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Cost-Effective Evaluation of Homemade Recipes in Cancer Patients on Liquid Diet from Low-Middle-Income Group Countries

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Abstract

Cancer patients, on liquid diet are at a high-risk of malnutrition. 10-20% of patients are estimated to die due to malnutrition rather than malignancy itself. In low-middle-income group countries (LMICs), patients are mostly undernourished. They need cost-effective, easily available and acceptable nutritional support. The study has been undertaken to evaluate the cost-effectivity of homemade recipes vs commercially available nutritional formulations for patients on liquid diet. Recipes for both vegetarian and nonvegetarian were designed using low-cost and locally available ingredients to fulfil the daily calorie requirement of $\approx 2,000$ kcal (30 kcal/kg for a 65 kg adult) with ≥ 90 gm of protein (1.5 gm/kg). Alongside, five commercial nutritional formulations were evaluated to meet the above requirements. The caloric (380 ± 80.1 kcal/100 gm, 260–474 kcal) and protein contents ($32.6 \pm 10.9/100$ gm, 15–49 gm) in commercial supplements were variable. For providing 2,000 kcal with minimum of 90 gm protein, the cost of commercial formulations ranged from INR 745 -3,461/day ($1,700 \pm 946$). Comparatively, the vegetarian and non-vegetarian homemade recipes were estimated to cost just INR 135/day and INR 182/day respectively. For the 2000 kcal diet, the difference in nutrient contents of commercial vs homemade preparations were non-significant, while the cost was significantly lower with homemade recipes ($p=0.03$). Homemade recipes designed and suited to individual needs could meet the dietary requirements for patients on liquid diet, be highly cost-effective and thereby especially suit patients from resource constraint settings, like LMICs.

Keywords: Nutrition; Cancer; Liquid diet; Malnutrition; Low middleincome countries; Nutrition supplement

Introduction

Cancer patients are at an increased risk of malnutrition as the disease and its treatment, both threaten their nutritional status. Some patients are forced to be on liquid diet for variable periods during their disease either due to advanced nature of disease or treatment related morbidities. These could severely compromise their normal food intake. It is estimated that 10-20% of deaths in cancer patients are due to malnutrition rather than due to the disease per se.⁽¹⁻³⁾ Maintaining caloric and nutrient intake is therefore critical during cancer treatment. Nutritional support during therapy can help to reduce unintentional weight loss, susceptibility to infections and facilitate post treatment recovery⁽⁴⁾.

Worldwide, the prevalence of malnutrition in cancer patients is reported in the range of 20% to 70% depending on age, cancer type and stage^(2,5,6). Patients with head and neck, gastrointestinal tract, lung, and hepatobiliary cancers are at an increased risk of malnutrition^(2,6-10). Further, as patients of head and neck cancer and upper gastrointestinal tract are usually treated with chemoradiotherapy (CTRT), treatment related acute toxicities could compel them to resort to soft solid or liquid diet for protracted periods both during and even following the completion of their treatment. This could further compromise their nutritional status.

Numerous studies have emphasized the consequences of malnutrition in cancer patients, namely poor health outcomes, lowered immunity, susceptibility to infections^(1,5,11), psychosocial stress⁽¹²⁾, lower quality of life⁽¹⁰⁾, treatment toxicity⁽¹⁰⁾, quality of life⁽¹³⁾ and higher risk of mortality^(1,14,15). Nutritional status during the treatment has been reported as an independent predictor of outcome in cancer patients influencing cost of health care, hospital stay and survival^(1,14).

In low-middle-income group countries (LMICs), patients are usually undernourished and present in advanced stages of their disease⁽¹⁶⁻²²⁾. Additionally, in most cases they must meet the cost of their treatment through out-of-pocket resources. The resulting financial constraints often forces patients to neglect their basic dietary needs that could adversely influence their final treatment outcome.

This study was therefore undertaken to formulate a cheap and easily available liquid homemade recipe for those unable to afford commercially available nutrition supplements. Comparative assessment of the nutritional content and cost was undertaken for homemade formulae versus some of the commonly prescribed commercial nutritional supplements locally.

Material and Methods

The nutritional requirement for an average adult male was calculated as 25 to 30 kcal/kg/day and at least 1.2 to 1.5 gm protein/kg/day^(23,24). Thus, a normal adult of 65 kg would need around 2,000 kcal/day and at least 90gm

proteins/day⁽²³⁻²⁵⁾. Nutritional values for calorie, protein and carbohydrate of each ingredient was estimated according to the nutritional value of Indian foods listed by the National Institute of Nutrition, Indian Council of Medical Research⁽²⁶⁾. Two separate formulations for vegetarian and non-vegetarian patients were designed.

The ingredients used were chosen to not only provide the required proteins and calories but also incorporate those with known medicinal properties. Thus, curcumin water as a morning drink has properties of an antioxidant, anti-inflammatory and antiproliferative agent. Further, it has been demonstrated to induce cytotoxic effects in tumor cells leading to cell cycle arrest, apoptosis, autophagy, changes in gene expression, and disruption of molecular signaling. It has also been reported to potentiate the effect of radiation on cancer cells while protecting the normal tissues^(27,28). Alternatively, a herbal drink with mint, a known antioxidant could be offered depending on patient's choice⁽²⁸⁾. Powdered roasted gram dissolved in milk is highly loaded with proteins, carbohydrates, fats, calories and rich in fibers. It also provides a good source for iron and magnesium. This could be further enriched by adding barley, quinoa or maize powders. The powder can be dissolved in milk or water as a smooth suspension and could be sweetened with sugar or jaggery and flavored with cardamom depending on patients' liking. Finger millet is also a nutritious product containing carbohydrates, fibers and is rich in calcium and potassium. This could be added to a vegetable soup and prepared as a part of the liquid diet. Broken/cracked wheat could also be boiled with milk and sweetened according to individual taste and preference. This forms a rich source of fibers, iron and potassium. In addition, vegetable soup provides calcium, iron beta-carotene, vitamin C, riboflavin and folic acid. Pulse soups are high source of protein and can be easily prepared at home at a low cost. Honey, apart from its high caloric value, is a known antioxidant and could be a part of the dietary formulation. Soy milk from soybean can provide high protein (36.39g/100 gm) along with iron (15.7mg/100 gm) and calcium (277 mg/100 gm). It could thus act as a rich source of proteins, especially in vegetarians⁽²⁹⁾. A detailed formulation of the daily diet for vegetarian to meet the dietary requirement is given in Table 1. Preparations of the recipe and nutrient value of the ingredients is detailed in Supplementary Table 1.

For non-vegetarians, the protein requirements are primarily met from chicken, egg and meat. In addition, various vegetables, namely carrots, potato, mushrooms, beans, cabbage and tomato along with chickpeas could meet the requirements of additional proteins, minerals and vitamins. Along with these, rice, especially the brown rice could be added in the chicken mix soup. Brown rice is rich in lipids, minerals, vitamins, dietary fiber, micronutrients, and contains three different types of antioxidants phenolics^(30,31). To make it nutritionally complete, subtle variations in the dietary for-

Table 1. A suggested homemade vegetarian recipe with nutritional content and cost in INR

Time	Food items	Proteins (gm)	CHO* (gm)	Fats (gm)	Calories (kcal)	Cost (INR)
Early morning	Curcumin water (1 glass)	0.189	2	0.15	10	5
Breakfast	Roast gram powder (50gm) + Milk 1 cup + fresh fruit juice	22	64	14	550	40
Lunch	Mix pulse boiled water (100 ml) + yogurt (1 cup) + legume veg soup (1 bowl) + broken cracked wheat sweet dish (1 cup)	32	71	13	590	40
Brunch	Jaggery (50gm) in water + Soy milk (100 ml)	4	51	2	200	10
Dinner	Roast gram powder water (50gm) + honey water (1 glass) + mix legume boiled water (100 gm)	30	58	15	600	30
Post-dinner	Milk with curcumin powder (1 glass)	4	4	4.5	77	10
Total		92	250	48.65	2027	135

*CHO: carbohydrate

mulations with chicken, meat or egg drops could be tried by adding various vegetables and pulses according to individual preferences and taste. In addition, the powdered roasted gram and soy milk as has been suggested earlier for vegetarians could also be incorporated. Drinks with curcumin, mint, orange can further add antioxidants and contribute essential minerals and vitamins as discussed above^(27,28). A suggested recipe for nonvegetarians designed to meet the daily requirement of $\approx 2,000$ kcal and ≥ 90 gm of proteins is given in Table 2. Preparations of the recipe and nutrient value of the ingredients is detailed in Supplementary Table 2.

The ingredients for both homemade formulations should be easily available, cheap, suited to the local customs and food habits. The items should be easily prepared, preparation process should be simple, easily understood and followed by the patient's caretakers. This would help to improve patient compliance, affordability and individual variations in the recipe could help to curb the monotony in the diet.

Five commonly prescribed and commercially available nutrition preparations were chosen. These included — Protinex (M/s Nutricia International Pvt. Ltd., India), Essential HP (M/s Azzurra Nurturing Human Lives, India), Celevida (M/s Dr. Reddy's Laboratories Ltd, India), Advitam (M/s Advitam Life Sciences Pvt Ltd, India) and Nutrimax (M/s Tushar Health Care, India) (Supplementary Table 3). They were chosen as a likely representative of the nutritional supplement usually taken by patients. To ascertain the cost effectivity of these homemade recipe, commonly prescribed commercially nutrition supplements were compared. For this study, the amount of supplement needed was computed to meet the daily requirement of $\approx 2,000$ kcal and ≥ 90 mg of protein.

The homemade recipes (both vegetarian and nonvegetarian) were individually compared with these five commercially

available nutritional supplements in terms of their calorie, protein, fat content and cost in INR/day both for a complete meal for 2,000 kcal or to provide only a 25% nutrition supplement to their normal liquid diet. The values obtained were subjected to t-test to ascertain if there are any significant differences between the homemade and commercial nutritional supplements.

Results

The vegetarian and nonvegetarian liquid diets have been formulated for early morning drink, breakfast, lunch, brunch, dinner and post-dinner meals. For 2,027 kcal, the vegetarian recipe would provide 92 gm of protein, 250 gm carbohydrate and 48.6 gm of fat (Table 1). This would cost INR 135/day. The nonvegetarian recipe has been designed for 2,078 kcal and provides 149 gm of protein, 186.9 gm carbohydrates and 22.6 gm fats, priced at INR 182/day (Table 2).

The composition of the five nutrition supplements evaluated had wide variation in the in terms of calories (mean \pm SD: 380.4 ± 80.1 gm/100 gm; range: 260-474), proteins (32.6 ± 10.9 gm/100gm; range 15-49), carbohydrate (43.2 ± 15.6 gm/100 gm; range 25–68) and fats (9.3 ± 8.4 gm/100 gm; range 0.1–19). The cost for 100 gm of these supplements ranged between INR 132 and INR 450 (INR 302.4 ± 120.8) (Table 3).

Thus, to provide 2,000 kcal by these supplements, the cost of these supplements would vary between INR 745.76 and INR 3,461.54 (INR $1,700.76 \pm 946.36$). The protein, carbohydrate and fat contents for providing 2,000 kcal by these preparations ranged between 85.9 gm and 230.8 gm (173.2 ± 56.8), 105.5 gm — 439.8 gm (249.5 ± 128.2), 2.8 and 81.7 gm (49.6 ± 35.6) respectively (Figure 1a-c). No apparent correlation could be seen between the price of the

Table 2. A suggested homemade non-vegetarian recipe with nutritional content and cost in INR

Time	Food items	Proteins (gm)	CHO* (gm)	Fats (gm)	Calories (kcal)	Cost (INR)
Breakfast	Orange juice (1 glass) + Chicken vegetable soup (2 bowls with cabbage and chickpeas)	40	36.6	3	315	40
Lunch	Chicken mix soup (2 bowls with rice and carrots) + eggs drop soup (1 bowl)	42	32.6	2	525	35
Brunch	Soy milk (1 glass) + chicken clear stock (1 glass)	7	40.49	2	310	40
Dinner	Strained meat with kidney beans vegetable soup (1 bowl with pumpkin, spinach and beans) + egg veggies soup (2 bowls with cauliflower, potato and tomato)	42	35.85	15.65	603	40
Post dinner	Milk + roast gram powder (50 gm)	18	41.4	0	315	20
Total		149	186.94	22.65	2078	182

*CHO:carbohydrate

Table 3. Comparison of five commercially available brands (per 100 gm)

Commercial formulations (100gm)	Brand A (Protinex)	Brand B (Essential HP)	Brand C (Celevida)	Brand D (Advitam)	Brand E (Nutrimax)	Range (All five preparations)
Energy (kcal)	354	465	474	260	349	260-474
Protein (gm)	34	35	49	30	15	15-49
Fat (gm)	0.5	19	19	8	0.1	0.1-19
CHO (gm)	53	40	25	30	68	25-68
Cost (Rupees)	132	260	430	450	238	132-450

product versus the key nutrient components listed in these formulations.

The corresponding values for homemade vegetarian and non-vegetarian recipe were 117 ± 36.7 , 34.8 ± 18.5 , 213.3 ± 47.1 gm respectively (Figure 1a-c). This difference in the main nutrient contents of protein, fat and carbohydrate were found to be non-significant for each content (p: ns for each content). However, the cost for 2,000 kcal for the five commercial supplements was significantly higher than the homemade recipe (INR $1,700.76 \pm 946.36$ vs INR 154 ± 29.7 , $p=0.03$) (Figure 1d).

Even if the nutrient supplements are used to just complement the daily intake with 25% of the caloric requirement, the average estimated cost would be INR 425 (range: INR 186 – 865). This would provide an average of 43% of the required protein (range: 21% - 57%). This is still higher than the cost incurred for homemade recipe to provide 100% of the total caloric and protein requirement. Thus, taking the average cost of homemade recipe (vegetarian or non-vegetarian) as INR 156, the commercial supplements are likely to cost around 4.8 times to 22.2 times for providing the required 2,000 kcal nutrition with a minimum of 90 gm of protein.

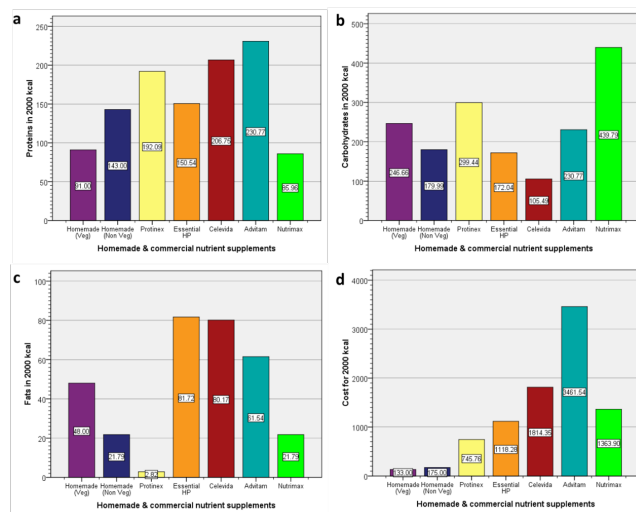


Fig 1. (a) Protein content (b) Carbohydrate content (c) Fat content and (d) Cost/day for 2000 kcal in home made vegetarian and nonvegetarian liquid diet and five commercial nutrient supplement preparation. Independent sample t-test for homemade preparations vs. commercial nutrient supplement, in terms of protein ($p=ns$), fat ($p=ns$), carbohydrate ($p=ns$) contents, cost/day ($p=0.03$) for 2000 kcal/day.

Discussion

Malnutrition is an important clinical predictor of disease progression and treatment in cancer patients⁽³²⁾. A large number of cancer patients need liquid diet during the course of treatment. Of the common cancers in the LMICs, head and neck cancers are one of the commonest cancers treated usually with CTRT. These patients often need liquid diet because of dysphagia or due to treatment related acute mucositis. Similar problems could be experienced in esophageal neoplasms depending on the grades of their dysphagia. In head and neck cancer, patients suffer from weight loss and moderate to severe malnutrition after radiotherapy (RT)⁽³³⁾. Malnutrition also leads to anemia, decreased immunity and low body protein content. On the other hand, patients of head and neck cancer on radiotherapy, whose daily protein and calorie requirement are maintained, are reported to experience lesser severity of treatment related morbidity from both RT and CTRT^(34,35).

Zahn *et al.*⁽³⁴⁾ evaluated the relation of protein and caloric intake to the severity of oral mucositis in patients of head and neck receiving RT to a dose to >60 Gy in 40 evaluable patients followed up for 2 years. In a multivariate analysis, the sole nutritional predictor of reduced severity of oral mucositis was adequate intake of proteins ($p=0.01$).

Cereda *et al.*⁽³⁵⁾ reported that whey protein isolate supplementation improves treatment tolerance in malnourished advanced cancer patients undergoing chemotherapy and reduces the risk of chemotherapy induced toxicity. In a randomized controlled clinical trial, patients who received whey protein supplementation, experienced a significant reduction in the risk of chemotherapy toxicity (risk difference, -9.8% [95% CI, -16.9 to -2.6]; $p = 0.009$) and severe (grade ≥ 3) events (risk difference, -30.4% [95% CI, -44.4 to -16.5]; $p = 0.001$).

Nutritional interventions are thus important to maintain nutritional requirements in cancer patients. Using oral nutritional supplements (ONS) could be one of the plausible ways. In a review of 84 clinical trials totaling 2,570 patients, ONS was found to provide macronutrients, essential vitamins, minerals and trace elements⁽³⁶⁾. Homemade supplements were used in four studies. The study suggested that ONS provides benefits to especially those with body mass index (BMI) $< 20 \text{ kg/m}^2$.

It becomes quite challenging to maintain the nutritional status in patients who are solely on liquid diet. Commercially available preparations are commonly prescribed and significant amount of these may be needed to fulfill the daily dietary requirement. The compliance of these would not only depend on the patient's acceptability to such formulations but also to the cost factor in cases where the patients must pay for these supplements without any reimbursement.

In LMICs, patients are already undernourished and often must meet the treatment expenses out-of-pocket. Thus,

patients could often find it difficult to bear these expenses to maintain their nutritional status which results in poor outcomes. In some situations, the patient could be the sole bread earner of the family and must not only meet the treatment expenses but also take care of the needs of the family. Thus, nutritional supplementation often takes a back seat. The cost could act as a likely deterrent for these patients to take the prescribed amount of these supplements to meet their daily requirements. This severely impacts the treatment compliance and directly exerts a negative influence on the therapeutic outcomes.

The homemade recipes could be easily formulated depending on the availability, local customs food habits and could be personalized to the patients need. As evident from this study, ingredients that are commonly used locally by patients have been used to create a recipe meeting the requirement of $\approx 2,000 \text{ kcal}$ and $\geq 90 \text{ gm}$ of protein. Cost of commercial nutritional supplements could be prohibitive and be 4.8 to 22.2 times to that of homemade recipes.

As a proportion of patients could be both vegetarian and nonvegetarian, the formulations have been tailored respecting the patient's individual preferences. Further, it also allows a mix and match and thus makes it more palatable and acceptable to the patients. In case, patient has a preexisting morbid condition, like diabetes, the recipe could be modified with the help of a dietician. The formulation suggested is made of easily available local ingredients which are cheaper and high in calorie and protein content. Use of this diet in cancer patients on liquid diet during treatment would improve outcomes and would also be a cost-effective way.

Thus, in LMICs, it's important to provide a personal homemade dietary formulation that could be easily acceptable, available, cheap and also meet the required dietary requirement. This may be supplemented using commercial nutritional formulations if needed. Nutritional status of a patient is one of the key parameters that allows a clinician to decide on the treatment strategy. It is therefore of paramount importance to focus on nutritional aspect of each patient with the help of a diet counselor. They could guide the patients and help them create their own preferred recipe that meets the desired caloric and protein intake and is also cost-effective.

Conclusion

Nutrition often takes a back seat in the management of cancer patients as emphasis is laid on the therapeutic options best suited for a patient's disease state. Nevertheless, it plays an important role to define outcomes in cancer patients, especially in patients who are already malnourished and thus vulnerable to further deterioration due to their disease or treatment related morbidities^(34,35). Thus, if the 2030 Agenda for Sustainable Development Goals of the United Nations have to be met to reduce the premature mortality of all noncommunicable diseases, including cancer by one-third, it's not

only important to create adequate treatment facilities including RT infrastructure in LMICs, but also to take care of the nutritional status in these patients.⁽³⁷⁾ The homemade dietary formulations could be a cost-effective option in patients on liquid diet and could be designed on a personalized manner depending on patient's choice, acceptance, and affordability. Commercial formulations could be used purely as supplements to these homemade recipes. The role of dietary counselors in these cases cannot be underestimated and should always be an integral part of the multidisciplinary team.

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Conflict of interest

Authors have no conflict of interest to disclose.

Ethical statement

All analysis in this study did not include data related to individual subjects and hence did not warrant necessity for obtaining ethical clearance.

Data availability statement

Datasets generated and analyzed in this study are available from the corresponding author upon request.

Authors Contribution

Pallavi Kalbande: Investigation, Resources, Writing-original draft, Methodology; **Pournima Kale:** Investigation, Resources, Writing-original draft, Methodology; **Payal Rangari:** Resources, Writing-original draft, Methodology; **Niloy R. Datta:** Conceptualization, Methodology, Formal analysis, Writing-Review and Editing, Visualization, Supervision.

Abbreviations

LMICs, low-middle-income group countries; RT, radiotherapy; CTRT, concurrent chemoradiotherapy; ONS, oral nutrition supplement; CI, confidence interval; INR, Indian National Rupee

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