Nutritional quality of a ready-to-use food, and its acceptability to healthy and HIV-infected children receiving antiretroviral treatment

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Abstract

Objectives: The objectives of this study were to determine the nutritional quality of a ready-to-use food (RUF), and its acceptability to children who were "healthy" and to those who were human-immunodeficiency virus (HIV)-infected and receiving antiretroviral therapy (ART).

Design: This was a cross-sectional survey that assessed the consumer acceptability of the RUF by the children.

Setting and subjects: One hundred and eighty-eight children were selected from six schools, a day care and a hospital in Pietermaritzburg. Of these children, 123 were "healthy", and 65 HIV-infected and receiving ART.

Outcome measures: The outcome measure of the study was the nutritional quality of the RUF in terms of its nutrient levels relative to appropriate nutritional standards, and its acceptability rating by the children.

Results: The RUF had appreciable levels of energy (2 624 kJ/100 g) and protein (15.7 g/100 g).The nutritional composition met the World Health Organization/World Food Programme/the United Nations Standing Committee on Nutrition/The United Nations Children's Fund recommendations for an RUF regarding energy, protein and essential amino acid levels. Sensory evaluation indicated that the RUF was acceptable to both children who were healthy and to those who were HIV-infected. Generally, more than 75% of the participants in both groups rated the product overall as "good". More than 65% of the children liked the taste, smell and mouth feel.

Conclusion: The RUF that was used in this study is a good source of energy and quality protein, and is acceptable to children. Further micronutrient analysis would determine the additional role of the RUF in alleviating micronutrient deficiencies, including vitamin A, zinc and iron. Since the RUF is acceptable to children who were healthy and to those who were HIV-infected on ART, it can be used to address protein-energy malnutrition in these target groups.

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Introduction

Currently, South Africa is experiencing both over- and undernutrition in its population. The 2005 National Food Consumption Survey-Fortification Baseline indicated that 18% of children between the ages of one and nine years were stunted.[1] The situation has not improved much. According to the 2013 South African National Health and Nutrition Examination Survey report, the prevalence of stunting was 15.4%, with severe stunting of 3.8%, wasting and severe wasting of 2.9 and 0.8%, respectively, and of underweight and severe underweight of 5.8% and 1.1%.[2] Common observed nutritional deficiencies in South African children are not limited to protein and energy deficiency. They also include micronutrient deficiencies, i.e. vitamin A, iron and zinc deficiency. At the same time, sub-Saharan Africa, particularly South Africa, currently has the highest number of children who are infected with human immunodeficiency virus (HIV) and acquired immune deficiency syndrome (AIDS) in the world.[3]

There is a direct link between HIV infection and malnutrition.[4] Despite tremendous advances in care for HIV infection and increased funding for treatment, morbidity and mortality due to HIV/AIDS in developing countries remains unacceptably high. A major contributing factor is that 1 800-million people remain chronically undernourished globally, and the HIV epidemic largely overlaps with populations that are already experiencing low diet quality and quantity.[4] Poverty and HIV/AIDS are interwoven. They have a complex bidirectional relationship that has been confirmed over the years.[5] Therefore, the high prevalence of undernutrition in South African children is consistent with the findings of local studies that show that a diet that is insufficient in both nutrient quality and quantity can be ascribed mainly to poverty and the HIV/AIDS pandemic.[6] The lack of appropriate intervention strategies in a population with a high prevalence of malnutrition, whether it relates to HIV or not, has led to the development of ready-to-use foods (RUFs) to address

malnutrition, and also in emergency disaster situations, such as famines.[7]

The use of RUFs in non-emergency situations and in the context of poverty and HIV/AIDS[3] has been found to be highly effective in alleviating malnutrition in developing countries, especially in sub-Saharan Africa, where there is a basic lack of health services.[8] The high and consistent success of RUFs in alleviating malnutrition has been ascribed to a number of factors, including the high-nutrient density of most of the products, they facilitate the treatment of protein-energy malnutrition and micronutrient deficiencies; the associated simplicity in delivering RUF-based nutrition rehabilitation programmes and fast recovery effects; the stability of the products at various temperatures and conditions; wide cultural acceptability; and adjustability to meet local nutritional needs and taste preferences.[8,9]

One such RUF, developed locally, has been used successfully for more than a decade. Unfortunately, substantiation of its use is still advocated purely based on anecdotal rather than scientific evidence. At the time of its development, there was not much opportunity for the product to be subjected to scientific scrutiny. AIDS-related weight loss and resulting malnutrition was the primary focus of clinical practitioners who had to deal with large numbers of dying patients. At the turn of the century (2000), 42 749 children under five years of age had died of HIV and AIDS alone, and an additional 4 564 of protein-energy malnutrition.[10] The development of the product was driven by need, and based on its success, arrived in the market without having received the necessary scientific backing. In addition, neither its nutritional quality nor consumer acceptability had been investigated under controlled conditions. Therefore, it is now necessary to evaluate whether or not the product meets the recommended nutritional quality of a RUF.

Furthermore, individuals who are HIV-infected and on antiretroviral therapy (ART) may perceive or accept food differently to healthy individuals, either because of their compromised physiological condition or the metabolic effects of their drugs.[11] Most complications associated with ART relate to nutrition in some way, or require nutrition management. Expected complications mainly occur because of acute interactions of the drug regimens with some nutrients, as well as chronic metabolic disturbances which occur over time. Other acute side-effects, such as nausea, diarrhoea, bloating, taste disturbances, gastrointestinal, appetite suppression, the inability to eat food secondary to complicated medical regimens, or fatigue, as well as the presence of opportunistic infections, could impair food intake or be detrimental to the patient.[11,12] Therefore, malnutrition is still a risk in patients who are treated with ART, and the need for appropriate RUFs still exists, even in the presence of ART.

The research reported in this article formed part of a comprehensive study[13] which investigated the nutritional quality and consumer acceptability of a RUF that is widely used, but which has never before been investigated under scientific conditions.

Method

This study comprised two parts, namely the nutritional analysis of four batches of a RUF (the name of the RUF has not been included for commercial purposes), and a sensory evaluation that measured the consumer acceptability of the RUF in children who were "healthy" and in those who were HIV-infected and receiving ART.

Data collection

Nutritional analysis

The RUF that was used in this study is a paste-like substance, with soy and peanuts as base ingredients. It was supplied by a South African nongovernmental organisation, Gift of the Givers. A smooth commercial peanut butter was used as a control, as both the peanut butter and RUF are peanut pastes and have similar physical properties. Two samples of the RUF were selected from four different batches manufactured in 2010 and 2011. Two samples of peanut butter of the same brand were randomly selected from a local supermarket. The samples were sent to a laboratory for analysis. Gross energy, crude protein, crude fat, fibre, ash (total mineral content) and the moisture content of the food samples were determined according to the methods of the Association of Official Analytical Chemists.[14] The amino acid profile of the samples was analysed by the well known PicoTag method (a reverse-phase high-performance liquid chromatography method), as described by Bidlingmeyer, Cohen and Tarvin.[15]

Sensory evaluation

The target population for this study included children aged 4-17 years, who were assumed to be either "healthy" or at risk of and/or already experiencing malnutrition. Consequently, children who were HIV-infected and on ART were identified as a group of children who were more likely to develop malnutrition and to use the product. Children who were HIV-infected and on ART were compared to a group of "healthy" children in order to determine the effect of health status on the acceptability of the RUF. For the purposes of this study, apparently "healthy" children were defined as children who had not been ill in the past seven days, were not taking any chronic or acute medication, and who were not HIV-positive, nor suffering from any disease.

Children who were present in the antiretroviral clinic of the hospital on the days that the study was conducted were invited to participate. The apparently "healthy" study participants were recruited from six quintile 4 and 5 schools and a day care in an urban area. It was anticipated that the children attending the higher quintile schools would have the lowest risk of malnutrition. Three children from each grade and children over the age of four years at the day care were invited to participate. The study participants were selected on the basis of being peanut butter consumers, and were therefore assumed not to have a peanut allergy and thus able to consume the RUF.

The consumer acceptability of the RUF was determined using a standard consumer acceptance test, in the form of a five-point facial hedonic rating scale. This scale was used to measure the taste, smell, colour, mouth feel and overall acceptability of the RUF. Additional information on age, race and gender, together with the most and least liked attributes by the participants was also collected. Validity was tested through the use of an expert panel of academics working in Food Science and Dietetics at the University of KwaZulu-Natal.

Table I: Nutritional composition of the ready-to-use food per 100 g sample*,**

Descriptor	Gross energy (kJ)	Protein (g)	Fat (g)	Fibre*** (g)	Ash (g)	Carbohydrates**** (g)
Batch 1	2 640	15.7	42	1.3	3.6	36.9
SD	2	0.2	0.8	0	0	0.5
Batch 2	2 604	16	39.4	1.6	3.7	36.9
SD	5	0.3	0.3	0.1	0.1	1.3
Batch 3	2 630	14.7	39.8	1.2	3.6	39.2
SD	3	0.3	0.4	0.1	0.1	0.9
Batch 4	2 621	16.2	38.9	1.5	3.4	39.4
SD	15	0.2	1.1	0.1	0	0.7
Grand mean	**2 624**	**15.7**	**40.1**	**1.1**	**3.6**	**38.1**
SD	15	0.6	1.4	0.2	0.2	1.4
CV (%)	1	4	3.5	15.5	4.1	3.8
Peanut butter	2 852	25.4	43.2	6.2	2.6	22.2
SD	12	0.1	0.4	0.6	0	0.1

SD: standard deviation; CV: coefficient of variation
*Mean values (n = 2)
**As is weight basis
***Neutral detergent fibre, i.e. indigestible, nitrogenous matter and cell wall constituents (cellulose, lignin, and silica and hemicelluloses)
****Glycaemic carbohydrates

Table II: Nutritional composition of the ready-to-use food compared to the World Health Organization/World Food Programme/the United Nations Standing Committee on Nutrition/United Nations Children's Fund recommendations for ready-to-use foods (100 g serving of sample)

Nutrient	RUF*	WHO/WFP/SCN/UNICEF recommendations
Energy (kJ)	2 624	2 176-2 302
Protein (% total energy)	10	10-12
Fat (% total energy)	58	45-60
Moisture (%)	0.6	< 2.5

WFP: World Food Programme, WHO: World Health Organization, RUF: ready-to-use food, SCN: Standing Committee on Nutrition (United Nations), UNICEF: United Nations Children's Fund
*Calculated using the grand mean from Table I

Data analysis

Results were analysed using Predictive Analytic Software® 18. Appropriate statistical methods were used to analyse the data, including descriptive statistics, the measurement of the coefficient of variation percentage and chi-square tests. Statistical significance was measured at the p-value < 0.05 level.

Ethical considerations

Ethical clearance for this study was obtained from the University of KwaZulu-Natal (HSS/0375/011M) Humanities and Social Science Ethics Committee. Permission was also obtained from the KwaZulu-Natal Department of Health (HRKM 15/12) and the Provincial Department of Education (2/4/8/68). Written consent was obtained from the parents of the children who participated in the study.

Results

Nutritional composition of the ready-to-use food

The nutritional composition of the RUF is presented in Table I. There were slight variations in the fibre content of the different batches (15.5%). The grand means of the nutrient values of the RUF, compared with the corresponding nutrient values of the commercial peanut butter (control), indicated that the RUF contained more ash and carbohydrate, but less energy, protein, fat and fibre.

Table II presents the nutritional composition of the RUF compared to the World Health Organization (WHO), World Food Programme (WFP), The United Nations Standing Committee on Nutrition (SCN) and the United Nations Children's Fund (UNICEF) 2007 recommendations for a RUF.16 The RUF in this study contained more than 14% of the energy content stipulated in these recommendations.

Table III: Percentage distribution of nutrients supplied by 50 g of the ready-to-use food to an individual between the ages of one and 18 years[17]

Age (years)	Energy EER (kJ/day)*	% EER met	Protein RDA (g/day)*	% RDA met	Carbohydrate RDA (g/day)*	% RDA met	Fat AMDR (g/day)*	% AMDR met	Fibre AI (g/day)*	% AI met
Males										
1-3	4 377	30	13	60	130	15	30-40	50-67	19	3
4-8	7 289	18	19	41	130	15	25-35	57-80	25	2
9-13	9 535	14	34	23	130	15	25-35	57-80	31	2
14-18	13 188	10	52	15	130	15	25-35	57-80	38	1
Females										
1-3	4 151	32	13	60	130	15	30-40	50-67	19	3
4-8	6 870	19	19	41	130	15	25-35	57-80	25	2
9-13	8 665	15	34	23	130	15	25-35	57-80	26	2
14-18	9 908	13	46	17	130	15	25-35	57-80	26	1

AI: adequate intake, AMDR: acceptable macronutrient distribution range, EER: estimated energy requirement, RDA: required dietary allowance

Table IV: Association between health status, gender and the acceptability of the sensory attributes of the ready-to-use food

Sensory attributes	Health status			Gender			p-values*
	"Healthy" % (n = 123)	ART % (n = 65)	Total % (n = 188)	p-values*	Male % (n = 94)	Female % (n = 94)	
Taste							
Bad	3.3	13.9	6.9	< 0.01	9.6	4.2	0.45
Neutral	17.9	1.5	12.2		9.6	14.9	
Good	78.9	84.6	80.9		80.9	80.8	
Smell							
Bad	5.7	13.8	8.5	0.15	5.3	11.7	0.06
Neutral	13.8	6.2	11.2		16.0	6.4	
Good	80.5	80	80.3		78.7	81.9	
Colour							
Bad	23.6	15.4	20.7	0.00	19.1	19.1	0.56
Neutral	31.7	6.2	22.9		24.5	24.5	
Good	44.7	78.5	56.4		56.4	56.4	
Mouth feel							
Bad	15.5	21.5	17.6	0.03	17.1	18.1	0.80
Neutral	17.9	6.2	13.8		14.9	12.8	
Good	66.7	72.3	68.6		68.1	69.1	
Overall liking							
Bad	6.5	13.9	9	0.02	8.5	9.6	0.62
Neutral	11.4	7.7	10.1		7.4	12.8	
Good	82.1	78.5	80.9		84.1	77.6	

ART: antiretroviral therapy
*Differences based on the chi-square test

The percentage nutrient contribution that 50 g of the RUF (recommended serving size) provides was compared to the estimated energy requirement (EER), required dietary allowance (RDA), acceptable macronutrient distribution range and adequate intake levels for an individual between the ages of one and 18 years (Table III). The estimated protein contribution of the RUF to the diet of children decreased with an increase in age.

When the RUF was compared to the Food and Agricultural Organization (FAO) of the United Nations/WHO pattern of amino acid requirements, it was found to contain twice the amount of histidine and the aromatic amino acids, phenylalanine and tyrosine. Also, the amount of isoleucine, threonine and valine was approximately 1.5 times that of the FAO/WHO pattern of amino acid requirements. Consuming 50 g of the RUF was estimated to provide more than 55% of the FAO/WHO recommended amino acid patterns for children aged 1-2 years.

Sensory evaluation results

Consumer demographics

The consumer panel consisted of 188 children (123 "healthy" children and 65 children receiving ART). The age range was 4-17 years, with a mean age of 11.5 years in the "healthy" category, while the age range was 4-14 years, with a mean age of 8.8 years in the ART group.

Association between consumer demographics and the acceptability of the ready-to-eat food

Subjects were asked to rate the taste, smell, colour, mouth feel and overall acceptability of the RUF as either "super bad", "bad", "maybe good or maybe bad", "good" or "super good". These results were then conflated into three categories of "bad", "neutral" and "good". The association between health status, gender and the consumer acceptability of the RUF is presented in Table IV. Generally, more than 75% of the participants in both the healthy and the ART group rated the product to be "good" overall. More than 65% of the children from both groups rated the taste, smell and mouth feel of the product as "good". More children in the ART group liked the sensory attributes of the RUF, compared to those in the healthy group. However, more healthy children rated the overall acceptability of the product higher than that of the ART group. No significant differences were observed in the rating of smell of the product.

Table V presents the consumer acceptability of the RUF according to consumer demographic groups. The taste, smell, mouth feel and overall liking were perceived to be "good" (mean of 4) by both the healthy and the ART group (p-value > 0.05). The acceptability of the RUF was not affected by age or gender (p-value > 0.05).

Table V: Consumer acceptability of the ready-to-use food according to consumer demographic groups*

Demographic groups	Taste		Smell		Colour		Mouth feel		Overall liking	
	"Healthy"	ART	"Healthy"	ART	"Healthy"	ART	"Healthy"	ART	"Healthy"	ART
Overall mean	4.1	4.1	4	3.9	3.4	3.8	3.8	3.7	4.1	3.8
Age										
4-11	4.3	4	4.2	3.9	3.6	3.7	4.2	3.6	4.4	3.8
12-18	4	4.2	3.8	3.9	3.2	4.2	3.5	3.8	3.9	3.9
Gender										
Male	4.2	3.8	4	3.7	3.4	3.6	3.9	3.4	4.3	3.7
Female	4.1	4.3	4	4	3.3	4	3.7	3.9	4	3.9

ART: antiretroviral therapy
* Means are reported (1 = "super bad", 2 = "bad", 3 = "neutral", 4 = "good", 5 = "super good"

Discussion

The purpose of this study was to investigate the nutritional quality and consumer acceptability of a RUF that is widely used, but which has never been investigated under scientific conditions.

Nutritional quality of the ready-to-eat food

The RUF had an energy content that was higher than that of the other RUFs that are available locally (Imunut®), and internationally (Plumpy'nut®, Nutributter® and RUCF India).[18,19] The high energy content of the RUF was largely owing to its high-fat content when compared with that of Imunut® Plumpy'nut, Nutributter® and RUCF India. The energy content of the RUF was also within the WHO/WFP/SCN/UNICEF recommendations used for classification as a RUF. This indicates that the RUF used in this study is able to meet the high energy needs of malnourished children effectively, similar to other available RUFs, such as Imunut®. The finding that the estimated contribution of 50 g of the RUF to the EER for healthy children between the ages of one and 18 years decreased with increasing age suggests that the amount of RUF consumed by children needs to be age specific. Therefore, the amount of RUF consumed should be increased as the age of the child advances. That way, the product will contribute significantly to the diet of child. However, it may not be financially feasible to consume more than 50 g of the RUF per day. (Its current retail price is R60/500 g).

The higher carbohydrate content of the RUF, when compared to that of the peanut butter, could be owing to the addition of sugar and soya to the product. Soy-peanut pastes have been reported to have a higher carbohydrate content when compared to that in a peanut butter-based product. The carbohydrate content in soya beans and peanuts is estimated to be approximately 26% and 19%, respectively.[20] The high carbohydrate content of the RUF, when compared to the protein content, allows the body to use the carbohydrate for energy as it is the preferred source thereof. The carbohydrate content stated on the label was higher than the actual measured carbohydrate content reported in this study (by 9.7 g). This could be because of different laboratory techniques and equipment.

The protein content of the RUF was slightly higher than that in other available RUFs, such as Imunut® Plumpy'nut®, Nutributter® and RUCF India,[18,19] which may be attributed to the addition of higher number of protein-rich ingredients (such as soya), than that in other available RUFs. The protein content of the RUF was within the WHO/WFP/SCN/UNICEF recommended range for RUFs, indicating that this product has the potential to be used to alleviate protein deficiency. This potential is further supported by the amino acid profile of the RUF, which showed that the amino acid scores of the product generally met the WHO/FAO standards.

Consumer acceptability of the ready-to-use food

The RUF was acceptable to the children in this study, which is in agreement with what has been documented in the literature about the consumer acceptability of RUFs. Generally, RUFs have been reported to be acceptable to both children and their mothers, regardless of the type of RUF and methodology used.[21-23] Comments made by the children in this study indicated that they perceived the RUF to be a form of a peanut butter. However, this could be a study limitation because only peanut butter consumers were included in this study, and this may have contributed to the high acceptability of the supplement. Its sweet taste may be another factor that may have increased the acceptability of the RUF. Parker et al[23] reported that mothers thought that their children liked RUFs because they have a sweet taste. The high acceptability of sweet foods by children has been associated with a genetic predisposition to a preference for sweet tastes.[24]

People who are HIV-infected have been reported to suffer from altered taste perception.[25] A common complaint is an unusual taste.[25] However, in this study, the taste of the RUF was highly acceptable to children who were "healthy" and also to those who were HIV-infected. This may be because the effect of HIV and ART on the taste perception was minimal. The smell of the RUF was also acceptable to children who were "healthy" and to those who were HIV-infected. This contrasts with common complaints made by people who are HIV-infected about the poor aroma of food. People who are HIV-infected report decreased smell sensitivity.[25] The high acceptability of the smell of the RUF may have been because of its strong nutty aroma. The mouth feel of the RUF was acceptable to children who were healthy and to those who were HIV-infected, despite the children describing the mouth feel to be "grainy", "sandy" or "rough". Children between the ages of 12 and 18 years in the "healthy" group neither liked nor disliked the colour of the RUF, and those between the ages of 4 and 11 years thought that it was "good". The age of the children had no effect on the colour acceptability of the RUF by the children who were HIV-infected. Making a comparison about the colour acceptability of the RUF by the children who were healthy, and

between those who were HIV-infected, should be carried out with caution. This is because the number of children in this age category was low in the children who were HIV-infected group, compared to that in the healthy group. Overall, the high acceptability of the RUF indicates that the product can be used effectively for the nutrition rehabilitation of children who are healthy, as well as for those who are HIV-infected and on ART.

Conclusion

The findings of this study indicate that the nutritional composition of the RUF that was tested in this study is sufficient in energy and protein for children aged 1-8 years. It does not contain sufficient energy and protein to meet the RDAs of older children (aged 9-18 years). However, the RUF is only intended as a supplement to a diet in this age group, to help individuals to meet their nutrient requirements in times of need. Moreover, in severe cases, more of the RUF can be recommended for older children and adults. The total mineral content of this product is also within the WHO/WFP/SCN/UNICEF recommended range specified for RUFs, which provides an additional possible avenue for this product to be used to alleviate selective mineral deficiencies. However, further research is required in this regard.

The acceptability of the RUF to the children was thought to be mainly because of its sweet taste and the perception that the RUF was a peanut butter. This is in agreement with reports found in the literature which indicate that RUFs are generally acceptable to children. The finding that acceptance of the RUF by the children who were HIV-infected and receiving ART was similar to that of the "healthy" children was encouraging. Finding appropriate products that are acceptable to consumers who perceive and accept food differently to healthy individuals, such as those on ART, could further assist in the fight against malnutrition in these high-risk groups.

Recommendations

The digestibility of the protein in the RUF should be determined to obtain more data on protein quality. A profile of the specific micronutrients needs to be analysed in order to determine the additional role of the RUF in alleviating common micronutrient deficiencies, such as vitamin A, zinc and iron deficiency. More consumer acceptability studies need to be conducted in other provinces of South Africa to factor in the cultural variations outside and within the different provinces. Also, studies can be conducted to determine the efficacy and appropriateness of the RUF in alleviating malnutrition, including protein-energy malnutrition, in the South African context. Factors such as cultural background, feeding practices and stigmatisation could affect the consumption and use of this RUF in the community.

Conflict of interest

No conflict of interest is declared.

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