Clinical Nutrition Open Science 56 (2024) 287–295

Contents lists available at ScienceDirect

Clinical Nutrition Open Science

journal homepage:
www.clinicalnutritionopenscience.com

Original Article

Culinary solutions to prevent or delay advanced malnutrition: Patients and chefs' contribution to the nutritional enrichment of standard recipes

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ARTICLE INFO

Article history:
Received 31 January 2024
Accepted 16 May 2024
Available online 18 June 2024

Keywords:
Taste
Nutrition
Preference
Culinary expertise
Cancer patients
Eating habits

SUMMARY

Around 40% of cancer patients undergoing chemotherapy are malnourished, i.e. they suffer from an imbalance between nutritional intake and requirements, particularly in terms of energy and protein. This condition is deleterious, as it can lead to a loss of quality of life for the patient, increased mortality, and higher risks of recurrence and progression. In cancer patients, the onset of undernutrition is mainly due to reduced food intake and metabolic alterations, mainly due to the side effects of chemotherapy treatments. Indeed, treatment can lead to alterations in taste and smell, as well as loss of appetite, nausea, difficulty swallowing … Consequently, it is advisable to adapt the patient's nutritional management according to the degree of severity.

The aim of this work is to propose food solutions providing protein enrichment to limit muscle loss and energy enrichment to limit weight loss. More specifically, culinary creativity sessions were conducted to propose enriched versions of standard recipes and a preference tests was conducted with patients to evaluate the recipes.

The culinary workshop involving multidisciplinary experts (chefs, sensory and nutrition experts) led to the development of enriched recipes for oncology services, a starter, a main course and a dessert. A survey was then carried out with 237 cancer patients and

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https://doi.org/10.1016/j.nutos.2024.05.010

measured their appreciation of the recipes developed. Using nutritional, sensory and preference performances of experimental recipes allowed to define the optimum variants to propose to undernourished patients.
This study demonstrated the value of involving chefs and patients in the creation of enriched recipes in order to offer tasty, nutritious and adapted meals.

Introduction

Changes in taste and smell perception are observed in 45–84% of patients undergoing chemotherapy [1]. Indeed, chemotherapy can cause change of smell and taste perception and impact food enjoyment and eating behaviours. Patients are then at risk of malnutrition in terms of nutritional imbalance, characterised by a negative energy and/or protein balance. It is a pathological condition characterised by insufficient intake in relation to the body's nutritional requirements. The consequences are tissue losses, particularly muscular, which favours the occurrence of numerous morbidities, worsens the prognosis of underlying diseases and increases the risk of death. [2].

Malnutrition in cancer patients is associated with an increase in the risk of cancer progression, recurrence and in overall mortality as shown in colorectal, lung, pancreatic, oesophageal, liver cancers [3]. Numerous studies have highlighted the deleterious consequences of malnutrition and the loss of muscle mass on morbidity, mortality, response to treatment, length of hospital stay, readmission rate, healthcare costs or the patient's quality of life [4–6].

Cancer patients often encounter eating difficulties or decrease willingness to eat due to various causes such as oral discomfort, nausea, heavy fatigue, disgust for food odors which leads to undernutrition in around 40% [7]. This prevalence varies according to the type of cancer, ranging from 20% for breast cancer, 40% for prostate cancer, and up to 54% for pancreatic cancer patients [8].

In cancer patients, the onset of malnutrition is explained by decreased food intake and metabolic alterations [9]. When asked about the reasons for the decrease in food intake, patients mainly mentionned anorexia or loss of appetite (63%), loss of taste (42%), both for salty (24%) and sweet (20%) foods, nausea (30%) difficulty swallowing (26%), inadequate nutrition (19%), constipation (19%), mouth pain (16%), abdominal pain (15%), vomiting (14%), diarrhea (13%) or loss of smell (12%) [7], all of which are consequences of the disease in the strict sense or of the treatment associated with it [10].

The reasons to reject certain foods in cancer patients could be either because foods are judged tasteless, or on the contrary, too high in taste [11]. They may occur cyclically or continuously throughout treatment and may persist for up to several months after treatment. Such side effects can lead to changes in patients' food preferences and intake, with taste being a major determinant of food choice.

The Global Leadership Initiative on Malnutrition (GLIM) has reached a consensus on the identification of criteria for the diagnosis of undernutrition. They developed a two-step model for risk screening and assessment for diagnosis and severity grading [12]: the diagnostic of undernutrition requires at least one phenotypic criterion (non-volitional weight loss or low body mass index or reduced muscle mass) and one etiologic criterion (reduced food intake or reduced assimilation or disease burden/inflammatory condition). For cancer patients malnourished or at risk of malnutrition, guidelines recommend nutritional intervention to increase oral intake. The aims is to encourage the intake of protein- and energy-rich foods. This includes dietary advices and oral nutritional supplements. If oral nutrition remains inadequate despite this intervention, enteral nutrition is recommended and parenteral nutrition if enteral nutrition is not sufficient or feasible [13]. For every patient with cancer at risk of undernutrition, nutritional strategies are needed such as enriched calorie and protein recipes. For severe undernutrition, solutions include enteral and parenteral feeding. To prevent reaching severe levels, patients' weight is thoroughly controlled and food solutions are proposed at moderate stages of undernutrition, i.e. when the patient starts loosing weight continuously. The main

one implemented in the case of moderate malnutrition in cancer patients is a dietary adjustment based in the first instance, of i) protein enrichment, to limit muscle loss and ii) energy enrichment to limit weight loss. Oral nutritional supplements are indicated if caloric intakes are not sufficient to cover needs [4]. The success of nutritional strategies depends largely on patient compliance, which in turn is closely linked to the acceptability of the food to be consumed. [14]. Strong correlations have indeed been shown in various populations between food liking and food intake, in other words between the sensory experience of eating and the overall consumption [15–17]. Improving patients' satisfaction through customized recipes is a target solution to fight malnutrition while ensuring food enjoyment.

The aim of this work is thus to involve chefs and patients to elaborate and evaluate food solutions: chefs to create adjusted recipes with adequate protein and energy content as well as compensating for smell and taste alterations and patients to give feedback and reach optimal recipes. More specifically, the objective of the work is to count on chefs and patients to reformulate dishes and provide enriched recipes as liked as standard recipes.

Materials and methods

Culinary design

Three recipes, a starter, a main course and a dessert, were selected from a standard menu in oncology. Chefs were briefed to develop alternative recipes taking into account several factors:

- Nutrition: protein and energy enrichment using natural ingredients such as dairy products or eggs,
- Senses: taste and flavour (herbs and spices) enrichment to compensate for alteration and visual contrasts (colors, shapes),
- Size: attention was given to volumes as patients also exhibit a decreased appetite,
- Functionality: ease of preparation, reproducibility
- Cost: standard ingredients for health care institutions.

During a one-day workshop, several alternatives were developed and tested all day long by a technical team composed of 6 persons, including chefs, nutritionists and sensory experts. The multi-expert tastings and discussions allowed chefs to adjust their proposals in real-time. At the end of the workshop, three enriched recipes were selected for patients' evaluation (see Table 1).

Patients evaluation

The study was designed for a population of cancer patients, with no restriction on the location of the cancerous tumour. Evaluation were done in two healthcare institutions (Institut de Cancerologie de l'Ouest, Nantes, FR and Centre de Soins de Suite et de Réadaptation, Le Bois Rignoux, Vigneux de Bretagne, FR). All patients were invited to participate to a food tasting on a voluntary basis.

Patients were welcomed in the lobby and after participation approval and signature of their informed consent, they were invited to seat in an individual booth and were asked to fill a self-administered questionnaire on age, gender, current treatment.

Then, the 3 dishes in two variations were served sequentially for tasting and liking evaluation. Patients didn't know if they had the standard or the enriched meal (simple-blind). Patients stated their food appreciation using a VAS Visual Analog Scale (*How much do you like this starter/dish/dessert ?* from *I don't like it at all* to *I like it very much*) coded from 0 to 10. After rating each sample, the patient was asked to comment the food in two categories, negative and positive comments (see Figure 1).

Statistics

Wilcoxon signed-rank tests were conducted for paired comparisons between recipes (Standard Vs Enriched) for each dish. The effects were considered as significant when $p < 0.05$. Data were analyzed using XlStat 2021.4.1.

Table 1
Name, picture and nutritional characteristics of standard and enriched recipes (data for one portion)

	Starters	Main course	Dessert
Standard	Beetroot & vinaigrette	Cauliflower & curry sauce	Poached pear & chocolate sauce
			
	Energy 103 kCal Protein 1.9 g	Energy 79 kCal Protein 3.1 g	Energy 121 kCal Protein 1.0 g
Enriched	Beetroot & vinaigrette, Enriched with crumbled cooked egg yolk	Cauliflower & curry sauce, Enriched with addition of milk powder	Poached pear & chocolate sauce, Enriched with addition of milk powder
			
	Energy 167 kCal (+61%) Protein 5.1 g (+168%)	Energy 105 kCal (+32%) Protein 5.0 g (+61%)	Energy 140 kCal (+16%) Protein 2.4 g (+140%)

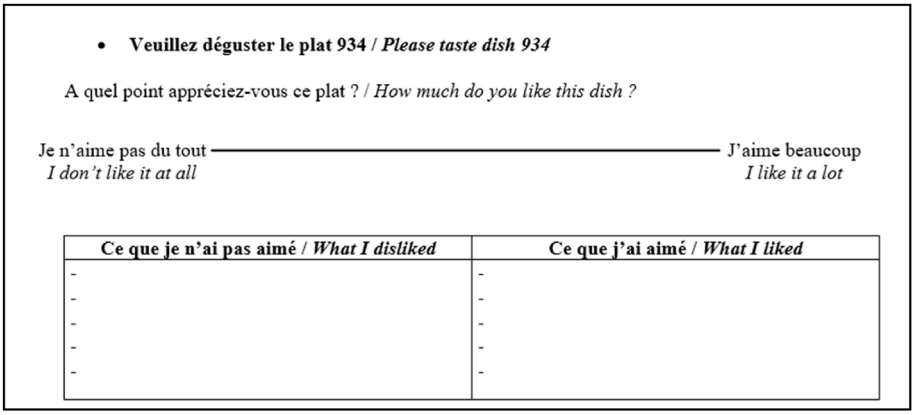

Figure 1. Example of the questionnaire (liking evaluation).

Ethical statement

The patients were freely invited to participate to a sensory preference test and informed the main objective was to evaluate new recipes in comparison to standard recipes. Informed consent was obtained prior starting the test. The full protocol was evaluated by the CHU Angers ethical committee (number 2021-165) and approved on September 8 2021.

Results

Culinary design

Characteristics (picture and nutritional values) of the 3 selected recipes in their standard and enriched versions are presented in Figure 2 and Table 2.

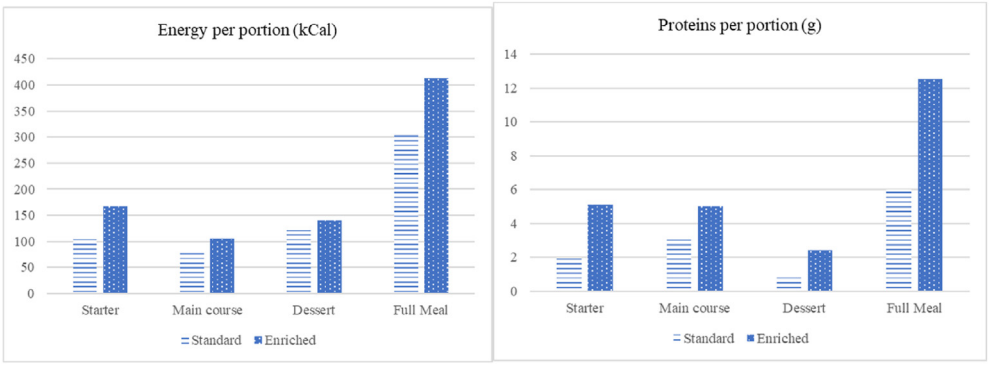

Figure 2. Nutritional values of standard and enriched recipes per portion (kCal and g proteins).

Table 2
Patients' mean liking scores (SD) (Wilcoxon test; *=significant at 0.05) and free comments (A = appearance, F = flavour, T = texture, main declared likes and dislikes) on standard and enriched recipes

	Starter		Main course		Dessert	
Standard	7.1 (2.5)		7.0 (2.4)		6.1 (2.7)	
Enriched	5.9 (2.8) *		6.4 (2.7) *		6.3 (2.6) NS	
	Likes	Dislikes	Likes	Dislikes	Likes	Dislikes
Standard	A. good appearance F. beetroot taste, sweet T. beetroot texture	A. industrial F. acidity, bland T. too oily	F. sauce taste T. cauliflower cooking	A. smell F. too spicy	A. freshness, visual, mix pear/chocolate F. chocolate flavour T. pear cooking, cream texture	A. visual aspect F. tasteless, bitter T. sauce texture
Enriched	A. visually attractive F. tasty T. mix beetroot/egg	F. tasteless T. too dry	F. sauce taste T. cauliflower cooking, sweetness	A. smell F. tasteless, sweet T. sauce texture	A. fresh, mix pear/ chocolate F. cream taste, more chocolate flavor, sweeter T. cream texture	A. visual aspect F. too sweet T. sauce too thin

The starter, a cooked beetroot salad with sauce was enriched by adding a crumble of cooked egg yolk, bringing more energy and more protein; Compared to the standard portion, then enriched recipe brings 63kcal more energy (+61%) and 3.2g more proteins (+168%). More, it brings visual contrast, expected to be more visually attractive than the dark original starter.

The main course is a vegetarian curry with a cauliflower base, enriched with milk powder. The enriched recipe brings 25kcal more energy (+32%) and 1.9g more protein (61%).

The dessert is a poached pear with a chocolate sauce enriched with milk powder. The enriched recipe bring 19kCal more energy (+16%) and 1.4g more protein (140%).

In the hypothesis of both meals would be consumed entirely, the nutritional values of the standard meal are 304kCal and 6g of protein to be compared to the enriched version bringing 412 kCal and12.5g of protein.

Patients evaluation

A total of 237 patients participated in the study, mean age 59 year-old, 79% female. The types of cancer vary among locations: 50 % breast, 10% lung, 7% ovary, 5% colorectal, 3% kidney, 3% brain, 2% melanoma, 2% liver, 2% prostate, 16% others.

A majority of patients were under a chemotherapy treatment, alone or combined to another treatment. The distribution of treatment was as follow: 55% Chemotherapy alone, 12% Immunotherapy alone, 6% Combination Chemotherapy and Immunotherapy, 4% Combination Chemotherapy/Radiotherapy, 5% Hormonotherapy alone, 18% Others.

All recipes are generally appreciated with mean scores ranging from 6.1 to 7.1. Results show differences between standard and enriched recipes with a significant preference for the standard starter and the standard main course (see Table).

The analysis of patients' free comments allows to explain the observed difference in liking.

The beetroot salad starter was enriched by the addition of a cooked egg yolk crumbled over the salad. It was less appreciated by the participants than the standard recipe. They considered its texture too dry and unpalatable. The enriched recipe for the egg-based dried out the rest of the dish. From a general point of view, patients like the visual contrast of the egg yolk and beetroot in the enriched starter but found the texture too dry. Taste and flavour are given as positive and negative reasons for both the standard and the enriched recipe, showing no clear consensus on those criteria. Texture is thus identified as the main improving factor to be worked out, possibly through a greater quantity of sauce that could be served aside.

The main course, enriched with milk powder, was less appreciated by the participants who found a sweet taste in the sauce. The enrichment with milk powder brought a sweetness to the sauce of the dish that was reported as unpleasant by the respondents. No clear direction appears as taste and smell are again here cited in both likes and dislikes for the two recipes. However, one relevant differentiating mention is the sweet taste of the enriched recipe, the milk powder potentially adding lactose and a sweet note. A rework of the curry mix could be a solution to balance the overall flavour. There seems to be room for improvement, especially by providing an appropriate sensory enrichment.

In the case of the dessert, there was no significant difference in appreciation between the two desserts. Indeed, it was “as much appreciated by the patients as the standard recipe”. The enriched dessert fits the objective of being as liked as the reference, validating the proposed recipe.

Discussion

This two-phase feasibility study has a main objective of combining chefs and patients input to formulate adequate food for cancer patients.

The first phase was a culinary workshop by chefs with contribution from culinary, sensory and nutrition experts. The workshop allowed to select recipes from the standard menu, to identify potential rich ingredients adapted to each recipe, conduct cooking trials with various proportions and to finally select pilot recipes following technical tastings. This work led to the development of three recipes available in two versions, a standard one and a nutritionally enriched one. The starter is beetroot salad with vinaigrette and the enrichment is with crumbled cooked egg yolk. The main course is baked cauliflower with curry sauce and the dessert is a pear in syrup with chocolate sauce, all enriched versions have milk powder in the sauces.

The second phase consisted of a product test carried out with 237 cancer patients who participated in tasting sessions. They evaluated each recipe in its standard and enriched versions and gave overall liking scores as well as reasons of likes and dislikes. All recipes were relatively appreciated with no significant differences for the dessert variants.

Regarding the nutritional criteria, the values of the full meal are significantly improved with the use of natural ingredients (egg, milk), from 304 kCal to 412 kCal (+135%) and from 6g of proteins to 12.5g (+208%). Besides the composition of the dishes, their acceptability was checked through patients' evaluation.

Significant differences in liking were observed between standard and enriched variants of both savoury dishes. The enriched starter recipe was well appreciated in terms of appearance: the yellow colour of the egg yolk contrasts well with the dark purple of the beetroot. However, the egg yolk brings dryness and the recipe needs to be improved in terms of texture. One option of reformulation could be to adapt the seasoning. For instance the sauce proportion could be increased or the composition and fluidity could be modified. Indeed, oral somatosensory perception is recognised as playing a great role in cancer patients' relation to food [18,19]. Dry mouth is identified to often occur in cancer patients

bringing discomfort while eating and swallowing. This criterion was not taken into account in the current culinary development and should be added as a parameter in future works and in culinary recommendations.

The enriched main course recipe is a vegetarian dish, a cauliflower curry. Both versions, standard and enriched, led to contradictory comments on the sauce flavour. Some did not like the standard version because it was too spicy and some did not like the enriched version because it was too bland. Same contradictory results are shown for taste: some declared sweetness of the enriched version in the reasons of liking, some declared it in the reasons of dislikes. All together, the added milk powder had an effect on the overall flavour and the question of a specific rework of the formula to balance sweet and spicy tastes is raised. Large variabilities are observed in taste and smell judgments, especially in cancer patients [20]. Writing general recommendations and developing consensual recipes might be an unreachable goal and the strategy of proposing personalised solutions is a direction under study.

The proposed enriched version of the dessert, a cooked pear with chocolate sauce, was well noted by patients and is thus validated, although some individual comments also emerged confirming food liking diversity.

The study presented here is based on a comparative assessment of the recipes. Combining the quantitative and qualitative patients' feedback allows to get precise information on the general liking and on the detailed perception. The average level of liking of each dish needs to be satisfactory; practitioners in the food domain usually consider a mean score over 6 (out of 10) as satisfactory. In this work, the validation criterion was more demanding: no significant difference should be observed between the standard and the enriched recipe. For two recipes, this goal was not reached. There comes the usefulness of the open-ended question providing detailed comments on the reasons of likes and dislikes. Although, as expected, the data show a great variability and contradictory judgments between patients, the comments draw some lines of reformulation for each recipe (texture wise for the starter, flavour wise for the main course).

This protocol is useful to evaluate the overall liking of standard and enriched recipes as well as to highlight the differences between versions and to identify potential directions of reformulation. This method is more complete than a simple liking test of the recipes making possible to measure the overall acceptance but not informing in a comparative way. An alternative approach is to conduct a monadic evaluation in a real meal time. It has the advantage of reflecting the general satisfaction in natural eating context and measuring consumed quantity has a complementary indicator of satisfaction and efficiency in terms of nutritional impact. However, it lacks the comparison of the variants which makes the interpretation of free comments difficult to interpret. In the future, we recommend to use focus groups with patients to screen several recipes, evaluate proposed variants and get detailed directions for recipe reformulation. Ideally, this step should be completed by a final validation on liking and consumption in eating situations.

In this study, the main focus of culinary design was on nutritional enrichment. In view of the results, it seems relevant to consider more thoroughly sensory adaptation as well. Indeed, pronounced changes are observed during or following the cancer treatments, and the restoration of sensory function is not consistently observed. The consequences on each patient's nutritional status, health and quality of life present distinctive challenges and implications. Particularly among cancer patients, sensory alteration was shown to impact eating pleasure, appetite, food intake, and psychological well-being [21]. Consequently, sensory alterations can be considered as a good lever to prevent malnutrition and improve quality of life [20,22,23].

Our results confirm the need of a holistic approach, improving both nutritional and sensory characteristics. This integrated approach corresponds to the needs of the target population of cancer patients undergoing treatment [24]. However, designing optimised foods in terms of sensory and nutrition appears to be quite complex due to the high variability of sensory capabilities together with a high variability in personality traits, food habits, and cultural preferences [25,26].

Working more closely in a multidisciplinary way with food and culinary knowledge on one side [27] and physiological, psychological and sociological knowledge on the other side (Dougkas et al., 2018) is the current strategy pursued in current collaborative projects as stated in the I-eAT manifesto [28].

In a broader view, this work opens new ways to consider fighting undernutrition in health institutions through a generalization of enriched meals and enriched snacks for fragile populations

according to inclusion criteria and conditions of use to be further determined and validated in randomized control trials.

Statement of authorship

A. Giboreau: Conceptualization, Methodology, Formal analysis, Writing—original draft preparation, Writing—review and editing, V. Mourier: Conceptualization, Methodology, Writing—review and editing, Funding acquisition. C. Rousseau: Formal analysis, Investigation, Data curation, Writing—original draft preparation, S. Lavergne: Conceptualization, Methodology, Investigation, Project administration, D. Vansteene: Conceptualization, Methodology, Formal analysis, Writing—review and editing.

All authors have read and agreed to the published version of the manuscript.

Funding

The authors thank Elior Santé for the financial support of the study.

Declaration of competing interest

None.

Acknowledgements

The authors wish to thank the chefs who developed the recipes: Julien Ferretti (Lyfe Institute) and Ronan Legendre (Elior), staff from ICO and Le Bois Rignoux centers for patients tests, Dalal Hankir (Lyfe Institute) for her support during culinary workshops and patients tests and Eugénie Guillin (ICO) for her editing support.

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