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Efficacy of the African Breadfruit (Treculia africana) in the Nutritional Rehabilitation of Children with Protein-energy Malnutrition

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Summary

Runsewe-Abiodun I, Olowu AO, Olanrewaju DM, Akesode FA. Efficacy of the African Breadfruit (*Treculia africana*) in the Nutritional Rehabilitation of Children with Protein-energy Malnutrition. *Nigerian Journal of Paediatrics* **2001; 28:128.** One hundred and fifty children with mild to moderate malnutrition (Group A) aged six to 66 months were recruited from four semi-urban/rural communities within Ikenne Local Government Area of Ogun State. They were offered supplementary feeds of African breadfruit (*Treculia africana)* porridge for a period of 12 weeks. Their anthropometric response to the feeds was compared with that of controls who were not offered the feeds and consisting of (a) 106 well-nourished children of the same ages recruited from within the same communities (Group B), and (b) 53 other children (Group C) of similar ages with similar grades of malnutrition. Observed prevalence of malnutrition in the study population ranged between 51.5 per cent and 64 per cent. No case of kwashiorkor was observed. During the study period, the mean weight gain of children in Group A was at 2.78kg ± 1.16, significantly greater than corresponding figures of 0.18kg ± 1.26 and 0.25kg ± 0.91 in Groups B and C, respectively ($p = 0.0000$). However, the nutritional supplementation did not significantly affect the heights ($p = 1.000$). An improvement in the mid-upper arm circumference (MUAC) was observed in children in group A who gained a mean of 1.10cm during the study; this gain was 16 times and twice the mean gains by Groups B and C, respectively. The breadfruit porridge was found to be acceptable to 96.7 per cent of group A children, and no adverse reactions were reported or observed. African breadfruit is thus suggested as a good, locally available and acceptable food of high nutritive value in the nutritional rehabilitation of children with mild to moderate protein-energy malnutrition.

Introduction

PROTEIN energy malnutrition (PEM) ranks among the commonest childhood diseases in tropical Africa.[1] Singly or in combination with other diseases, PEM is one of the leading causes of childhood morbidity and mortality.[2-4] Fifty-two per cent of all under-five deaths are associated with PEM while 48-80 per cent of these deaths are in children with mild to moderate malnutrition.[5] Although various workers have shown that the pathogenesis of PEM, especially, kwashiorkor, involves more than the child's nutritional intake, [6,7] there is no doubt that the clinical condition in this disease improves with appropriate dietary therapy.[8]

Ignorance and poverty are key factors in the aetiology of PEM,[9] hence it has become necessary that we look inward at our local diets especially those that are sources of good quality protein with a view to ascertaining their efficacy in the prevention and/or rehabilitation of cases of PEM. Some of the local diets, which are not alien to the adult populace, whose method of preparation is well known and which abound everywhere, are however, still neglected due to inadequate knowledge of their nutritional values. One of these is the African breadfruit (*Treculia africana*), which is variously known as "*Afon*" in the south-west of Nigeria and "*Ukwa*" in the south-east of Nigeria. The tree grows wildly in these localities although it can be cultivated. Seed production from the African breadfruit is enormous; a mature tree produces up to fifty fruits annually with each fruit yielding from five to ten kilograms of seeds after processing. Its fruiting is seasonal (March

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to April) but the processed seeds are usually stored all year round in its dried form after processing. The seeds are often sold in the local markets using local measuring bowls, or cooked and hawked in porridge or sauce forms. It is eaten in several forms as porridge, sauce or boiled, roasted and as dessert-nut. The seeds can be milled and the powder used in preparing breadfruit cakes. Various laboratory studies have established the nutritive value of African breadfruit.[10-13] In a study, the "cooked *Afon* diet" yielded 417 kilocalories per 100 grams dry matter, 17.56 per cent of this coming from protein.[10] Its malting characteristics have been studied,[14] its possible use in poultry diets is being studied,[11] but its use in human nutritional rehabilitation has not been explored. In view of the fact that this fruit of nutritive value is readily available in our environment, we recently studied its efficacy in the nutritional rehabilitation of children with protein-energy malnutrition.

Subjects and Methods

The study was a prospective community based nutritional intervention study. It took place in five of the 11 communities that made up the Ikenne Local Government Area of Ogun state viz: Ode-remo, Isara, Irolu, Ipara and Orile-oko. The study involved 150 children aged six to 66 months with mild to moderate malnutrition according to Bengoa classification.[15] They were recruited consecutively from four contiguous communities. They were labelled Group A and were offered nutritional advice plus nutritional supplementation with a local diet – the African breadfruit "(*Afon*)" three times per week while they continued with their normal diets at home. They were compared with two groups of controls. The first (Group B) consisted of 106 age and sex-matched well-nourished children recruited from within the same communities; this group received only nutritional advice and also continued with their normal diets at home. The second control group (Group C) comprised 53 children who also had mild to moderate malnutrition, and were recruited from a community that was not contiguous with the other four. This was in order that the knowledge of the nutritional supplementation could be kept hidden from them. They were neither offered the African breadfruit nor was any mention of it made while giving them nutritional advice. They however, continued with their usual diets at home.

The nutritional rehabilitation and monitoring lasted for 12 weeks in each of the study groups.

Feeding procedure

Group A

During the rehabilitation phase, subjects in this group were fed with the African breadfruit porridge three times a week for 12 weeks. The supplementation was based on a daily protein intake of 2gm/kg body weight.[16] The method of preparation of the breadfruit porridge was as described by Lawal,[10] and it had earlier been determined that 100g of the cooked breadfruit porridge would deliver 17.56g of protein.[10] The ladle used for serving in this study delivered about 100g of porridge and thus served as the unit of measurement. The absolute quantity offered each child was reviewed fortnightly as the weight changed.

Monitoring procedures

Group A

Children in this group were brought by parents/guardians to the clinic at two-weekly intervals for weighing and determination of mid-upper arm circumference (MUAC) and height. Those who did not keep appointments were traced to their homes and either weighed on the bathroom scales or brought to the clinic to be weighed on the beam balance scale.

Group B

Because these children were apparently well, it was difficult asking them to come to the clinic every other week. Hence, anthropometric measurements were taken at the beginning and at the end of the twelve weeks, only. This group of children however, had free treatment of minor ailments during the study period.

Group C

Due to the appreciable distance between the abodes of the authors and the Orile-oko villages (about 60 kilometres), in addition to poor accessibility of these villages during the rainy season, these mildly to moderately malnourished children were weighed and measured only at the beginning and at the end of the 12 weeks.

Data analysis

The EPI-INFO statistical software was used for data entry, validation and analysis. Each child was expected to have a minimum of 32 feeding entries to qualify for final inclusion in the data analysis. Measures of central tendency and of dispersion were computed for all quantitative variables, e.g. height etc. For categorical variables, frequency distributions were generated. Chi-squared test was used to test for association between categorical variables. The analysis of variance test (ANOVA) was used for the comparison of means. Where baseline measurements were compared with terminal measurements, the paired t-test was the test of choice. Correlation tests were undertaken between weight and mid-upper arm circumference. All statistical analysis was interpreted in a two-tailed fashion. Intergroup comparisons were made and level of significance was put at values less than five per cent.

Results

The mean ages for the three study groups were 33 months, 25 months and 27 months for Groups A, B and C, respectively. A total of 168 males and 141 females (ratio 1.2:1) completed the study in the three study groups.

Table I shows that there was no significant difference in the distribution of the nutritional status of children in Groups A and C ($P_3 = 0.25$). Children in Groups A and C were however, significantly different from those in Group B (P_2 and $P_4 = 0.000$, respectively). At the onset of the study, the mean weights of the children in group B were significantly higher than those of children in Groups A

Table I

Baseline Nutritional Status of Subjects and Controls

Percentage of Expected Weight for Age(WFA)	*Group A (Subjects)*	*Group B (Well nourished Controls)*	*Group C (Malnourished Controls)*
Moderate (WFA = 61%-75%)	50(33.3)	0(0.0)	23(43.4)
Mild (WFA = 76 %-89%)	100(66.7)	0(0.0)	30(56.6)
Normal (WFA =90%)	0 (0.0)	106(100)	0(0.0)
Total	150(100)	106(100)	53(100)

P_2 = P value of Gp A vs Gp B = 0.000
P_3 = " Gp A vs Gp C = 0.25
P_4 = " Gp B vs Gp C = 0.000
WFA = Weight for age expressed as percentage of standard
Figures in brackets are percentages of total

Table II

Baseline Mean Weights (kg) of Subjects and Controls

Age (mon)	*Group A (Subjects)*	*Group B (Well nourished Controls)*	*Group C (Malnourished Controls)*	*P Values*			
				P_1	P_2	P_3	P_4
6 - 11	7.22(1.5)	8.54(0.9)	5.77(0.9)	0.0000	0.0000	0.0029	0.0000
12 -17	7.55(1.9)	10.42(1.7)	8.95(2.2)	0.0007	0.0002	0.0812	0.0407
18 -23	8.31(2.7)	11.28(1.1)	8.95(1.2)	0.0131	0.0149	0.6663	0.0059
24 -35	9.63(1.9)	12.91(1.7)	10.22(0.4)	0.0000	0.0000	0.4907	0.0009
36 -47	11.01(2.7)	14.45(1.0)	11.24(1.8)	0.0000	0.0001	0.825	0.0000
48 -59	13.00(1.7)	15.75(1.8)	12.20(2.0)	0.0005	0.0006	0.2284	0.0004
60 -66	13.92(2.2)	16.25(2.7)	12.50(0.0)	0.0289	0.0382	0.2931	0.2568

P_1 = P value of Gp A vs Gp B vs Gp C
P_2 = P value of Gp A vs Gp B
P_3 = P value of Gp A vs Gp C
P_4 = P value of Gp B vs Gp C
Figures in brackets are standard deviations

Table III

Mean Weights (kg) 12 weeks after Nutritional Rehabilitation

Age (mon)	*Group A (Subjects)*	*Group B (Well nourished Controls)*	*Group C (Malnourished Controls)*	*P Values*			
				P_1	P_2	P_3	P_4
6-11	9.88(1.7)	8.60(0.9)	6.84(0.9)	0.0000	0.0024	0.0000	0.0002
12 -17	10.89(2.1)	10.97(1.8)	8.94(2.0)	0.0143	0.8912	0.0229	0.0063
18 - 23	11.00(2.6)	11.27(1.4)	8.75(0.7)	0.1285	0.7832	0.0438	0.0068
24 - 35	12.79(2.0)	13.14(2.1)	9.75(0.7)	0.0111	0.5654	0.0067	0.0041
36 - 47	12.96(2.8)	14.51(1.7)	11.24(2.4)	0.1176	0.0619	0.1515	0.0010
48 - 59	15.88(1.8)	16.08(1.9)	12.45(2.1)	0.0001	0.8412	0.0000	0.0021
60 - 66	16.21(2.2)	16.08(2.0)	13.00(0.0)	0.4334	0.8979	0.1917	0.2188

P1 = P value of Gp A vs Gp B vs Gp C
P2 = P value of Gp A vs Gp B
P3 = P value of Gp A vs Gp C
P4 = P value of Gp B vs Gp C
Figures in brackets are standard deviations

Table IV

Mean Weight Gains (kg) in Subjects and Controls

Age (mon)	*Group A (Subjects)*	*Group B (Well nourished Controls)*	*Group C (Malnourished Controls)*	*P Values*			
				P_1	P_2	P_3	P_4
6 - 11	2.67(0.8)	0.06(1.0)	1.07(5.0)	0.0000	0.0000	0.0000	0.0013
12 - 17	3.34(0.8)	0.55(0.7)	-0.01(0.5)	0.0000	0.0000	0.0000	0.0226
18 - 23	2.69(1.2)	-0.01(1.0)	-0.20(0.7)	0.0001	0.0001	0.0001	0.7394
24 - 35	3.16(1.1)	0.22(1.5)	-0.47(1.0)	0.0000	0.0000	0.0000	0.6668
36 - 47	1.95(1.2)	0.06(2.1)	0.00(1.0)	0.0001	0.001	0.0002	0.1942
48 - 59	2.88(1.2)	0.28(0.8)	0.25(1.2)	0.0000	0.0000	0.0000	0.9585
60 - 66	2.29(1.6)	-0.17(1.1)	0.50(0.0)	0.0053	0.0053	0.2748	0.6102

P_1 = P value of Gp A vs Gp B vs Gp C
P_2 = P value of Gp A vs Gp B
P_3 = P value of Gp A vs Gp C
P_4 = P value of Gp B vs Gp C
Figures in brackets are standard deviations

(at all age groups; $P_2<0.05$) and C (at all age groups [$P_4<0.05$] except 60-66 months) whereas the mean weights of children in Groups A and C were generally comparable ($P_3>0.05$) except at the age group 6-11 months (Table II). At the conclusion of the experimental phase however, the mean weights of Group A children became significantly higher than those in Group C ($P_3<0.05$) except in the age categories 36-47 and 60-66 months (Table III). In addition, the mean weights of children in Group A were now comparable to those of their Group B counterparts at all age categories ($P_2>0.05$) except 6-11 months age category where children in Group A weighed significantly more than their Group B counterparts (P_2 = 0.002). However, Group C children remained significantly lighter than those in Group B ($P_4<0.05$). The mean weight gain in each study group for the various age categories are shown in Table IV. The highest increases were noted in Group A children; these were significantly higher than the values observed in Group B ($P_2<0.05$) and Group C ($P_3<0.05$) except for those in the 60-66 months old category. The mean increases in Groups B and C were generally comparable in children aged more than 18

Table V

Means of Gains in Anthropometric Measurements

Anthropometric Measurements	*Group A (Subjects)*	*Group B (Well nourished Controls)*	*Group C (Malnourished Controls)*	*P Values*			
				P_1	P_2	P_3	P_4
MUAC (cm)	1.10(1.05)	0.07(1.67)	0.64(0.95)	0.000	0.000	0.000	0.023
Height (cm)	2.48(1.11)	2.48(1.48)	2.94(1.34)	0.0413	1.000	0.015	0.059
Weight (kg)	2.78(1.16)	0.18(1.26)	0.25(0.91)	0.000	0.000	0.000	0.720

MUAC = Mid-upper arm circumference
P_1 = P value of Gp A vs Gp B vs Gp C
P_2 = P value of Gp A vs Gp B
P_3 = P value of Gp A vs Gp C
P_4 = P value of Gp B vs Gp C
Figures in brackets are standard deviation

Table VI

Nutritional Status of the Subjects and Controls after 12 Weeks of Experimentation

Percentage of Expected Weight For Age (WFA)	*Group A (Subjects)*	*Group B (Well nourished Controls)*	*Group C (Malnourished Controls)*
Moderate malnutrition (WFA 61%-75%)	4(2.7)	0(0.0)	20(37.7)
Mild malnutrition (WFA 76%-89%)	26(17.3)	8(7.5)	22(41.5)
Normal (WFA =90%)	120(80.0)	98(92.5)	11(20.8)
Total	150(100.0)	106(100.0)	53(100.0)

P_2 = P value of Gp A vs Gp B =0.014
P_3 = P value of Gp A vs Gp C =0.000
P_4 = P value of Gp B vs Gp C =0.000
Figures in brackets are percentages of total

months (P_4>0.05). A paired t-test analysis on weight changes indicate highly significant weight gains in the Group A children after 12 weeks of dietary intervention.

The baseline MUAC measurements indicate that Group A children generally compared favourably with their counterparts in Group C (P_3>0.05) except in infancy where the figure for Group A children was significantly higher than that for Group C. The mean MUACs of children in Group B were significantly higher than those of Groups A and C children (P<0.05 in both cases). After 12 weeks of dietary intervention however, the mean MUAC values in Group A children closely approximated those of their Group B counterparts (P_2>0.05) with significant differences only still being observed between ages 12 and 17 months and between 24 and 35 months. Furthermore, the mean MUAC values in Group A children became significantly higher than those in Group C children at the extremes of the age brackets (P_3 <0.05). When compared with Group B however, the mean MUAC values in children in Group C remained significantly lower in children less than three years old. As shown in Table V, inter-group comparison of gains in the MUAC showed significantly higher gains in Group A when compared with Group B for all age categories (P_2 <0.05). However, significantly higher gains were noted only in children below the age of four years when Group A was compared with Group C (P_3<0.05). Paired t-test analysis revealed that children below the age of two years achieved significant gains in their MUAC in Group A.

At the beginning of the study, the heights of children in Group A were comparable with those of the children in Group C ($P_3>0.05$) except in children aged 6-11 months and generally significantly lower than in Group B children ($P<0.05$). Heights of children between 6-11 years were however, comparable in Groups A and B. Twelve weeks after the nutritional intervention in Group A, there were no significant gains in height.

Table V shows that there were significant gains only in the weights and MUAC of the children. Children in Group A gained significantly more weight and MUAC than children in Groups B and C (P_2 and P_3 <0.005, respectively). Significant correlation was found between the baseline weight and MUAC ($r=0.75$, $P<0.001$) and the final weight and MUAC ($r=0.33$, $P=0.001$). Overall, as shown in Table VI, while 80 per cent of the children in Group A attained weights for age above 90 per cent of expected weight for age at the end of 12 weeks of the study, only 20 per cent of the children in Group C fell into this category. The nutritional status of children in Group A approximated to that of the Group B children, as the P_2 value got less significant. The statistically significant difference in the nutritional status of Groups B and C children however, remained.

Discussion

This study has shown that the African breadfruit can be successfully used in the nutritional rehabilitation of children with mild to moderate protein-energy malnutrition. There were marked improvements in two of the anthropometric indicators in group A children following nutritional intervention. Similar to the experience of other workers,[17] the weight was the most sensitive indicator with the most remarkable changes. The mean weight gain of 0.23 kilogram per week with nutritional rehabilitation is similar to the findings of other workers.[18,19]

The rate of weight gain observed in this study is remarkable in many respects. First, the children involved were mildly to moderately malnourished with theoretically slower catch-up growth rate than severely malnourished children. Secondly, feeding took place at home, outside the strict supervision implied in hospital based studies. This remarkable weight gain may be attributed to many factors namely, the efficacy of the diet introduced during the study period, the motivation of the mothers to ensure proper feeding of the children, the presence of one of the authors in the community that ensured prompt medical service and the fact that the children were supplemented with calculated feeds so that they neither had too much or too little. The children below the age of one year in group A gained so much weight that they significantly exceeded that of the well-nourished children. This may be an indication that the African breadfruit could serve as a good complementary diet.

The group A children had a baseline mean MUAC percentage of 84.9 per cent. This was above the 80 per cent values set by the Wolaski year constant standard as normal. It was also clearly above the 60 per cent and 70 per cent standard set for marasmus and kwashiorkor, respectively. It is however, in keeping with earlier reports from Tanzania,[20] which observed that underweight children might have sufficient subcutaneous fat to give a relatively high arm circumference. However, the significant positive correlation between the arm circumference and the weight observed in this study is similar to earlier observations.[21-23]

Generally, the malnourished children in this study exhibited a low height for age (stunting) from the age of 18 to 24 months. This is similar to findings in earlier studies, which suggested that stunting does not become manifest until about the age of 24 months.[24] At the end of the experimental period, there was no significant differential increase in height among the three study groups. This is not unexpected considering the period of observation. It has been established that stunting takes a relatively longer time to reverse even with a favourable environment.[25] Since earlier studies [26] have however, suggested that malnourished children with adequate nutrient following rehabilitation can achieve normal height, the effect of the diet on height might have become manifest had the follow up period been much longer.

Anthropometrics is regarded as giving evidence of previous nutrition. A repeat survey after as little as three months of intervention, by indicating any improvement could give an assessment of the diet in the intervening period.[27] Hence, it can be concluded that the African breadfruit used in this study has proved highly efficacious in promoting growth of the children with mild and moderate malnutrition. Apart from being efficacious, there were no reports of adverse reactions. This is an advantage over some other proteinous food items, e.g cowpea and cow-milk, the ingestion of which has been reported to cause diarrhoea in some children;[28,29] the former as a result of the bulk effect of the cellulose covering and the latter due to lactose intolerance. Furthermore, the breadfruit was available, affordable and acceptable to the people whilst the children accepted it freely and often asked for more. In addition to these advantages, the place of health education as an integral part of nutritional rehabilitation would appear to have been established by the exercise, as 11 of the children in Group C who were not offered the supplement, attained normal weight for age within the three months. It is possible that the health education offered, contributed to the improvement in their nutritional status.

One can safely expect that the inclusion of the African breadfruit tree in the national afforestation programme, and the development of appropriate technology by Polytechnics and Institutes of Technology to mechanize the processing of "*Afon*" seeds would ensure large scale production of its seeds. This would make the African breadfruit more readily available with a resultant reduction in its price and consequent increased consumption by the populace, children inclusive.

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