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Nutrition in Disguise: Development, Testing and Cost-Analysis of Nutrient-Enhanced Food for Residential Care

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ABSTRACT

Older adults living in residential care are at risk for micronutrient deficiency and malnutrition. This study aims to demonstrate the feasibility of micronutrient-enhanced recipes to meet this need.

Three phases were used to develop micronutrient-enhanced foods, made with novel ingredients, appropriate for residential care. Nutrients, ingredients and food vehicles to be enhanced were identified through published literature, consultation with providers and nutrient analysis to determine ingredients/foods high in nutrients shown to be low in the diets of residents. 21 recipes were developed by residential chefs of which 10 were taste-tested by residents without (n=18) and with (n=11) cognitive impairment. Liking and sensory appeal were measured using hedonic scale (9 point), a cued facial response scale (9 point), weighing remaining test foods and unprompted facial expressions and comments. A 7-day residential menu was substituted with one or two nutrient-enhanced foods and nutrient analysis and cost were compared to the original menu.

Recipes were created for desserts, baked products, soups, quiche and a smoothie. Nutrients enhanced were: vitamin B_6, folate, vitamins B_{12}, D, E and K, calcium, magnesium, selenium and zinc. Taste-testing across persons with and without cognitive impairment identified that desserts and baked products were preferred, although there was no single tasting method that clearly identified preferences for persons living with cognitive impairment. Cost increase was less than 10% and nutrient content increased for one, and two food item substitutions in the residential menu, but differences were not statistically significant.

Enhancement of micronutrients through novel ingredient recipes for residential care is a feasible strategy to mitigate micronutrient malnutrition.

Keywords: Food intake, Nutrient density, Residential care, Acceptability

Introduction

Poor food intake and consequent malnutrition are common in residential care and specifically long term care [1-5]. The cause of poor food intake in these settings is multifactorial and can include resident characteristics (e.g. dysphagia), dining room and home factors (e.g. size, nutrient density and quality of menus), staff (e.g. training on providing eating assistance) and regional factors (e.g. funding provided for food) [6]. These and other determinants were identified in a large comprehensive study (>600 participants with >1000 variables) that explored food intake in long term care [1,7]. Although many factors influencing food intake occur at the level of the resident (e.g. requirement for eating assistance, malnutrition, age and sex), factors at the level of the home are also important [7,8]. For example, planned menus do not provide recommended levels of many micronutrients [7], which correspond to a risk for inadequate micronutrient intakes [1].

Modifying the nutrient density (i.e. promoting micronutrient and protein content without increasing energy content) of food provided in residential care is an appealing and acceptable strategy to improve nutritional status of residents [9-12]. This strategy may also be more feasible since it is focused on food service operations and does not require resident or care staff resources. Fortification of foods with targeted micronutrient formulations [9,13-15] has been trialed with some success, however its application to all poorly consumed micronutrients is challenged with concerns about toxicity, manipulation of food products and poor palatability, especially with mineral formulations [9,15].

Menu nutrient enhancement research to date has focused on protein and calories to mitigate malnutrition in residential care [12,16,17]. Currently, menu planners focus on protein as well as a few other key nutrients (e.g. dietary fibre, sodium) when developing residential menus, but do not focus on the entire nutrient profile [18], potentially due to lack of capacity (e.g. time, skill, software) for a comprehensive nutrient analysis. However, micronutrient malnutrition may also be common, based on the inadequate intake previously demonstrated and the limited use of micronutrient supplements in this population [1,19]. Attention therefore needs to be focused not only to the full micronutrient complement when planning menus, but also on increasing micronutrient density by using ingredients and recipes that promote nutrition while minimizing sodium and excess calories. To this regard, micronutrient enhancement through novel use of familiar ingredients in traditional recipes is an approach worthy of exploration.

Micronutrient intake could be improved with focused effort on recipe development and menu planning, particularly since there is documented variability in the nutrient quality of planned menus, even in regions with the same raw food funding [7]. For instance, it was demonstrated that a hypothetical menu [10] could be significantly higher in dietary fibre, vitamin E, niacin, folate, calcium, iron, phosphorous, potassium, and zinc, and be lower in sodium by simply modifying the ingredients in the home recipes (e.g. using red peppers vs. green peppers, adding spices). It was shown that intake recommendations for all micronutrients except vitamins D and E could be met in this hypothetical menu that had an energy level consistent with the real-world comparator long term care home menus [10]. However, research that demonstrates the feasibility of this strategy considering food preferences, ingredient availability, acceptability of final products, and cost constraints is required.

The purposes of this paper are to: a) describe the three-phase process of the Nutrition in Disguise (NiD) project that aimed to enhance menus for residential care through the creation and taste-testing of nutrient-enhanced foods, and b) demonstrate the feasibility of ingredient selection and substitution in familiar foods to enhance menus in residential care. Learnings from this process can provide guidance to others interested in enhancing the micronutrient content of residential menus.

Materials and Methods

The NiD project employed a three-phased process to create nutrient-enhanced recipes that could be feasibly included in residential menus (Figure 1). The process and concept resulted in ten recipes that were taste-tested by residents. The research was approved by the Research Ethics Board of the Universities of Guelph (REB#18-03-012) and Waterloo (ORE#31541).

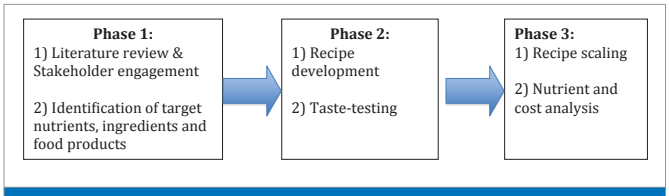

Figure 1: Summary of NiD project phases.

Phase 1: Identification of nutrients, ingredients, and food vehicles for enhancement

Phase one started with a literature review using MEDLINE completed by three researchers to identify relevant publications to inform what nutrients should be enhanced, what ingredients would be most relevant to use and what foods were preferred by older adults and could thus be targets for enhancement. The researchers extracted article details, including participants studied, health areas of focus and the core aspects of the interventions including nutrients, ingredients and food vehicles used as well as amounts, qualities and main results. Identified articles were also hand-searched for additional relevant publications. Researchers worked in tandem, reviewing and cross-checking each other's extracted data to ensure accuracy.

Identification of the nutrients that may be inadequately consumed by older adults was completed first. A scoping review on micronutrient inadequacy based on biomarkers and inadequate food intake had been completed [19], and formed the basis for identification of micronutrients to enhance. Researchers updated this review by searching literature between 2013 and 2018 on nutrient intake in older adults in residential and community living seniors. This included a 32-site study focused on rigorously collected food intake of over 600 residents in long term care [1].

Identification of ingredients that could conceivably be included in new recipes in a residential menu was completed using two strategies. The first was a literature search between 2013-2018 to identify ingredients used in intervention studies to mitigate frailty, sarcopenia and/or cognitive impairment, which are common health issues in this age group. As this strategy did not result in a comprehensive identification of ingredients, a second strategy was used. Nutrient analysis (ESHA version 11.2) was completed to determine the top candidate ingredients for each micronutrient identified to be often poorly consumed in the scoping review [19] and in the updated literature search.

Identification of food vehicles appropriate for nutrient enhancement was the final step of phase 1. Qualities of target foods for enhancement included those that: were consumed by most residents, could be enhanced by changing ingredients, and were currently used in residential care but were not typically nutrient-dense. Since a literature search revealed minimal information, consultation with stakeholders was used to guide identification of food vehicles. Dietitians of a corporate residential care group (n=19 homes) were emailed a questionnaire and asked to complete one for each home, consulting with their dietary staff. Seven homes responded (n = 11 chefs; 11 dietary assistants; 5 dietitian; 2 food service managers provided input) with identification of the most common foods consumed at each meal and best foods to enhance. Foods considered feasible for enhancement based on this consultation were used in the next stakeholder engagement activity. This involved a webinar

delivered by an author (HK) on food intake in residential care. The webinar included a closed-option polling question asking attendees (n =165) what food products (e.g. soups, desserts, hot cereal, smoothie/milkshake, egg dishes) should be enhanced; 97 responses were recorded. Baked goods that could be used at breakfast, snacks or desserts; soups; smoothies; and egg or potato-based dishes were recommended based on this food product identification.

Phase 2: Recipe development and taste-testing

Phase two involved the development of new recipes based on the target ingredients and food products followed by taste-testing by older adults in residential care. This phase was led by two residential care chefs whose relevant expertise allowed them to consider ingredients and preparation methods used in residential kitchens (e.g. bran muffin mix vs. raw ingredients), and preferences and needs of residents (e.g. soft textures) when creating the recipes. Twenty-one initial nutrient-enhanced foods were rated for appearance, flavour, texture, and overall liking using 9-point hedonic scales (1= dislike extremely, 9= like extremely) in a single session by a group of researchers, trainees, food service managers, chefs and other residential staff members (n =19). To obtain a single liking score to aid in selection of most liked foods, the hedonic scores for each of the tested modalities (appearance, flavor, texture and overall liking) were totaled and then averaged across all participants. The top 10 recipes were reviewed to determine how micronutrient nutrition could be further enhanced or other improvements made, after which the final recipes were established.

Taste-testing of 10 foods was completed by cognitively-well and cognitively-impaired (included due to their prevalence in residential care) participants recruited from residential homes (long term care and retirement) in Guelph and Waterloo, Canada. Exclusion criteria included allergy to any ingredient in the NiD foods and requirement for a modified texture diet. Potential cognitively-impaired residents were identified by residential care staff prior to recruitment. Written consent was provided by cognitively-well-participants, and by substitute decision makers for cognitively- impaired participants. Assent from participants with cognitive impairment was demonstrated when asked to eat the food; some did refuse specific foods. All tasting sessions were completed in "country kitchens" (family-style kitchens located in each living area) and shared living spaces at the residential homes. To prevent fatigue, 3 to 4 foods were tested in each of three tasting sessions conducted in each home. The test foods were presented in foam and plastic cups of four and 3.5 oz. respectively, and individuals were allowed to eat as much or as little as they wanted using plastic utensils if needed.

Participants (or family informants for those with cognitive impairment) completed a questionnaire, including information about food preferences and aversions, and demographic information (age, sex, time since admission). Nutrition risk was determined by completing the Mini-Nutrition Assessment Short Form (MNA-SF) [20] with residents and care providers. Difference in nutrition risk for cognitively-well and impaired was determined with a t-test, with $p<0.05$ considered as statistically significant.

For the cognitively-well participants, NiD foods were rated for liking of appearance, texture and flavor using a 9-point hedonic scale (1= dislike extremely and 9= like extremely). Means and standard deviations for each sensory attribute for each food were calculated (XLSTAT 2019.2.3). Participants also selected words from a list (Figure 2) that best described the food. For analysis, the frequency of selection of each word for a particular food was tabulated and used to conduct a Check All That Apply (CATA) data analysis (package found in XLSTAT 2019.2.3). This analysis is a correspondence analysis to examine the associations between the words selected to describe the foods and the foods themselves. The results from this analysis are plotted to visualize the similarities between each of the foods and the words selected to describe the food. The number of participants completing each test varied because of absences due to illness, an outbreak in a home, and restrictions due to allergies or perceived intolerance to ingredients.

For the cognitively-impaired participants, NiD foods were rated using two different approaches to determine liking. The first method included a single 9-point hedonic scale for liking where 1 corresponded to "dislike extremely" and 9 corresponded with "like extremely." The responses and numbers associated with each response were read to participants, and they were asked to indicate which word or number was best related to their liking. The second

Table 1: Phase 1 results of potential target nutrients, ingredients, and food products to develop nutrient-enhanced foods for residential care.

	Target Ingredients	Target Food Products
Protein	Whey powder, soybeans, yogurt	Cereal, smoothies, baked goods
Dietary fibre	Wheat bran, berries, lentils/beans	Cereal, smoothies, dessert, soup
Vitamin B_6	Hemp hearts, flax seeds	Smoothies, baked goods, cereal
Folate (B_9)	Spinach, kale	Soup, smoothies, baked goods, eggs
Vitamin B_{12}	Skim milk powder, cheddar cheese	Soups, cereal, baked goods, desserts
Vitamin D	Skim milk powder, egg yolks	Smoothies, cereal
Vitamin E	Wheat germ, almonds, spinach	Cereal, baked goods, desserts
Vitamin K	Kale, spinach	Baked goods, soups
Calcium	Skim milk powder, cheddar cheese	Smoothies, eggs
Magnesium	Dark chocolate, hemp hearts	Desserts, cereals, smoothies
Potassium	Dark chocolate, skim milk powder	Baked goods, soups, smoothies, cereal
Selenium	Chia seeds, eggs, flax	Cereal, desserts, smoothies, soups
Zinc	Wheat germ, dark chocolate, hemp	Breakfast cereal, smoothies

Please select all the words that you feel are present in the food while you are eating it:

Flavour

Sweet	Spicy	Sour
Bitter	Fresh	Earthy
Stale	Bland	Salty

Texture

Sticky	Moist	Dense
Grainy	Soft	Smooth
Thick	Thin	Powdery
Slippery	Doughy	Dry
Creamy	Chunky	

Figure 2: Word list for food description during taste-testing with cognitively-well participants.

method was a cued facial response scale [21] for which participants were shown three faces (smiling, neutral, frowning) and asked to indicate which face best represented their liking of the food. If they selected the smiling or the frowning face, they were then presented with another set of smiling (original and two with larger smiles) or frowning (original and two with larger frowns) faces and asked to indicate which face best represented their liking. All faces were coded from 1 to 9 where 1 corresponded to the largest frown (great degree of disliking) and 9 corresponded to the largest smile (great degree of liking) and 5 corresponded to the neutral face. Data from the hedonic and cued facial response scale scores were analyzed to determine mean and standard deviation (XLSTAT 2019.2.3). Unprompted comments made by participants or facial expressions (e.g. frown, smile) made during testing were noted. Comments were recorded verbatim and facial expressions described. In addition to determining liking, the amount of food that was consumed by each participant was weighed and subtracted from the original volume of food served to tabulate the percent food consumed using a calibrated food scale (Ohaus, Model: V22PWE3T). The average of proportion consumed is presented.

Phase 3: Recipe scaling, nutrient and cost analysis

Phase three involved scaling the final recipes to meet the needs of a residential home (i.e. 90-150 portions) and conducting a nutrient and cost analysis. As costing of food in homes is dependent on group purchasing contracts for food products and ingredients, the authors partnered with a corporate for-profit home to conduct nutrient and cost analysis using Sysco Synergy on Demand™ software (Mealsuite 8.7); analysis was completed by the lead food service manager who plans menus for this corporation. This software allows for the creation of recipes, menus and automatically determines nutrient content (based on manufacturer values, and the Canadian Nutrient File and US Department of Agriculture databases). The software also determines the daily cost of the menu per portion/resident using assumptions for home location, distribution site and costing provided to the corporate purchaser. Where ingredients were unavailable in the software, nutrient content and cost were attained from a bulk commercial baking supplier available in many urban Canadian communities (i.e. Bulk Barn). The cost of these ingredients was included in recipes to determine per unit cost.

Nutrient content and cost was estimated using a current 7-day regular texture menu substituted with one or two of the NiD foods on each day (Table 5). Seven-day average nutrient content and cost per resident were compared among the three menus (original, one NiD food included and two NiD foods included) using ANOVA with $p<0.05$ considered significant. SPSS (Version 25) was used for this analysis.

Table 2: Residential taste-testing participant characteristics (n=29).

	Cognitively-well N= 18	Cognitive Impairment N= 11
Age in years % (n)		
< 69	0	9 (1)
70-79	33 (6)	27 (3)
80-85	28 (5)	46 (5)
86-89	28 (5)	0
>90	11 (2)	18 (2)
Gender % (n)		
Male	17 (3)	18 (2)
Female	83 (15)	82 (9)
Length of Stay (years)% (n)		
N/A[1]	6 (1)	0
< 1	11 (2)	0
> 1 to 3	33 (6)	82 (9)

Results

Phase 1

The scoping review [19] identified 34 articles on food intake in residential care and 22 articles focused on nutrient biomarkers. Key nutrients found to be inadequate (< 50% Recommended Dietary Allowance or < Estimated Average Requirement) [22] in the diet in multiple papers were: vitamins D (18 citations) and E (6 citations), folate (7 citations), and calcium (6 citations). Single reports also noted inadequate intake of thiamin, vitamins B6, B12, C, and A, selenium, iodine and magnesium in residential participants. Of the 22 articles that assessed biomarker status of various micronutrients, vitamins D (8 citations), C (3 citations), folate (1 citation) and iron (3 citations) were found to be inadequate based on reference ranges from the American Medical Association [23] and the Centre for Disease Control [24].

Recently published articles on food and micronutrient intake in long term care [1] also drove identification of food components for enhancement and nutrients with high proportions of residents consuming less than the Estimated Average Requirement. The supplementary literature review from 2015-2018 did not reveal further nutrients that should be enhanced. Based on these findings the following were identified as targets for enhancement: dietary fibre, folate, vitamins B6, B12, D, E, K, and calcium, potassium, magnesium, selenium, and zinc. Nutrient analysis of key ingredients identified several candidates for inclusion in recipes (Table 1). The literature review on food ingredients with potential to help prevent or manage sarcopenia, cognitive impairment, and frailty identified several potential recipe additions including: berries, carrots, cinnamon, cocoa, cruciferous vegetables, kale, nuts, olive oil, spinach, tomatoes, and turmeric.

Foods most commonly consumed by older adults in residential care, as determined through consultation with residential chefs, dietitians, food service managers and dietary staff from seven homes included: breakfast- toast, eggs, bacon, oatmeal, yogurt; lunch-sandwich, soup, pasta/casserole, pudding; dinner- mashed potatoes, chicken, meatloaf, pasta; and desserts. When asked what foods should be enhanced the following were proposed: desserts (n=5 of 7 responses), soup (n=4 of 7 responses), hot cereal (n=3 of 7 responses), potatoes (n=2 of 7 responses), sauces (n=2 of 7 responses), with pudding/ custards, pasta, casseroles, bread, and beverages all recorded once. Using this data, attendees of a webinar voted on a closed-item question identifying what foods they thought should be enhanced. The majority (43%) of respondents worked in food service, dietary or hospitality management. Other respondents were dietitians (22%) and other administrative personnel in residential care (9%). The highest vote for food enhancement was desserts (41% i.e. 40/97) followed by hot cereal (23%), soup (20%), smoothies/milkshakes (13%) and finally egg dishes (3%). Recommendations for incorporation of target ingredients and food vehicles for enhancement are provided in Table 1.

Phase 2

Residential chefs developed recipes that emphasized cereal, desserts or baked goods, soups, smoothies and egg dishes. Twenty-one recipes were created and trialed in initial testing with researchers and residential providers. Average liking scores ranged from 13 to 33.7 (out of a maximum of 36) (Figure 3). The recipes selected for further development based on these results were: cranberry almond streusel (to be used as topping for yogurt, puddings, hot cereal or desserts); oatmeal berry parfait; quiche; Mulligatawny soup; tomato cream cheese and wild rice soup; beef & barley soup; apple cider muffins; orange and carrot muffins; and raspberry banana smoothie. Recipe adaptations after this initial taste-testing were used to resolve any sensory limitations of the products and further enhance nutrition where possible (e.g. spinach added to quiche). In addition, a chocolate lentil brownie was added.

Taste-testing included 28 residents and one community-dwelling participant who was the spouse of a resident participant. Demographic results are provided in Table 2.

Liking scores (mean ± SD) for the NiD foods for cognitively-well participants are summarized in Table 3 and the relationships between the NiD foods and words selected by participants to describe the products are shown in Figure 4. In general, the baked products, dessert and quiche were liked more than the soups and the smoothie. The orange carrot muffin was rated the highest for liking of appearance, texture and flavor, falling between "like moderately" and "like very much" on the 9-point hedonic scale. The oatmeal berry parfait had a higher average liking score for flavour, but lower liking scores for appearance and texture. This parfait was described by individuals as having a soft texture (Figure 4); the textures from raspberries and the crumbs composing the different layers of the parfait may have affected the liking score for texture. The tomato cream cheese and wild rice soup was the least liked NiD food, with liking scores of all sensory properties falling between "dislike slightly" and "neither like nor dislike." The Mulligatawny soup had liking scores only slightly above the tomato cream cheese soup, falling between "neither like nor dislike" and "like slightly" on the 9-point hedonic scales for flavor, texture and appearance. As shown in Figure 4, the soups were characterized as "dense," and "thick," which may have contributed to lower scores for these products.

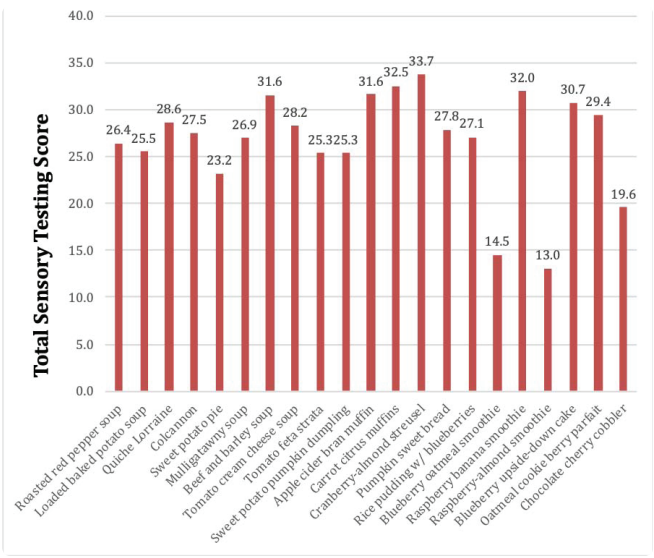

Figure 3: Initial sensory evaluation of 21 NiD recipes.

Table 3: Liking responses in order from most liked to least liked based on appearance – cognitively-well participants (n=18).

	Appearance Mean ± Standard Deviation	Texture Mean ± Standard Deviation	Flavour Mean ± Standard Deviation
Orange Carrot Muffin[1]	7.6 a ±0.8	7.4 a ±0.9	7.4 a ±1.0
Apple Cider Muffin[1]	6.9 a ±1.4	6.5 a ±1.7	6.3 a ±1.4
Oatmeal Berry Parfait[2]	6.7 a ±2.2	6.7 a ±1.9	7.5 a ±1.0
Lentil Brownie[2]	6.5 a ±1.6	6.4 a ±1.6	6.7 a ±1.2
Cheese & Spinach Quiche[2]	6.4 a ±2.2	6.4 a ±1.9	7.1 a ±1.1
Cranberry Almond Streusel[1]	6.3 a ±2.4	5.6 a ±2.8	6.2 a ±2.4
Raspberry Banana Smoothie[1]	6.1 a ±1.7	5.9 a ±2.3	5.5 a ±2.3
Beef & Barley Soup[3]	5.9 a ±2.3	5.9 a ±2.0	6.1 a ±2.3
Mulligatawny Soup[4]	5.6 a ±2.5	5.4 a ±2.7	5.5 a ±2.9
Tomato Cream Cheese and Wild Rice Soup[4]	4.1 a ±2.3	4.5 a ±2.4	5.2 a ±2.3

[1]n=14 (4 participants were absent on day of testing)

[2]n=13 (3 participants were absent on day of testing; 2 participants had intolerances to wheat, eggs and/or dairy)

[3]n=17 (1 participant had a barley intolerance)

[4]n=18

Liking scores for participants with cognitive impairment are shown in Table 4. The three most liked foods were the lentil brownie, the oatmeal berry parfait, and the spinach quiche, all for which had liking scores that fell between "like moderately" and "like very much" on the 9-point hedonic scale. These were higher than the scores collected using the cued facial scale where scores fell between 5.8 and 7.7 (out of 9). The high liking scores given using the 9-point hedonic scale were reflected in the observation of positive facial expressions and a high consumption rate for both the brownie and the parfait. The spinach quiche also received high scores in both scales, and the consumption rate was very high. One negative facial expression, frowning, was observed when a participant ate the quiche.

The NiD foods with the lowest liking scores were the Mulligatawny soup and the raspberry banana smoothie with low scores using both the hedonic and cued facial scales. These results were confirmed by the several negative expressions observed being made by participants, such as frowning or lip corners being down for the smoothie, and lips pursed, eyes diminishing and nose wrinkling for the soup. These foods also had lower rates of consumption with less than half of both foods consumed. Furthermore, participants used negative words such as "crunchy, bland, grainy, hard, tough" for the soup, and "sour, very sour" for the smoothie (Table 1).

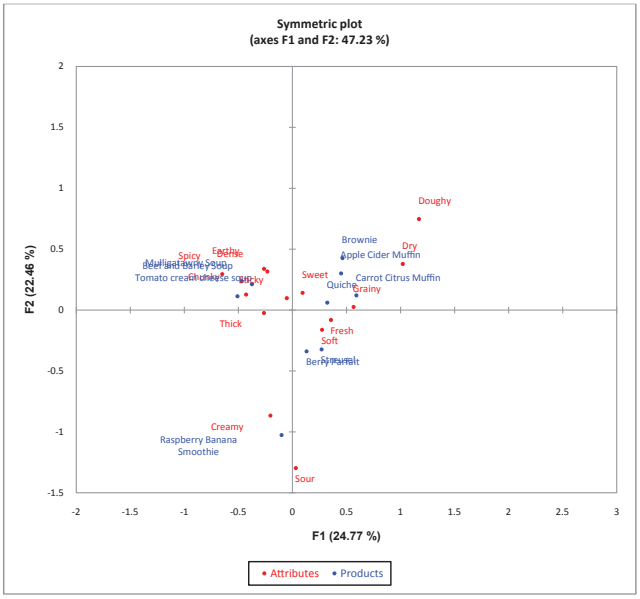

Figure 4: Associations between the tested foods and the words selected to describe the flavor and texture of the foods tested by cognitively-well participants (n=18).

The beef & barley soup received good liking scores ranging from "like moderately" to "like very much." Also, participants consumed an average of 66% of the soup that was served to them. While an equal number of positive and negative comments were collected from participants, there were more positive facial expressions than negative. Therefore, this product could be considered to have a favourable level of acceptance. Both muffins received similar scores falling between "like slightly" and "like moderately". However, the consumption rate for the orange carrot muffin at 88% was higher than the apple cider muffin at 74%. No negative facial expressions were observed for these foods, and there were both positive and negative comments provided. The cranberry almond streusel was slightly liked with consumption of approximately 50% of the portion served to participants. Similar to the tomato cream cheese and wild rice soup, there was no consensus about the overall liking of the product; there were positive and negative facial expressions and positive and negative comments. Unlike the cognitively-well group, the cognitively-impaired group scored the tomato cream cheese and wild rice soup relatively high (9-point hedonic close to "like moderately" and a cued facial scale of 7.6 out of 9). However, the consumption rate was low, and three participants were frowning while eating. There were four participants with positive facial expressions of eyes widening and lips pressed, and some positive comments ("lovely, good"). However, many negative words were recorded: "mushy, bland, thick, and hard."

Phase 3

Average micronutrient content and cost of food for a day per portion across the 7-day menus is presented in Table 6. The average nutritional content of the 7-day menu with the addition of one or two nutrient-enhanced foods increased but was not significantly different from the original menu, with the exception of oleic acid. However, the two NiD recipe versions resulted in a menu that met the Dietary

Table 4: Liking responses in order from most liked to least liked based on 9-point hedonic scale- cognitively-impaired participants.

	9-point Hedonic Scale Mean ± SD	Cued Facial Scale Mean ± SD	Positive Facial Expressions (count)	Negative Facial Expressions (count)	% consumed Mean ± SD	Positive words	Negative words
Lentil Brownie[1]	7.6 ±1.7	6.3 ±1.7	Smile (2)		77 ±34	Very good, good	Dry
Berry Parfait[2]	7.3 ±1.5	5.8 ±1.7	Smile (2), Eyes widening (2)		81 ±35	Good	
Cheese & Spinach Quiche[2]	7.2 ±3.1	7.7 ±2.1	Smile (1), Lips pressed (1)	Frowning (1)	95 ±12	Good	
Tomato Cream Cheese Soup[3]	6.9 ±1.9	7.6 ±1.7	Eyes widening (4), Lips pressed (4)	Frowning (3)	48 ±35	Lovely, good	Mushy, bland, thick, hard
Beef & Barley Soup[3]	6.9 ±1.3	8.0 ±1.0	Lips pressed (6), Eyes Widening (3)	Eyes diminishing (3)	66 ±36	Tasty, dense, chunky, good	Crunchy, bland, grainy, hard, tough
Orange Carrot Muffin[4]	6.6 ±2.1	7.0 ±2.6	Eyes widening (5), Lips pressed (5)		88 ±28	Good, tasty, very nice	
Apple Cider Muffin[4]	6.5 ±2.3	6.8 ±2.6	Smile (3), Lips pressed (4)		74 ±28	Moist, good, very good	Too dry, dull
Cranberry Almond Streusel[4]	6.0 ±1.9	6.3 ±2.6	Smile (4), Eyes widening (3)	Frowning (4)	52 ±36	Interesting, tasty, delicious, very nice	Powdery, dry
Raspberry Banana Smoothie[5]	5.9 ±1.3	4.7 ±3.3		Frowning (3), Lip corner down (3)	44 ±38	Good, fruity	Very sour, sour
Mulligatawny Soup[3]	4.5 ±2.2	5.8 ±1.5		Frowning (6), Eyes diminishing (5), Lips pursed (4), Nose wrinkle (4)	36 ±30	Very nice	Mushy, thick, spicy, sweet

[1]n = 8, [2]n = 7, [3]n = 11, [4]n = 10, [5]n = 9

Table 5: NiD recipes substituted into the original long term care menu.

	Nutrition in Disguise Menu 1						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	Apple Cider Muffin	N/A	N/A	N/A	N/A	N/A	N/A
Lunch	N/A	Orange Carrot Muffin	Lentil Brownie	Beef & Barley Soup	Mulligatawny Soup	Cheese & Spinach Quiche	Oatmeal Berry Parfait
	Nutrition in Disguise Menu 2						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	Apple Cider Muffin	N/A	Apple Cider Muffin	Cranberry Almond Streusel	N/A	N/A	N/A
Lunch	Quiche	Beef & Barley Soup Orange Carrot Muffin	Lentil Brownie	Beef & Barley Soup Soup	Mulligatawny Soup Lentil Brownie	Cheese & Spinach Quiche Mulligatawny Soup	Cheese & Spinach Quiche Oatmeal Berry Parfait

Table 6: Mean 7-day menu cost and nutrient content of original and nutrient-enhanced food substituted menus .

	EAR/RDA or AI	Original Menu	NID Sub 1[a]	NID Sub 2[b]
Cost	--	$6.08	$6.40	$6.59
Energy (kcal)	--	2125.71	2202.72	2270.25
Protein (g)	--	85.45	87.99	89.09
Carbohydrates (g)	100/130	271.33	275.30	276.72
Total fat (g)	--	82.87	91.64	99.91
Linoleic acid (g)	14	4.27	4.88	5.50
Oleic acid (g)	--	11.51	13.73*	17.18*
Dietary Fibre (g)	30	**22.69**	**24.30**	**24.63**
Vitamin A (mg RE)	624/900	1277.77	1445.86	1573.20
Thiamin (B1) (mg)	1.0/1.2	1.48	1.46	1.44
Riboflavin (B2) (mg)	1.1/1.3	1.99	2.00	2.03
Niacin (B3) (mg)	12/16	**13.17**	**13.05**	**12.59**
Vitamin B6 (mg)	1.4/1.7	**1.41**	**1.44**	**1.44**
Folate (B9) (DFE)	320/400	**258.98**	**261.28**	**272.91**
Vitamin B12 (mcg)	2.0/2.4	3.93	4.01	4.19
Vitamin C (mg)	75/90	92.99	100.42	105.15
Vitamin D (IU)	400/800	**241.52**	**243.84**	**247.17**
Vitamin E (mg)	12/15	**3.25**	**3.71**	**4.48**
Vitamin K (mcg)	120	**84.23**	**100.82**	126.55
Calcium (mg)	1000/1200	1215.55	1241.02	1283.80
Iron (mg)	6/8	15.88	16.91	17.48
Magnesium (mg)	350/420	**287.23**	**297.20**	**303.27**
Manganese (mg)	2.3	2.53	2.72	2.89
Phosphorus (mg)	580/700	1242.24	1254.54	1280.22
Potassium (mg)	3400	**2762.08**	**2810.98**	**2820.63**
Sodium (mg)	1500	2089.39	2244.63	2342.32
Zinc (mg)	9.4/11	**8.80**	**9.60**	**10.26**

[a] Original menu substituted with 1 nutrient-enhanced food [b] Original menu substitute with 2 nutrient-enhanced foods
*Significantly different at $p < 0.05$ from original menu (ANOVA).
Bold text represents values below the DRI (Recommended Dietary Allowance for >70-year-old male)
Abbreviations used: EAR= estimated average requirement; RDA= recommended dietary allowance; AI= adequate intake; kcal = kilocalorie; g = gram; mg = milligram; mcg = microgram; RAE = retinol activity equivalent; IU = international unit; DFE = dietary folate equivalents.

Reference Intake (DRI) for vitamin K. Cost analysis showed that substitution of one and two nutrient-enhanced foods increased the average cost/per resident/per day by $0.32 and $0.51 or approximately a 5% and 8% increase, respectively.

Discussion

The primary result of the NiD project was the development of a rigorous process for development and taste-testing of foods enhanced in micronutrients through the manipulation of familiar ingredients and recipes in residential care and the learnings in this process. The current project created 10 nutrient-enhanced recipes that proceeded to taste-testing with older adults. Although the original 7-day menu did not significantly improve in nutrient content with the addition of one or two nutrient-enhanced foods, all nutrients/food components examined increased. This finding does suggest that more than two nutrient-enhanced foods are required to be added to current residential menus to significantly enhance a menu. Potentially, all recipes in a menu could be examined to determine how they could be enhanced with nominal changes, in addition to recipes enhanced with more novel ingredients (e.g. chia, wheat germ, turmeric, and kale powder) for this population. This study demonstrates that micronutrient content of menus can be improved and that these enhancements do not result in excessive cost additions; it is anticipated that portion cost would be reduced further if a retail provider was not used for ingredients currently not available in the Synergy system. It is important to note that the average day cost provided in Table 6 is not the actual raw food spend in this home, which would also include modified texture products, oral nutritional supplements, enteral products, thickener used for dysphagic foods and fluids, foods specific to therapeutic diets or individualized resident needs, as well as all beverages.

Adjustment of the original residential menu with one or two NiD foods resulted in several nutrients being closer to reaching the DRI requirements (e.g. vitamin B_6, D, zinc). This suggests that further minor adjustments to the NiD recipes, emphasis of a few key fortified foods (e.g. products fortified with vitamin D), or addition of more than two NiD foods could result in meeting these requirements and that a nutrient-dense menu is feasible for Canadian long term care homes. One nutrient, vitamin E, continued to be well below (i.e., <5 vs. 15 mg) the DRI target with the addition of NiD foods, suggesting that alternate avenues such as fortification or supplementation are required to meet this nutrient's requirement. Indeed, there are few ingredients that are high in vitamin E and although we used wheat germ, spinach and almonds in recipes to provide this nutrient, it did not reach levels to meet the DRI target.

This work exhibits that a significant current challenge in the development of enhanced recipes is the availability of familiar but novel ingredients by group purchasing organizations, which are typically contracted by homes for the provision of food. These organizations purchase ingredients and products in large volumes, resulting in cost efficiencies that can be passed on to the buyer. Yet, only if there is sufficient demand for products will they be routinely sourced and provided by these organizations. Several ingredients used in NiD recipes (e.g. kale powder, chia seed, wheat germ, hemp hearts) had to be accessed through commercial retail, resulting in higher total costs for each portion of the enhanced foods including these ingredients. With the growing interest in quality ingredients, local food, and desire for less processed products in residential care, group purchasing organizations will need to update their food and ingredient offerings so that homes can include quality ingredients that promote micronutrient nutrition [25].

Another issue raised in this study was the readiness of residents for healthful ingredients. Some of the participants preferred their traditional foods and ingredients, while others noted challenges with some ingredients causing gastrointestinal discomfort. To meet nutrient requirements, more than one strategy is needed as already noted; novel enhanced recipes can be supplemented with quality recipes that use traditional ingredients high in nutrients. For future novel products, focusing on the incorporation of lentils and beans to promote fibre and plant-based protein is a priority, with the updated Canada's Food Guide [26]. As well, desserts and baked products were generally well accepted, indicating these should continue to be a focus for enhancement. Soups and the smoothie were more challenging with textures and flavours not as appealing to the residents in our taste-testing. According to Doets and Kremer [27], "the perception of texture largely determines the identity of a food and seems an important driver of food liking"; residents may have disliked foods due to their unexpected texture. The higher liking scores for desserts and baked products, which are traditionally sweet foods may be due to the preference for this flavour and dislike for sour tasting foods [28]. Moving forward, greater attention to texture and traditional preferred flavours will need to be considered in new nutrient-enhanced foods.

Taste-testing with cognitively-impaired participants is another challenge that must be considered in future work. These individuals were included in the study as they represent a large portion of residents living in residential care and, as with the cognitively-well individuals, those with cognitive impairments must be satisfied with the foods that they are served. Some participants with cognitive impairment were suspicious of the test and refused to eat the food. This refusal could be attributed to lack of familiarity with the researcher, as it was observed that when participants were with a care provider, foods were not refused. Future research should include the presence of a familiar care provider when taste-testing with persons living with cognitive impairments. Prior research suggests that food refusal may be due to lack of familiarity or recognition of food [29]. Another recommendation for future taste-testing in residential care would be to use familiar cutlery and tableware instead of the sample containers made of plastic and foam. We were however limited in the use of these containers to promote efficiency in the homes where data collection occurred.

Testing with individuals who were cognitively-well was straight forward and only a few participants from the cognitively-well group needed assistance to eat and complete the taste-testing forms. This was not the case, however for individuals with cognitive impairment. Even though the number of participants was small, the need for focused attention and support for each participant was higher than in the cognitively-well group. The researcher filled in all the responses for the liking tools for this group. Capacity for participants with cognitive impairment to complete the 9-point hedonic scale or the cued facial response scale is questioned based on the experience of this study; they were challenged with associating these scales to their perceptions of the food. For example, some participants would mention they appreciated a certain food but then chose a negative facial expression. Results show variability in liking across the various measures used for this group. Food waste provided an objective scaling that may be

more relevant for this group. However, one participant mentioned, "I will eat all the food because my parents told me to do so." It is recommended that acceptability of foods for residential care may be more effectively assessed by using a waste audit using a larger number than is feasible in a taste-test procedure.

This research has implications for chefs, food service managers, and dietitians. These providers will also need to respond to the growing demand for nutrient-dense recipes and food offerings in long term care. Each brings a unique skill set to food provision in long term care, from understanding nutritional requirements and importance of micronutrients to health, to menu planning to remain within cost and labour constraints, to innovative ways to use raw ingredients in providing quality food. Through this investigation and prior work [18], it was noted that improving the knowledge of chefs on ingredients that are high in specific nutrients is needed. Once developed, these recipes will need to be confirmed by food service managers and dietitians with nutrient analysis software, adjusting the daily menu to meet diet recommendations while remaining within budget. Further, the importance of micronutrients to health needs to be emphasized; residential providers understand the importance of providing variety and emphasizing protein and fibre, while reducing sodium [18], but often prioritize resident preference and cost of products over micronutrient content. Providing training and skill building with nutrient analysis and menu development is another way that menu quality can be improved. Home and government policy to drive the prioritization of quality menus, the time and effort required to create nutrient dense recipes and conduct a comprehensive nutrient analysis of the menu is also needed. Legislation on how a menu should be prepared will drive practice. Currently, regional menus in Canada are based on Canada's Food Guide [26]. Redirecting the standard towards the Dietary Reference Intake [22] will support this goal.

This study has presented a framework for the inclusion of nutrient-dense menus for residential care to contribute towards the prevention micronutrient malnutrition in older adults. Yet, there are some limitations to this work. Recipes were not tested to determine compliance with the International Dysphagia Diet Standardization Initiative [30]. Although attempts were made to make foods that were easy to chew and could be pureed or minced, no formal testing of how products should be modified for texture specifications was undertaken. Only 10 recipes moved on to taste-testing, eight of which passed taste-testing with cognitively-well participants and were used in the 7-day menu analysis. This research demonstrates that a great deal of effort is required to create quality recipes: future efforts in recipe design require focusing on the most nutrient dense ingredients that can significantly improve nutrient profile and still be acceptable to consumers. Recipe sharing among providers in this sector is likely required to result in significant shifts in menu planning due to the limited capacity for providers to develop and test enhanced recipes. Research is limited with respect to taste-testing methods for this population and specifically persons living with cognitive impairment. No single method worked the best for this group. Further standardization of the qualitative methods used (e.g. facial expressions, comments) is needed to supplement weighing of food portions remaining. Utility of hedonic and cued facial response scales is questioned based on this sample. The nutrient analysis was completed with the Synergy on Demand Mealsuites™ software and completed by a non-researcher, due to the skills required for using the Synergy platform. Nutrient analysis is at best, an estimation, due to various errors from nutrient data base comprehensiveness to recipe construction [7], thus the nutrient profile of NiD products should be considered approximate. Finally, the sample size can always be larger; however meaningful results were obtained with the current study's sample.

Conclusion

The NiD project demonstrated that many steps are involved to create nutrient dense menus for residential care. However, a more nutrient dense menu is a feasible approach for mitigating micronutrient malnutrition. Two enhanced recipes are not sufficient to significantly improve the micronutrient content of a 7-day regular texture menu and all food products on menus should be reviewed to promote micronutrients, protein and fibre, while limiting calories and sodium. Standardized taste-testing has its challenges in this population and a variety of objective and qualitative methods are recommended, as well as simple waste audits for new recipes. This research does lay the foundation for further research focused on food enhancement by identifying the nutrients, ingredients and food vehicles to be targeted for novel enhanced recipes in residential care.

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