 4207, F-49000 Angers, France

Corresponding author: Virginie VAN WYMELBEKE, CHU Dijon, Unité de Recherche Pôle Personnes Âgées, Centre Champmaillot, 2 rue Jules Violle, BP 87909, 21079 Dijon Cedex, France, virginie.vanwymelbeke@chu-dijon.fr

E-mail addresses : virginie.vanwymelbeke@chu-dijon.fr (V. Van Wymelbeke), claire.sulmont-rosse@inrae.fr (C. Sulmont-Rossé), valerie.feyen@inrae.fr (V. Feyen), sylvie.issanchou@inrae.fr (S. Issanchou), patrick.manckoundia@chu-dijon.fr (P. Manckoundia), i.maitre@groupe-esa.com (I. Maître).

Abbreviations

ANOVA, analysis of variance; BMI, Body Mass Index; MNA, Mini Nutritional Assessment, MMSE, Mini Mental State Examination

Abstract

A decline in appetite and consequently in food intake is often observed with ageing, particularly in older adults living in nursing homes. Several strategies have been tested in nursing homes to counter this phenomenon. However, the approaches have rarely focused on food improvement, and most studies have assessed the impact of flavor enhancement on eating behavior. The present experiment aimed to assess the impact of improving sensory quality *versus* increasing sensory variety on food intake and meal enjoyment in elderly individuals living in a nursing home. Four conditions were compared: control condition, a *Quality+* condition (recipes were improved according to sensory preference of the target population), a *Variety+* condition (participants were offered a variety of main dishes and several condiments throughout the meal) and a *Quality&Variety+* condition combining the two previous conditions. Eighty-two residents (age range: 71-101 years) participated in eight lunchtime sessions (2 replicates × 4 conditions). Compared to control condition, our results showed that improving the sensory quality of the dishes and/or providing variety led to increased meal enjoyment and food intake (energy intake: +5% for *Quality+*; +7% for *Variety+*). No additional effect was observed when the two factors were combined (+7% for *Quality&Variety+*). These results suggest that meal improvement strategies can be used to increase food intake in order to prevent and treat malnutrition in dependent older adults.

Keywords

Malnutrition; older adults; aged; eating; energy intake; condiment

1. Introduction

Several studies have highlighted the increased prevalence of malnutrition in older adults living in nursing homes (20-68%) compared with those living at home (4-10%) (Maître et al, 2014; Torres et al, 2014; van Nie et al, 2014; Borgström-Bolmsjö et al, 2015; Riches & Jeanes, 2015). Malnutrition is due to inadequate intake of nutrients, *i.e.* an imbalance of energy, protein and other nutrients (Elia, 2000). The risk of malnutrition is associated with older age and presence of disease (Leij-Halfwerk et al 2019). Without prevention and care, malnutrition leads to altered body composition and functional decline, it increases the risk of falls and fractures, and vulnerability to infectious disease and it exacerbates chronic disease. Finally, malnutrition leads to a decreased quality of life and an increased risk of death (Merrell et al 2012, Rasheed et al 2013).

According to van der Pols-Vijlbrief et al. (2014), malnutrition is mainly linked to a decline in appetite. Poor appetite can reduce food and nutrient intake (Payette et al., 1995) and increase the risk of weight loss and nutritional deficiency that leads to malnutrition (Brownie, 2006). The aetiology behind appetite decline in the elderly is complex and multifactorial (Morley, 2012; Pilgrim et al., 2015). It includes physiological aspects such as hormonal and metabolic changes (de Boer et al., 2012; Burd et al 2013), a decline in sensory perception (de Jong et al., 1999), impairments in oral health (Kiesswetter et al., 2018), psychosocial aspects such as loneliness (Locher et al., 2005; Ramic et al., 2011), and inadequate financial resources or physical disabilities that affect food shopping or cooking (van der Pols-Vijlbrief et al., 2017). It also integrates health-related factors such as chronic illness with acute infection (Langhans, 2007), depression (Cabrera et al., 2007), dementia (Marcus & Berry 1998) and use of drugs (Zadak et al., 2013).

The high prevalence of malnutrition in nursing homes may be partly related to the fact that institutionalized elderly people suffer more from functional and cognitive deficiencies and have poorer health than those living independently at home. However, whether voluntary or not, admission to a nursing home is a major turning event in the life of an older adult: it modifies their physical and social environment as well as their activities of daily living, including food-related habits (Nieuwenhuizen et al, 2010). In France, nursing home residents are seldom involved in decisions related to food and meals because such decisions tend to be governed by hygiene, nutritional guidelines, and organisational constraints. This may disengage an elderly individual from his/her diet, which in turn may have a negative impact on appetite and food intake. Finally, the menus and the dishes served in nursing homes do not always fulfill residents' expectations and preferences. Sulmont-Rossé et al (2012) observed that eating is still an important pleasure in advanced age, but meal satisfaction is significantly lower in nursing homes than at home.

The systematic literature review by Abbott et al. (2013) showed that several strategies have been developed and tested in nursing homes to improve residents' food intake and/or meal enjoyment. These strategies include improvements in food service (*e.g.* bulk food service; buffet style; extra options), dining environment (*e.g.* family-style mealtimes; background music), training staff, and/or food improvements. Regarding food sensory improvement, only a handful of studies have been published since 2000 (Table 1). Five studies assessed the impact of flavour enhancement, namely the impact of adding an aroma or a taste compound into a food to compensate for the decline in olfactory and gustatory capacities frequently observed with ageing (Schiffman & Warwick, 1993). For instance, Mathey et al. (2001) enhanced the flavour of the protein dishes served to elderly people living in nursing home. After 16 weeks of intervention, the authors observed a significant increase in energy intake (+ 7%) in people eating enhanced dishes compared with residents who continued to eat standard

dishes (control group). However, when Essed et al. (2007) replicated this study under the same conditions, this positive impact of flavour enhancement was no longer observed. So, flavour enhancement does not always have a positive impact on food intake or meal enjoyment (Kremer et al., 2014). Furthermore, none of these studies seems to have consulted the target population, *i.e.* the residents, before choosing the type or intensity of the added flavour compounds. Three studies observed that providing sauce or seasoning to the residents during the meal significantly improved food intake and/or meal enjoyment (Appleton et al., 2009; Best & Appleton, 2011; Divert et al., 2015). Finally, one study observed that increasing food variety (*i.e.* providing two side dishes instead of one or condiments on the table) also led to an increase in food intake and meal enjoyment in Divert et al., 2015.

The aim of the present experiment was to compare the impact of improving the sensory quality and/or increasing sensory variety of meals on food intake and meal enjoyment in institutionalized older adults. Sensory quality was improved according to the sensory expectations and preferences of the target population. A methodology was developed to collect feedback from the residents regarding the sensory characteristics of the dishes, and then to check that the improved recipes (based on the feedback) actually matched the preferences expressed by the population (Sulmont-Rossé et al., 2018). Sensory variety was improved by providing two rather than one side dishes for the main dish (Divert et al., 2015) and by providing several condiments throughout the meal. The range of condiments was chosen to offer a variety of flavour, texture and colours that could be combined in several ways with the different components of the meal.

Table 1. Review of studies assessing the impact of food improvement on food intake and/or food enjoyment in older adults living in nursing homes.

Studies	Country	Sample size	Age	Design	Follow-up	Intervention	Outcome
Mathey et al., 2001	ND	67	>65 yrs	Controlled trial	16 weeks	*Flavour enhancement*: addition of flavour compound and/or MSG to the main dish	Energy intake + Body weight +
Essed et al., 2007	ND	83	>65 yrs *M*= 84-85 yrs	Randomized controlled trial	16 weeks	*Flavour enhancement*: addition of flavour compound and/or MSG to the main dish	Food intake 0 Meal pleasantness 0 Body weight 0 / +
Laureati et al., 2008	Italy	36	57-98 yrs *M*=83.2 (♀) *M*=80.2 (♂)	Within-subject	11 days, a dish rated per day	*Sensory enhancement*: increased intensity of colour, flavour and taste in fortified food	Food liking 0 / +
Essed et al., 2009	ND	53	>65 yrs *M*=86 yrs	Within-subject	2 replicates	*Flavour enhancement*: addition of MSG to the main dish	Food intake 0
Pouyet et al., 2015	France	104	>70 yrs	Within-subject	No replicate	*Flavour enhancement*: addition of flavour compound in an appetizer	Food intake + Food liking +
Appleton et al., 2009	Ireland	28	>65 yrs	Within-subject	2 replicates	*Seasoning*: addition of sauce to the meat	Food intake + Meal pleasantness 0
Best et Appleton 2011	Ireland	18	65-91 yrs *M*=77	Within-subject	No replicate	*Seasoning* : addition of sauce or condiment to the meal	Food intake + Meal pleasantness +
Divert et al., 2015	France	30	71-99 yrs *M*=86,6	Within-subject	No replicate	*Seasoning*: condiments were provided to the resident	Food intake + Meal enjoyment +
Divert et al., 2015	France	30	71-99 yrs *M*=86,6	Within-subject	No replicate	*Variety*: two garnishes offered for the main dish instead of one	Food intake + Meal enjoyment 0

ND: The Netherlands; *M*: mean age; MSG: monosodium glutamate; 0: no effect; +: significant positive effect

2. Methods

2.1. Design

Two factors varied according to a 2×2 full factorial within-subject design: two sensory quality conditions (standard; improved) and two sensory variety conditions (standard; improved). This design was replicated twice: participants first took part in four sessions once every three weeks corresponding to the *standard quality and variety* condition (*Control*), *improved quality and standard variety* (*Quality+*), *standard quality and improved variety* (*Variety+*), and *improved quality and variety* (*Quality&Variety+*). The conditions were presented in a different order in the six nursing homes that took part in the study. Once month later, the participants were again presented with these four conditions once every three weeks, in a different order than during the first replicate (Table 2). Overall, the participants took part in 8 meal sessions.

Table 2. Overview of the presentation order of the conditions across the nursing home.

	Meal session	Nursing home					
		A	**B**	**C**	**D**	**E**	**F**
First replicate	1	*Control*	*Quality& Variety+*	*Variety+*	*Quality+*	*Control*	*Quality& Variety+*
	2	*Quality+*	*Control*	*Quality& Variety+*	*Variety+*	*Quality+*	*Control*
	3	*Variety+*	*Quality+*	*Control*	*Quality& Variety+*	*Variety+*	*Quality+*
	4	*Quality& Variety+*	*Variety+*	*Quality+*	*Control*	*Quality& Variety+*	*Variety+*
Second replicate	5	*Variety+*	*Quality+*	*Control*	*Quality& Variety+*	*Variety+*	*Quality+*
	6	*Quality+*	*Control*	*Quality& Variety+*	*Variety+*	*Quality+*	*Control*
	7	*Control*	*Quality& Variety+*	*Variety+*	*Quality+*	*Control*	*Quality& Variety+*
	8	*Quality& Variety+*	*Variety+*	*Quality+*	*Control*	*Quality& Variety+*	*Variety+*

2.2. Participants

Participants were recruited from six nursing homes in two French cities, Angers and Dijon. Sample size was calculated to detect a 10% increase in meal intake. Considering an average SD of 80 for meal intake in institutionalized elderly people (Divert et al., 2015), a minimum of 64 subjects was required (power=0.90; α=0.05). To account for a dropout rate of 20% a sample size of 77 subjects was considered sufficient. Participants were eligible for this study if they were 65 years old or over and if they were able to eat without assistance. Participants were excluded from the study if they were suffering from an acute condition at the time of the study, if they were allergic to one of the foods used in the study, if they had a prescribed diet or if they were served texture-modified food. After obtaining participants' informed consent, the following baseline characteristics were collected: nutritional status, measured by the Mini Nutritional Assessment (MNA; Vellas & Guigoz, 1999), and cognitive capacities, measured by the Mini Mental State Examination (MMSE; Folstein et al., 1975).

The design was approved by the French Ethics Committee for Research (IDRCB N° 2012-A00928-35). In accordance with ethical standards, informed consent was provided by each participant or their legal representative.

2.3. Procedure

The meals took place at lunch time, in the same room, using the same crockery as usual in the establishment. The meal was then served in accordance with the usual serving rhythm. The menu was the same across the different conditions. It was composed of grated carrots (starter), veal blanquette with steamed potatoes (main dish), two cheese products (dairy product), one high-protein and high-energy dense vanilla custard (dessert, 151.7kcal and 8.9g

of protein /100g) and bread. An overview of the meal conditions is displayed on Table 3. The nutritional compositions were similar for the different meal conditions.

In the control condition (*Control*), the participants received the standard recipes of veal blanquette and vanilla custard. They were served a portion of La Vache qui Rit® (semi-soft spreadable cheese) and of 'Fromage à Raclette' (semi-hard cheese) for the cheese, and a baguette levain (sourdough bread) for the bread.

In the improved sensory quality condition (*Quality+*), the participants received the improved recipes of veal blanquette and vanilla custard. We used a methodology (developed according to the reverse engineering principle) to improve the recipes according to the sensory expectations and preferences of older adults (Sulmont-Rossé et al., 2018). In the first stage, independent-living and institutionalized older adults were asked to taste the standard recipes and to suggest how the sensory characteristics could be improved (e.g. appearance, flavour, and texture). On the basis of these results, different variants were developed for each dish. In the second step, a second panel of independent-living (n=103) and institutionalized (n=63) older adults rated their "liking" for each variant. The results were used to select the recipes with the highest scores. Compared to the standard recipe, the improved veal blanquette recipe had soft meat, whole and crunchier mushrooms and carrots, enhanced salty taste and enhancement of gravy's aroma. The improved custard cream recipe had a fluid texture and an more pronounced vanilla aroma. In addition, participants were served a portion of Camembert (soft-ripened cheese) and of Comté (semi-hard cheese) for the cheese, and baguette tradition (traditional French bread making process) for the bread. Preliminary tests were done to check that Camembert, Comté and baguette tradition were respectively preferred to La Vache qui Rit®, 'Fromage à Raclette' and baguette levain by older adults.

In the improved sensory variety condition (*Variety+*), the participants were offered a second garnish, green beans, in addition to the potatoes for the main dish. There were also seven more condiments (butter, fresh cream, mustard, mayonnaise, tomato sauce, parsley, lemon) in addition to the usual condiments supplied by the nursing home (salt, pepper). These condiments were served in bowls placed in the middle of the table before the arrival of participants. The participants were free to help themselves to condiments whenever they wished during the meals (participants with functional disorders could ask the experimenter for help). A preliminary study has demonstrated that providing two garnishes instead of one for the main dish or providing the participants with condiments improved meal enjoyment and food intake (Divert et al., 2015).

The grated carrots were the same for each condition. In France, it is usual to offer a selection of various cheeses (‘plateau de fromages’), and so, in line with the habits of the nursing homes, a selection of two cheeses was systematically offered. For the 16 participants who had chewing problems or who disliked carrots, the grated carrots were replaced with vegetable soup. The 11 participants who did not like cheese and the 6 who did not like custard were served yoghurt and apple puree, respectively. For the first helping, the portion weight adhered to the recommendations of the GEM-RCN (2015) (Appendix 1). For each dish, participants who finished their plate were systematically offered a second helping that corresponded to one half of the weight of the first helping. One slice of bread was served to each participant, and another slice was systematically offered if the first one was consumed.

Table 3. Overview of the four meal conditions and of the corresponding nutritional composition (for the first helping).

	Control	Quality+	Variety+	Quality&Variety+
Starter	Grated carrots			
Meat	Standard recipe of veal blanquette	Improved recipe of veal blanquette	Standard recipe of veal blanquette	Improved recipe of veal blanquette
Garnish	Steamed potatoes	Steamed potatoes	Steamed potatoes Green beans	Steamed potatoes Green beans
Dairy product	La Vache qui Rit Raclette	Camembert Comté	La Vache qui Rit Raclette	Camembert Comté
Dessert	Standard recipe of vanilla custard	Improved recipe of vanilla custard	Standard recipe of vanilla custard	Improved recipe of vanilla custard
Bread	baguette levain	baguette tradition	baguette levain	baguette tradition
Condiments	No	No	Yes	Yes
Total energy (kcal)	810.0	806.0	810.0	806.0
Protein (g)	58.2	56.3	58.2	56.3
Fat (g)	37.6	43.5	37.6	43.5
Carbohydrates (g)	59.7	47.3	59.7	47.3

2.4. Outcomes

Food intake was measured by weighing the plates before and after consumption (SOEHNLE scales, precision: ± 1g). This was done for each participant and for each meal course. The consumption of water was not assessed since water bottles were placed in the middle of the table and available to all lunches. For the *Variety+* condition, an experimenter noted for each participant the type and the quantity (number of spoons or number of units) of condiments consumed.

Participants rated their feeling of hunger on a 7-point scale ranging from "Not at all" to "Extremely" before and after lunch. In addition, after the lunch, participants rated their

enjoyment of the whole meal and of each course (starter, main dish, dairy product, dessert, bread) on a 7-point scale ranging from “I didn’t enjoy it at all” to “I enjoyed it very much”.

2.6. Statistical analysis

Only the participants who took part in the four conditions in at least one replicate of four meal sessions were included in data analysis. Overall food intake, and energy, protein, fat and carbohydrate intake were determined per participant and per condition, for the whole meal and for each course. The nutrient composition (energy, protein, fat, carbohydrate) of each food item was determined from the nutritional information provided by the supplier or the packaging. Scaled responses (hunger, meal enjoyment) were converted into scores ranging from 0 (left anchor) to 6 (right anchor). The participants who scored lower than 20 on the MMSE questionnaire (*i.e.* suffering from moderate to severe cognitive impairment) were excluded from data analysis carried out on the scale scores. Intake variables and rating scores were submitted to a three-way Analysis of Variance (ANOVA), with *condition* and *repetition* as fixed factor, *participant* as random factor and the *condition×repetition* interaction. Regarding energy intake, this analysis was done for the whole sample but also by sub-groups considering the intake level observed in the control condition. For each participant, energy ratio was computed by dividing the energy intake with the recommended lunch allowance of calories (*i.e.* 30 kcal/kg of body weight/day for energy with 45% of the daily energy intake consume at lunch (HAS, 2007). This allowed distinguishing three sub-groups: normal eaters who fulfil their nutritional allowance (energy ratio $\geq$ 100%), small eaters (100% < energy ratio $\geq$ 66%) and very small eaters (energy ratio < 66%). ANOVAs were performed using the General Linear Model (GLM) procedure of SPSS software (SPSS 12.0.1 Institute INC., Cary, NC, USA). For each significant effect, a multiple comparison of means was done using the

LS-means option of the GLM procedure. Means (*M*) are associated with their standard error of the mean (*SEM*). The threshold for significance was set at 5%.

3. Results

3.1. Participants

Eighty-nine participants were included. Four participants withdrew (1 moved to another nursing home; 1 received texture-modified meals, and 2 died), and three participants did not complete at least four meal sessions. Finally, 82 participants (63 women and 19 men; mean age: 87.5 (SEM=0.77); age range: 71-101) were included for analysis of intake data. Among this sample, 60 participants had a MMSE score ≥ 20 and were thus included in the analysis of rating scores data. For the MNA scores, 52% of participants had a normal nutritional status and 38% were at risk of malnutrition or malnourished (10% missing data).

3.2. Food and nutrient intake

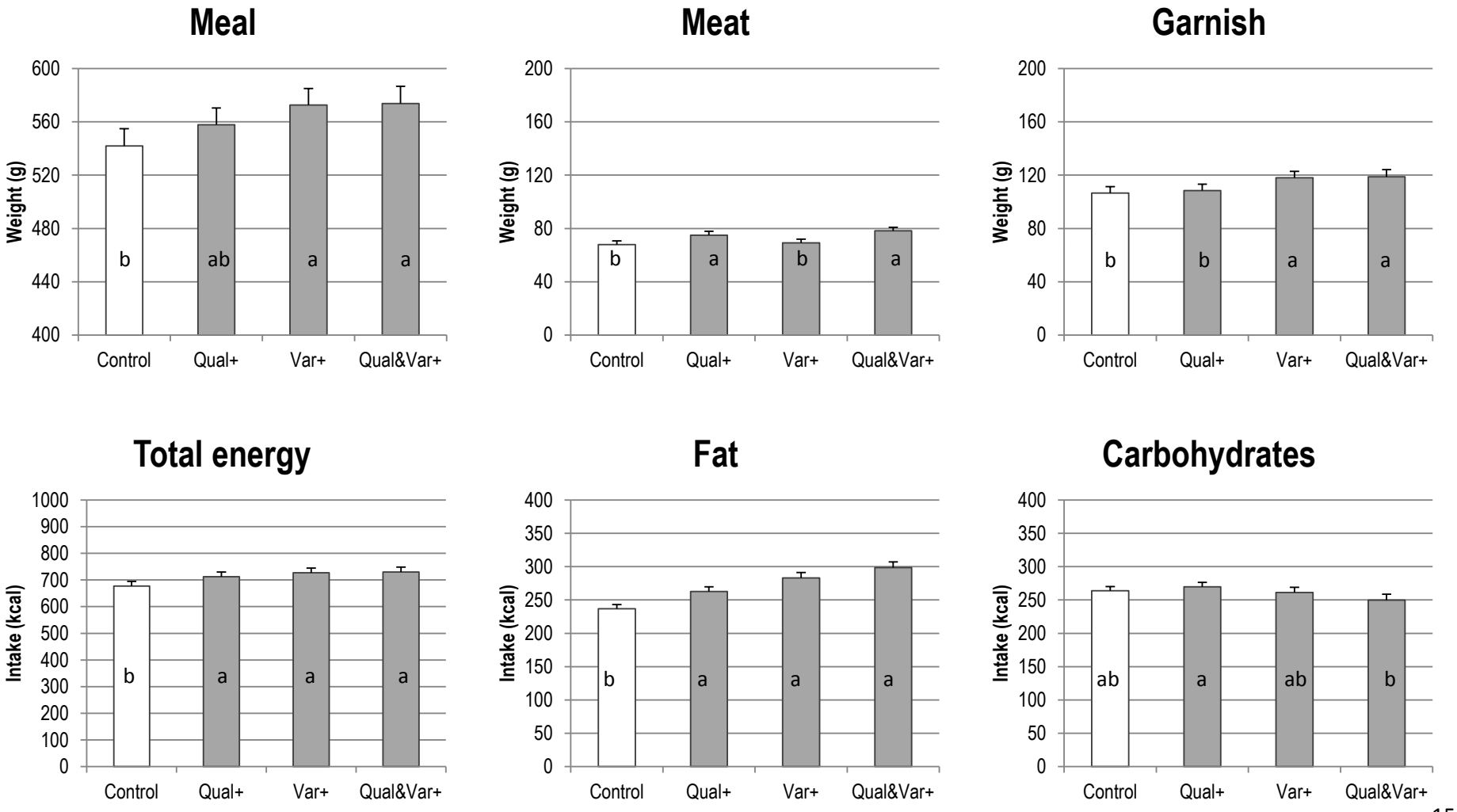
Table 4 depicts ANOVA results for each food and nutrient intake variable. For food intake, a significant *condition* effect was observed for the whole meal, the meat, the garnish and for the bread intake, as well as a significant *condition×repetition* interaction for the dessert and the bread intake. According to post-hoc analyses, food intake for the whole meal was higher in the conditions that included sensory variety (*Variety+*; *Quality&Variety+*) than in the control condition; no significant difference was observed between the *Quality+* condition and the other conditions. Meat intake was higher when the quality of meat was improved (*Quality+* and *Quality&Variety+* vs. *Control and Variety+*). Conversely, garnish intake was higher when participants were served potatoes and green beans (*Variety+*; *Quality&Variety+*) than when they were served only potatoes (*Control; Quality+*) (Figure 1). Bread intake was higher in the

Variety+ and *Quality&Variety+* conditions than in the control condition during the second replicate, but there was no significant difference between the conditions during the first replicate. Looking at the main *condition* effect, bread intake was higher in the three experimental conditions than in the control condition. For the dessert, the interaction resulted in a higher dessert intake for the *Variety+* condition in the second repetition than in the first one; no such difference was observed for the other conditions, and no significant difference was observed between the conditions in the first or second replicate.

Table 4. Results of the ANOVA performed on intake variables.

	Meal condition	**Repetition**	**Interaction**
FOOD INTAKE			
Meal intake	F=4.43; p<0.01	F=0.39; p=0.53	F=2.19; p=0.08
Starter intake	F=1.00; p=0.39	F=5.67; p<0.05	F=0.61; p=0.61
Meat intake	F=8.00; p<0.001	F=0.53; p=0.46	F=1.68; p=0.16
Gravy intake	F=1.57; p=0.19	F=1.56; p=0.21	F=1.02; p=0.38
Garnish intake	F=3.77; p<0.01	F=0.03; p=0.85	F=0.56; p=0.64
Dairy intake	F=1.27; p=0.28	F=2.67; p=0.10	F=0.27; p=0.84
Dessert intake	F=0.89; p=0.44	F=1.76; p=0.18	F=3.59; p<0.05
Bread intake	F=3.38; p<0.05	F=7.08; p<0.01	F=4.04; p<0.01
NUTRIENT INTAKE			
Energy intake	F=6.17; p<0.001	F=1.11; p=0.92	F=2.91; p<0.05
Protein intake	F=0.66; p=0.57	F=0.06; p=0.79	F=1.97; p=0.11
Fat intake	F=33.56; p<0.001	F=0.09; p=0.75	F=0.39; p=0.75
Carbohydrate intake	F=4.18; p<0.01	F=8.00; p<0.01	F=5.28; p<0.001

Fig. 1. Weight intake for the whole meal, for meat and garnish, total energy, fat and carbohydrates intakes and for each condition. The error bars correspond to standard error of the mean. For each variable, the means with the same letter are not significantly different ($p > 0.05$).



Regarding nutrient intake, there was a significant *condition* effect for energy and fat intake, as well as a significant *condition×repetition* interaction for energy and carbohydrate intake. Looking at the main *condition* effect, energy intake was higher in the three experimental conditions compared with the *control* condition. A similar result was observed for fat intake (Figure 1). We found no difference between the conditions during the first replicate, while during the second replicate, energy intake was higher in the sensory variety conditions (*Variety+*; *Quality&Variety+*) than in the control condition. The *Quality+* condition was not significantly different from any of the other conditions. In the *Variety+* and *Quality&Variety+* conditions, condiment intake represented around 2% of the whole food intake and 5% of energy intake, and was similar in the two conditions. Interestingly, the sub-group analysis showed a significant *condition* effect for the 'very small eater' (*i.e.* participants for which energy intake in the control condition was below 66% of recommended allowance). For these participants, energy intake was significantly higher in the three experimental conditions than in the control one (F=6.56; p<0.001). No such effect was observed for the 'normal eaters' who fulfil their nutritional allowance (F=0.41; p=0.75) neither for the 'small eaters' (F=1.67; p=0.17).

The possible existence of difference between the nursing homes was checked by submitting each variable to an ANOVA with *condition*, *repetition* and *nursing homes* as fixed factor and the *condition×nursing home* interaction. A significant *nursing homes* effect was observed on meal intake, with nursing home B displaying higher meal intake (682g) than the other nursing homes (from 502 to 566g ; F=20.16; p<0.001). Consistently, the former also displayed higher energy and protein intake than the latter. However, the *condition×nursing home* interaction was never significant for intake variables: the pattern of results between the conditions is similar across nursing homes and similar to the ones described in Figure 1. Regarding meal

enjoyment, a significant *nursing home* effect (F=13.17; p<0.001) and a significant *condition×nursing home* interaction (F=1.87; p<0.05) were observed. According to post-hoc analysis, no significant difference was observed between the conditions for nursing homes A, C and E. For B, meal enjoyment was lower for the control condition than for the three other conditions. For D and F the pattern of results was the same as the one displayed on Figure 2.

3.3. Hunger and enjoyment rating

Table 5 depicts ANOVA results for each rating score. For the hunger rating before the meal, the *condition* effect was marginally significant (p=0.051). The participants reported a higher hunger level in the *Quality+* condition (M=3.4; SEM=0.14) than in the *control* condition (control: M=3.1; SEM=0.14). No difference was observed between these conditions and the *Variety+* (M=3.1; SEM=0.14) and *Quality&Variety+* conditions (M=3.3; SEM=0.13). No significant effect was observed on hunger rating after the meal.

Regarding enjoyment, a significant *condition* effect was observed for the whole meal, the starter, the main dish, the dairy product, and the dessert. There was also a significant *condition×repetition* interaction for the bread. For the whole meal, enjoyment was significantly higher in the *Quality+* and *Quality&Variety+* conditions than in the *Variety+* condition, which was significantly higher than in the *Control* condition. Enjoyment was also higher in the three experimental conditions than in the *Control* condition for the main dish and the dessert. Cheese enjoyment was higher when participants were served Camembert and Comté (*Quality+*; *Quality&Variety+*) than when they were served La Vache qui Rit® and 'Fromage à Raclette' (*Control; Variety+*). Conversely, starter enjoyment was higher when participants were provided condiments (*Variety+*; *Quality&Variety+*) than in the other conditions (*Control; Quality+*) (Figure 2). Bread enjoyment was lower in the *Variety+*

condition than in the *Quality+* condition during the first replicate. No other significant difference was observed for bread enjoyment.

Table 5. Results of the ANOVA performed on rating scores.

	Meal condition	Repetition	Interaction
Pre-meal hunger	F=2.79; p=0.05	F=0.87; p=0.35	F=0.14; p=0.93
Post-meal hunger	F=0.81; p=0.48	F=2.33; p=0.12	F=0.76; p=0.51
Meal enjoyment	F=26.56; p<0.001	F=11.36; p<0.001	F=0.35; p=0.78
Starter enjoyment	F=3.98; p<0.001	F=1.61; p=0.20	F=0.67; p=0.56
Main dish enjoyment	F=41.81; p<0.001	F=9.48; p<0.01	F=1.31; p=0.27
Dairy product enjoyment	F=22.34; p<0.001	F=2.22; p=0.13	F=1.09; p=0.35
Dessert enjoyment	F=6.43; p<0.001	F=2.35; p=0.12	F=0.66; p=0.57
Bread enjoyment	F=1.50; p=0.21	F=0.99; p=0.32	F=2.96; p<0.05

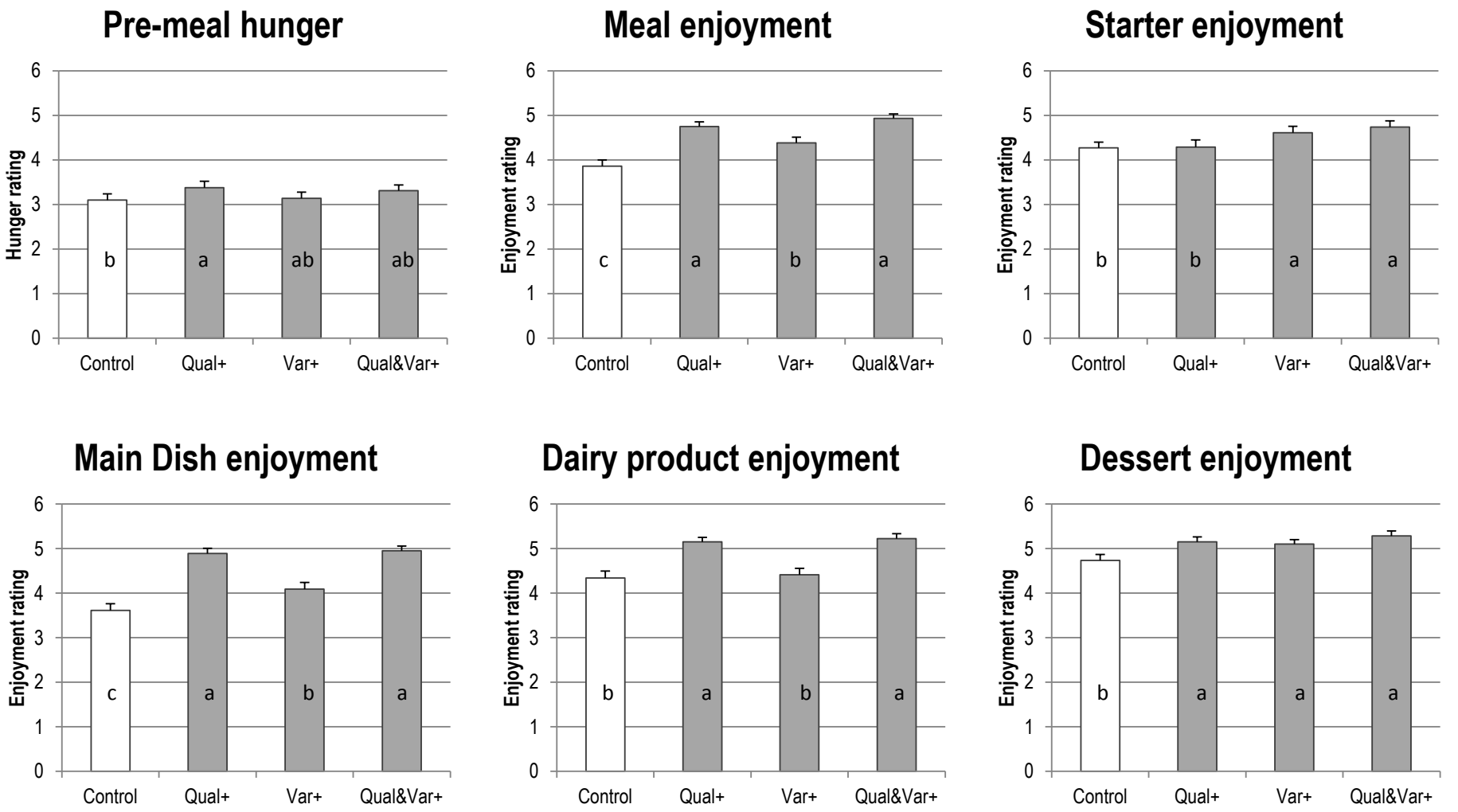
4. Discussion

We aimed to compare the impact of improving the sensory quality and/or increasing sensory variety of meals on food intake and meal enjoyment in institutionalized older adults. In the first condition, institutionalized older adults were served improved versions of standard dishes (*Quality+*). In the second condition, participants were provided with a variety of side dishes and a set of condiments throughout the standard meal (*Variety+*). The third condition combined the improvements of the two previous meals (*Quality&Variety+*).

The first result of the present experiment is that when the sensory quality of the dishes is improved, there is an increase in meal enjoyment and calorie intake. Interestingly, in the *Quality+* condition, there was an increase in enjoyment for the improved recipes of veal blanquette (main dish) and vanilla custard (dessert), but not for the grated carrots (starter) whose recipe was identical to the control condition (unfortunately, it was not possible to

improve the starter recipe). Two features make the present experiment set it apart from previous studies that have assessed the impact of food improvement on eating behaviour in nursing homes (Table 1).

Fig. 2. Pre-meal hunger score and meal, starter, main dish, dairy product and dessert enjoyment scores for each condition. The error bars correspond to standard error of the mean. For each variable, the means with the same letter are not significantly different ($p > 0.05$).



First, the recipes were improved *for* the target population and *with* their input (Sulmont-Rossé et al., 2018). This ensured that the sensory expectations and preferences of older adults were better taken into account. Food preferences and aversions may be different in younger and older individuals because of changes in food habits across generations (Hébel & Recours, 2007), but also because of a decline in the ability to perceive odours and tastes over time (Mackay-Sim et al., 2006; Methven et al., 2012; Sulmont-Rossé et al., 2015). Secondly, the sensory improvements assessed in the present experiment were multidimensional, taking into account not only flavour, but also texture (*i.e.* improvement of meat tenderness for the veal blanquette) and appearance (*i.e.* whole mushrooms instead of sliced mushrooms for the veal blanquette). Similarly, Kremer et al. (2014) observed a significant increase in food liking in dishes combining visual, textural and flavour enhancement (*e.g.* enhancement of taste intensity and thickness of gravy; visual and flavour enrichment by adding visible celery leaves in mashed potatoes). In addition, Kremer et al. (2014) observed that enriched recipes were preferred by elderly people both with olfactory loss and with normal olfactory function. According to the authors, this result was more a reflection of better alignment to the food preferences of their older sample than a specific compensation for olfactory loss.

The second key result of the experiment is that providing variety for the main dish (*i.e.* two garnishes instead of one) and a wider selection of condiments throughout the meal leads to an increase in food and energy intake as well as an increase in meal enjoyment. Several studies have reported that variety has a positive impact on food intake in an adult population (Pliner et al., 1980; Rolls et al., 1981; Spiegel & Stellar, 1990; Raynor & Epstein, 2001; McCrory, Burke, & Roberts, 2012; Meengs, Roe, & Rolls, 2012). Hollis and Henry (2007) observed that older adults (mean age of 70 years) consumed more sandwiches when they were served four different types of sandwiches (cheese, cucumber, ham and turkey) than

when they were served only one type of sandwich. It has been argued that providing food variety may prevent the onset of specific-sensory satiation that refers to a drop in pleasantness of an eaten food aroused by its ingestion in contrast to other non-eaten foods. In fact, Rolls et al. (1981) observed that liking decreased more for an eaten food than a non-eaten food and that changes in liking were highly correlated with subsequent food intake. Thus, participants ate more when they were served a different food (the "non-eaten food") than when they were served the same food (the "eaten food"). The provision of condiments may also contribute to the decrease of specific-sensory satiety. Brondel et al. (2009) showed that young subjects consumed a larger quantity of french fries and brownie cakes when provided condiments (ketchup and mayonnaise for the fries, vanilla cream and whipped cream for the brownies) than without condiments. In elderly people living in residential homes, Appleton (2009) observed higher food and energy intake when the main dish was served with sauce than without (*e.g.*, chicken, mixed vegetables, potatoes with *versus* without white sauce; chicken, sweetcorn/carrots, boiled potatoes with *versus* without chasseur sauce). In Best and Appleton (2011), free-living older adults consumed the same basic dish (*i.e.*, chicken with two types of vegetables and mashed potatoes) for three separate meals: one with a choice of seasonings (*i.e.*, Cajun seasoning, smoky barbecue seasoning), one with a choice of sauces (*i.e.*, onion gravy, creamy mushroom sauce) and one without seasoning or sauce. Results showed higher calorie consumption in the seasoning and sauce conditions than when the meals were served plain. There was no difference between seasoning and sauce conditions, but the increase in energy intake could have been partly due to the consumption of the condiments themselves. In fact, 70% of the increased calorie intake in Appleton (2009), 66% in the *Variety+* condition and 53% in the *Quality&Variety+* condition result from the consumption of the condiments. However, offering a choice of condiments in nursing homes may have an indirect impact on food intake by allowing people to season the dishes to their taste and thus improve

the sensory quality of the dishes according to their expectations and preferences. This may result in an increase of meal enjoyment (in fact, enjoyment was higher in the *Variety+* condition than the *Control* condition for the whole meal), which may in turn have a positive impact on food intake. In fact, several studies have shown a positive relationship between food enjoyment and food intake (Yeomans, 1996; De Graaf, De Jong, & Lambers, 1999; Bolhuis et al., 2012). In addition, allowing institutionalized elderly people to season the dishes to their taste may have allowed them to regain control over their meal. According to the self-determination theory, social contexts (such as providing choice) that fulfil the individual need for autonomy will enhance intrinsic motivation and satisfaction for that behaviour (such as eating a dish) (Iyengar & Lepper, 1999; Ryan & Deci, 2000; Patall, Cooper, & Robinson, 2008). In the present experiment, the presence of condiments on the table also triggered discussion among the residents (conversation about the recipes, advice about adding condiments). This friendlier atmosphere may have contributed to the increase in meal enjoyment. Finally, Best and Appleton (2011) suggested that sauces may contribute to food lubrication during oral processing and thus may facilitate chewing and swallowing in older adults who often have difficulties linked to the decline in salivary flow (Muñoz-Gonzàlez et al., 2018). However, it is interesting to note that meat intake and enjoyment were lower in the *Variety+* condition than in the two conditions with increased meat tenderness (*Quality+* and *Quality&Variety+* conditions). In other words, it seems that providing variety and condiments was not enough to increase meat consumption while improving meat texture was an effective approach.

Compared to the *Control* condition, the improvement of meal sensory quality leads to a 5% increase in calorie intake while the provision of sensory variety leads to a 7% increase. No additional effect was observed between these two factors. The improvement of sensory quality and the provision of variety lead to a 7% increase in calorie intake. Considering a

recommended allowance of 30 kcal per kg of body weight per day with 45% of the calorie intake from the lunch, the participants of the present experiment should consume an average of 913 kcal. However, in the control condition, they only consumed an average of 677 kcal, much lower than the recommended allowance. In the *Quality&Variety+* condition, the total energy consumption is equal to 730 kcal, namely 53 kcal more than in the control condition, which is a quite modest effect (Figure 1). Improving the sensory quality and increasing sensory variety of meals should be considered as one possible and efficient lever to stimulate food intake, but should be implemented aside with other actions, such as for instance food fortification (*i.e.*, increasing energy and protein rates in foods without increasing portion size). Interestingly, a close examination of the results showed that older residents with a very low energy intake (<66% of the recommended allowance) increased more their energy intake in the experimental conditions compared to the control condition (+10-12%; n=25) than people who fulfil the nutritional allowance (+4%; n=12). In other words, improving the sensory quality and/or increasing sensory variety of meals benefited 'very small eaters' more than 'normal eaters'.

The high prevalence of small eaters (30%) and people at risk of malnutrition (38%) among the institutionalized older people emphasize the importance of developing innovative strategies to sustain and improve food intake in this population. However, these strategies must take into account the organizational and economic constraints of the nursing home to ensure their implementation on a routine basis. It is interesting to report that following the experiment, some nursing homes (different from the ones involved in the present experiment) began to offer condiments and make dressings them available on the table of the dining room. Furthermore, some institutions (nursing homes or hospital) or catering service are now asking small groups of users to taste and assess new recipes before adding them on the menu card. It

is hope that such actions will continue to be developed and evaluated through experimental protocols, in order to enable elderly individual to fulfill their nutritional needs.

5. Conclusion

The results of this experiment demonstrate that improving the sensory quality or the sensory variety of the meals served to institutionalized older adults may be an effective way to increase food intake and meal enjoyment. Despite the relatively small sample size, these straightforward strategies are worth pursuing as a way to to prevent and treat malnutrition as the population ages. However, future research is needed to investigate the longer-term benefits of improving meal quality of dependent elderly people for health and nutrition as well as quality of life and well-being. The importance of this subject is reflected in the results of a study where "eating tasty food" was listed as very important to 70% of nursing home residents over 65 years (Sulmont-Rossé et al., 2016).

Author contributions

The authors' contributions were as follows: VVW, CSR, PM, SI and IM designed the study; VVW, CSR,VF and IM conducted the experiments; VVW analyzed the data, VVW performed the statistical analysis, and VVW and CSR wrote the manuscript.

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Compliance with ethical standards

All procedures performed in the studies were in accordance with the ethical standards of the institutional research committee and with the declaration of Helsinki and its later amendments. Informed consent was obtained from all individual participants included in the studies.

Declarations of interest: none

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References

Abbott, R.A., Whear, R., Thompson-Coon, J., Ukoumunne, O.C;, Rogers, M., Bethel, A., Hemsley, A., Stein, K. (2013). Effectiveness of mealtime interventions on nutritional outcomes for the elderly living in residential care: a systematic review and meta-analysis. *Ageing Research Reviews, 12*(4):967-81. https://doi:10.1016/j.arr.2013.06.002

Appleton, K.M. (2009). Increases in energy, protein and fat intake following the addition of sauce to an older person's meal. *Appetite 52*, 161–165. https://doi:10.1016/j.appet.2008.09.009

Best, R.L., Appleton, K.M. (2011). Comparable increases in energy, protein and fat intakes following the addition of seasonings and sauces to an older person's meal. *Appetite, 56,* 179–182. https://doi:10.1016/j.appet.2010.10.011

Bolhuis, D. P., Lakemond, C. M. M., de Wijk, R. A., Luning, P. A., & de Graaf, C. (2012).Effect of salt intensity in soup on ad libitum intake and on subsequent food choice. Appetite, 58(1), 48e55. http://doi.org/10.1016/j.appet.2011.09.001

Borgstrom Bolmsjo, B., Jakobsson, U., Molstad, S., Ostgren, C.J., Midlov, P. (2015). The nutritional situation in Swedish nursing homes - A longitudinal study. *Archives of Gerontology and Geriatrics, 60*:128-133. https://doi:10.1016/j.archger.2014.10.021

Brondel, L., Romer, M., Van Wymelbeke, V., Pineau, N., Jiang, T., Hanus, C., et al. (2009). Variety enhances food intake in humans. Role of sensory-specific satiety. *Physiology & Behavior, 97,* 44–51. https://doi:10.1016/j.physbeh.2009.01.019

Brownie, S. (2006). Why are elderly individuals at risk of nutritional deficiency? *International Journal of Nursing Practice, 12*:110–118. https://doi:10.1111/j.1440-172X.2006.00557.x

Burd, N.A., Gorissen, S.H., van Loon, L.J. (2013). Anabolic resistance of muscle protein synthesis with aging. *Exercise and Sport Sciences Reviews, 41*(3):169–73.

Cabrera, M.A.S., Mesas, A.E., Garcia, A.R.L. and de Andrade, S.M. (2007). Malnutrition and depression among community-dwelling elderly people. *Journal of the American Medical Directors Association, 8*: 582-584.

de Boer, A., Ter Horst, G.J., Lorist, M.M. (2012). Physiological and psychosocial age-related changes associated with reduced food intake in older persons. *Ageing Research Reviews, 12*:316–328. https://doi:10.1016/j.arr.2012.08.002

De Graaf, C., De Jong, L. S., & Lambers, A. C. (1999). Palatability affects satiation but not satiety. Physiology & Behavior, 66(4), 681e688. https://doi:10.1016/s0031-9384(98)00335-7

De Jong, N., De Graaf, C., Van Staveren, W.A. (1996). Effect of sucrose in breakfast items on pleasantness and food intake in the elderly. *Physiology and Behavior, 60*(6):1453-62. https://doi:10.1016/s0031-9384(96)00306-x

Divert, C., Laghmaoui, R., Crema, C., Issanchou, S., Van Wymelbeke, V., Sulmont-Rossé, C. (2015). Improving meal context in nursing homes. Impact of four strategies on food intake and meal pleasure. *Appetite, 84*:139-47. https://doi:10.1016/j.appet.2014.09.027

Elia, M., Zellipour, L., Stratton, R.J., (2005). To screen or not to screen for adult malnutrition? *Clinical Nutrition, 24* (6), 867–884. https://doi:10.1016/j.clnu.2005.03.004

Essed, N. H., van Staveren, W. A., Kok, F. J., de Graaf, C. (2007). No effect of 16 weeks flavor enhancement on dietary intake and nutritional status of nursing home elderly. *Appetite, 48*(1), 29-36. https://doi:10.1016/j.appet.2006.06.002

Folstein, M., Folstein, S., & McHugh, P. (1975). Mini-Mental-State: a practical method for grading cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*, 189-198. https://doi:10.1016/0022-3956(75)90026-6

GEM-RCN. (2015). Recommandation relative à la nutrition. Le Journal Officiel de la République Française, Version 2.0 - Juillet 2015. Recommandations nutritionnelles pour les personnes âgées - Version 1.0 https://www.economie.gouv.fr/daj/recommandation-nutrition (last accessed March 28, 2019)

Hébel, P., & Recours, F. (2007). Effets d'âge et de génération : transformation du modèle alimentaire. *Cahiers de Nutrition et de Diététique, 42*, 297-303.

Hollis, J.H., Henry, C.J. (2007). Dietary variety and its effect on food intake of elderly adults. *Journal of Human Nutrition and Dietetics, 20*(4):345-51. https://doi:10.1111/j.1365-277X.2007.00796.x

Iyengar, S.S., Lepper, M.R. (1999). Rethinking the value of choice: a cultural perspective on intrinsic motivation. *Journal of Personality and Social Psychology, 76*(3):349-66. https://doi:10.1037//0022-3514.76.3.349

Kiesswetter, E., Poggiogalle, E., Migliaccio, S., Donini, L.M., Sulmont-Rossé, C., Feart, C., Suwalska, A., Wieczorowska-Tobis, K., Pałys, W., Łojko, D., Saba, A., Sinesio, F., Polito, A., Moneta, E., Ciarapica, D., Brug, J., Volkert, D. (2018). Functional determinants of dietary intake in community-dwelling older adults: a DEDIPAC (DEterminants of DIet and Physical ACtivity) systematic literature review. *Public Health Nutrition, 21*:1886-1903. https://doi:10.1017/S1368980017004244

Kremer, S., Holthuysen, N., Boesveldt, S. (2014). The influence of olfactory impairment in vital, independently living older persons on their eating behaviour and food liking. *Food Quality and Preference, 38*:30-39.

Langhans, W. (2007). Signals generating anorexia during acute illness. *Proceedings of the Nutrition Society, 66*:321–330. https://doi:10.1017/S0029665107005587

Leij-Halfwerk, S., Verwijs, M., van Houdt, S., Borkent, J.W., Guaitoli, P.R., Pelgrim, T., Heymans, M.W., Power, L., Visser, M., Corish, C.L., de van der Schueren, M.A.E., the MaNuEL Consortium (2019). Prevalence of protein-energy malnutrition risk in European older adults in community, residential and hospital settings, according to 22 malnutrition screening tools validated for use in adults ≥65 years. A systematic review and meta-analysis. *Maturitas, 126*, 80–89. https://doi:10.1016/j.maturitas.2019.05.006

Locher, J.L., Robinson, C.O., Roth, D.L., Ritchie, C.S., Burgio, K.L. (2005). The effect of the presence of others on caloric intake in homebound older adults. *The journals of gerontology. Series A, Biological sciences and medical sciences, 60* (11):1475-8. https://doi:10.1093/gerona/60.11.1475

Mackay-Sim, A., Johnston, A.N., Owen, C., Burne, T.H. (2006). Olfactory ability in the healthy population: reassessing presbyosmia. *Chemical Senses, 31*(8):763-71. https://doi:10.1093/chemse/bjl019

Maître, I., Van Wymelbeke, V., Amand, M., Vigneau, E., Issanchou, S., Sulmont-Rosse, C. (2014). Food pickiness in the elderly: Relationship with dependency and malnutrition. *Food Quality and Preference, 32*, 145-151. https://doi.org/10.1016/j.foodqual.2013.04.003

Marcus, E.L., Berry, E.M. (1998). Refusal to eat in the elderly. Nutrition Review, 56(6):163-71. Review. https://:10.1111/j.1753-4887.1998.tb06130.x

Mathey, M.F., Siebelink, E., De Graaf, C., Van Staveren, W., 2001. Flavor enhancement of food improves dietary intake and nutritional status of elderly nursing homeresidents. *Journal of Gerontology: Medical Sciences 656A*, M200–M205. https://doi:10.1093/gerona/56.4.m200

McCrory, MA., Burke, A., Roberts, S.B. (2012). Dietary (sensory) variety and energy balance. *Physiology and Behavior, 5*;107(4):576-83. https://doi:10.1016/j.physbeh.2012.06.012

Meengs, J.S., Roe, L.S., Rolls, B.J. (2012). Vegetable variety: an effective strategy to increase vegetable intake in adults. *Journal of the Academy of Nutrition and Dietetics, 112*(8):1211-5. https://doi:10.1016/j.jand.2012.05.013

Merrell, J., Philpin, S., Warring, J., Hobby, D., Gregory, V. (2012). Addressing the nutritional needs of older people in residential care homes. *Health & Social Care in the Community, 20*, 208–215. https://doi:10.1111/j.1365-2524.2011.01033.x

Methven, L., Allen, V.J., Withers, C.A., Gosney, M.A. (2012). Ageing and taste. *Proceedings of the Nutrition Society, 71*(4):556-65. https://doi:10.1017/S0029665112000742

Morley, J.E. (2012). Undernutrition in older adults. *Family Practice, 29* Suppl 1:i89-i93. https://doi:10.1093/fampra/cmr054

Muñoz-González, C., Feron, G., Brulé, M., Canon, F. (2018). Understanding the release and metabolism of aroma compounds using micro-volume saliva samples by ex vivo approaches. *Food Chemistry, 1*;240:275-285. https://doi:10.1016/j.foodchem.2017.07.060

Nieuwenhuizen, W. F., Weenen, H., Rigby, P., & Hetherington, M. M. (2010). Older adults and patients in need of nutritional support: review of current treatment options and factorsinfluencing nutritional intake. *Clinical Nutrition, 29*, 160-169. https://doi:10.1016/j.clnu.2009.09.003

Patall, E.A., Cooper, H., Robinson, J.C. (2008). The effects of choice on intrinsic motivation and related outcomes: a meta-analysis of research findings. *Psychological Bulletin, 134*(2):270-300. https://doi:10.1037/0033-2909.134.2.270

Payette, H., Gray-Donald, K., Cyr, R., Boutier, V. (1995). Predictors of dietary intake in a functionally dependent elderly population in the community. *American Journal of Public Health, 85*:677–83. https://doi:10.2105/ajph.85.5.677

Pilgrim, A.L., Robinson, S.M., Sayer, A.A., Roberts, H.C. (2015). An overview of appetite decline in older people. *Nursing Older People, 27*(5):29-35. https://doi:10.7748/nop.27.5.29.e697

Pliner, P., Polivy, J., Herman, C.P., Zakalusny, I. (1980). Short-term intake of overweight individuals and normal weight dieters and non-dieters with and without choice among a variety of foods. *Appetite, 1*, (3); 203-213. https://doi.org/10.1016/S0195-6663(80)80029-8

Ramic, E., Pranjic, N., Batic-Mujanovic, O., Karic, E., Alibasic, E., Alic, A. (2011). The effect of loneliness on malnutrition in elderly population. *Medical Archives, 65*(2):92-5.

Rasheed, S., Woods, R.T. (2013). Malnutrition and quality of life in older people: a systematic review and meta-analysis. *Ageing Research Reviews, 12* (2),561–566. https://doi:10.1016/j.arr.2012.11.003

Raynor, H.A., Epstein, L.H. (2001). Dietary variety, energy regulation, and obesity. *Psychological Bulletin, 127*(3):325-41. Review. https://doi:10.1037/0033-2909.127.3.325

Riches, K., Jeanes, Y.M. (2015). A comparison in the prevalence of malnutrition of elderly residents in a warden-assisted compared with home-living setting. *Clinical Nutrition ESPEN, 10*(5):e184. https://doi:10.1016/j.clnesp.2015.03.020

Rolls, B.J., Rolls, E.T., Rowe, E.A., Sweeney, K. (1981). Sensory specific satiety in man. *Physiology and Behavior, 27*(1):137-42. https://doi:10.1016/0031-9384(81)90310-3

Ryan, R.M., Deci, E.L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist,55*(1):68-78. https://doi:10.1037//0003-066x.55.1.68

Schiffman, S.S., Warwick, Z.S. (1993). Effect of flavor enhancement of foods for the elderly on nutritional status: food intake, biochemical indices, and anthropometric measures. *Physiology and Behavior, 53*(2):395-402. https://doi:10.1016/0031-9384(93)90224-4

Spiegel, T.A., Stellar, E. (1990). Effects of variety on food intake of underweight, normal-weight and overweight women. *Appetite, 15*(1):47-61. https://doi:10.1016/0195-6663(90)90099-t

Sulmont-Rossé, C., Maître, I., Van Wymelbeke, V. (2012). Improving pleasure of elderly people for fighting against malnutrition. Vitagora - the 7th International Taste-Nutrition-Health Congress, March 20-21, Dijon, France.

Sulmont-Rossé, C., Maître, I., Amand, M., Symoneaux, R., Van Wymelbeke, V., Caumon, E., Tavarès, J., Issanchou, S. (2015). Evidence for different patterns of chemosensory alterations in the elderly population: impact of age versus dependency. *Chemical Senses, 40*(3):153-64. https://doi:10.1093/chemse/bju112

Sulmont-Rossé, C., Van Wymelbeke, V., & Maître, I. (2016). Le plaisir à manger en EHPAD : point de vue du senior consommateur. In C. Hugol-Gential (Eds.), Se Nourrir ou Manger ? Les Enjeux du Repas en Etablissement de Santé (pp. 73-92). Paris, France: L'Harmattan.

Sulmont-Rossé, C., Symoneaux, R., Feyen, V., Maître, I. (2018). Improving food sensory quality with and for elderly consumers. *In* G. Ares, P.A. Varela Tomasco (Eds.), Methods in Consumer Research Volume 2: Alternative Approaches and Special Applications. Cambridge, USA: Elsevier, pp. 355-372.

Torres, M.J., Dorigny, B., Kuhn, M., Berr, C., Barberger-Gateau P., Letenneur L. (2014). Nutritional status in community-dwelling elderly in France in urban and rural areas. *PLoS One*, *18*;9(8):e105137. https://doi:10.1371/journal.pone.0105137

van Nie, N.C., Meijers, J.M., Schols, J.M., Lohrmann, C., Spreeuwenberg, M., Halfens, R.J. (2014). Do structural quality indicators of nutritional care influence malnutrition prevalence in Dutch, German, and Austrian nursing homes? *Nutrition*, *30*:1384-1390. https://doi:10.1016/j.nut.2014.04.015

van der Pols-Vijlbrief, R., Wijnhoven, H.A., Schaap, L.A., Terwee, C.B., Visser, M. (2014). Determinants of protein-energy malnutrition in community-dwelling older adults: a systematic review of observational studies. *Ageing Research Reviews, 18*:112-31. https://doi:10.1016/j.arr.2014.09.001

van der Pols-Vijlbrief, R., Wijnhoven, H.A.H., Visser, M. (2017). Perspectives on the Causes of Undernutrition of Community-Dwelling Older Adults: A Qualitative Study. *Journal of Nutrition Health and Aging, 21*(10):1200-1209. https://doi:10.1007/s12603-017-0872-9

Vellas, B., Guigoz, Y., Garry, P.J., Nourhashemi, F., Bennahum, D., Lauque, S., Albarede, J.L. (1999). The Mini Nutritional Assessment (MNA) and its use in grading the nutritional state of elderly patients. *Nutrition, 15* (2):116-22. Review. https://doi:10.1016/s0899-9007(98)00171-3

Yeomans, M. R. (1996). Palatability and the micro-structure of feeding in humans: the Appetizer effect. *Appetite, 27*(2), 119e133. http://doi.org/10.1006/appe.1996.0040

Zadak, Z., Hyspler, R., Ticha, A., Vlcek, J. (2013). Polypharmacy and malnutrition. *Current Opinion in Clinical Nutrition & Metabolic Care, 16*(1):50-5. Review https://doi:10.1097/MCO.0b013e32835b612e.