# Sorghum in a Mixed Diet for Preschool Children. I. Good Acceptability With and Without Simple Reduction of Dietary Bulk†

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**Summary**

**The palatability and acceptability of sorghum based Faffa was evaluated in Ethiopian children aged 2–5 years. The Faffa was offered in sufficient amounts to make a significant contribution to the dietary intake of the children. The sorghum based Faffa was well accepted when offered as porridge, bread or pancake mixed with the traditional Ethiopian diet so as to contribute about 50 per cent of the daily protein intake. Bulk reduced Faffa porridge was prepared by adding porridge made from germinated (malted) sorghum to ordinary Faffa porridge. The bulk reduced porridge contained 25 per cent more Faffa flour compared to ordinary porridge though of similar consistency. However the mean daily intake of solid food was less in bulk-reduced Faffa (758 g) compared to ordinary Faffa (839 g) resulting in about the same average daily energy intake. This finding suggests that the children were able to adjust their energy intake by modifying their food intake.**

## Introduction

The Ethiopian weaning food Faffa has been modified in composition and wheat flour, which is mainly imported and expensive, has been substituted with locally produced sorghum flour.

The new sorghum Faffa‡ mixture, which is a dry blend has been evaluated nutritionally in preclinical tests as well as in children and has shown favourable results.[1] However, before being introduced to the market, such a new mixture should be evaluated for its palatability and acceptability when given to children for whom the product is intended.

Another aspect which has recently been emphasized in the etiology of Protein Energy Malnutrition (PEM) and studied mainly in connection with weaning foods is the concept of dietaty bulk and its importance in relation to child-feeding.[2–5] 'Dietary bulk' refers to factors that make it difficult for individuals to consume enough food to meet daily nutrient and energy requirements.

Weaning foods in most developing countries are based on starch-rich local staples such as cereal and root flours made into thin gruels with adequate feeding consistency, thus containing much water and large volume. If the amount of solids is raised to increase the nutrient and energy content, the gruel will be too thick and viscous. This high-volume/viscosity factor of a diet is referred to as 'dietary bulk' and is considered a major limitation in providing children with enough food in areas where starchy staples are the main foods.[6–9] This is even so when protein-rich supplements are added as in the case of faffa.

In attempts to find solutions to this problem the use of traditional food preparation procedures like germination has been shown to reduce the dietary bulk of cereal-based weaning foods considerably.[8] The starch structure of the cereal is modified by the action of amylases developed and activated during the germination process, which thus results in lower water-binding of the starch when prepared as gruels. Flour of germinated sorghum could be used as an additive ('power flour') to already prepared porridges[10] due to its high amylase content. The amylolytic activity of the germinated flour will rapidly reduce the viscosity of a thick porridge to produce a thin gruel acceptable to small children.

The objective of this voluntary intake study in pre-

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‡ Composition of sorghum faffa per 100 g: sorghum (Gambella 1107 variety) 57 g, chickpeas 18 g, defatted soy flour 10 g, dried skimmed milk 5 g, sugar 8 g, minerals and vitamins 2 g.

  

school children was therefore twofold: In the first study period, the palatability and acceptability of sorghum faffa was evaluated when faffa made a significant contribution to the ordinary diet of the children. In the second period of the study, an equivalent diet was served but, by adding germinated (malted) sorghum flour to all meals with faffa, porridges with reduced bulk were prepared. The aim was to increase the nutrient and energy density of the diet and to determine whether this treatment influenced the total amount of food consumed by the children.

### Children

The subjects were twenty preschool girls, aged from 2 to 5 years, living in a crowded room in a Children's home in Addis Ababa. Anthropometric and laboratory data are given in Table 1 for each child. Seven of the girsl were 'stunted', i.e. below −2 SD in height for age compared to Swedish standards. However, the children's ages were somewhat uncertain as they were born outside of the Children's Home without any birth certificates. All children were normal in weight for height, that is within 2 SD of Swedish standards.

Only three girls were free of intestinal parasites. The rest had ascariasis, strongyloidiasis, or hymenolepiasis, some of the girls having multiple infections with two or more parasites. All children with intestinal parasites were treated and showed no clinical sign of infection at the start of the study. Clinical check-ups and weight measurements were performed once a week throughout the study.

TABLE 1
*Anthropometric and laboratory data on the children in the food intake study*

| Subject No. | Age (yrs) | Weight (kg) | Height (cm) | MUAC* (cm) | Hb | ESR |
|---|---|---|---|---|---|---|
| 1 | 3 | 11.0 | 81.0† | 14.5 | 13.0 | 34 |
| 2. | 2 | 11.2 | 81.0 | 15.0 | 13.0 | 26 |
| 3. | 2 | 11.5 | 82.0 | 14.5 | 13.3 | 35 |
| 4. | $2\frac{4}{12}$ | 11.3 | 82.5 | 14.0 | 13.6 | 22 |
| 5. | $3\frac{8}{12}$ | 12.3 | 83.5† | 14.5 | 12.1 | 40 |
| 6. | $3\frac{10}{12}$ | 12.0 | 86.0† | 15.0 | 15.9 | 36 |
| 7. | 3 | 11.4 | 86.0† | 14.0 | 11.8 | 27 |
| 8. | $2\frac{6}{12}$ | 12.6 | 86.0 | 15.5 | 14.2 | 27 |
| 9. | $2\frac{2}{12}$ | 12.5 | 87.0 | 15.0 | 14.2 | 25 |
| 10. | $3\frac{4}{12}$ | 13.6 | 89.0 | 15.0 | 12.7 | 35 |
| 11. | $4\frac{4}{12}$ | 14.0 | 89.0† | 15.0 | 13.3 | 21 |
| 12. | $3\frac{9}{12}$ | 14.2 | 91.0 | 15.5 | 13.3 | 14 |
| 13. | 2 | 13.4 | 91.0 | 15.0 | 12.4 | 57 |
| 14. | $3\frac{9}{12}$ | 15.6 | 91.5† | 16.5 | 13.3 | 16 |
| 15. | $4\frac{8}{12}$ | 14.3 | 93.5† | 15.5 | 13.3 | 17 |
| 16. | 4 | 15.1 | 95.0 | 15.5 | 12.5 | 23 |
| 17. | 4 | 14.5 | 95.5 | 15.5 | 12.2 | 13 |
| 18. | $3\frac{4}{12}$ | 15.0 | 98.5 | 14.5 | 14.4 | 30 |
| 19. | $4\frac{9}{12}$ | 14.6 | 98.5 | 14.5 | 13.6 | 13 |
| 20. | 4 | 18.5 | 104.0 | 16.0 | 12.4 | 28 |

* Middle upper arm circumference.
† 'Stunted', below −2 SD of standard height for age.

### Diets and food intake measurements

The ordinary menu, which was previously designed by the Ethiopian Nutrition Institute, was used and where appropriate sorghum faffa was included as a substitute for other food items. One meal each day was served as porridge, either at breakfast or at supper. Other suitable dishes prepared from the sorghum faffa were Ethiopian types of bread, kitta and chechebsa, and pancakes. The amount of sorghum faffa served per day was intended to contribute about 50 per cent of the daily protein intake of the children. The protein and energy contents of the diet were calculated according to the latest FAO/WHO (1973) recommendations.[11]

Using a top balance scale, each child was served a weighed portion of every food item, including all liquids, and left to eat on her own or with the usual assistance of the children's attendants. Care was taken not to force the food on the child. After the meal, any left-overs were weighed and recorded. The daily food intake for each child was calculated from the recorded amounts served minus the left-overs.

Food intake measurements were recorded on the ordinary diet for 5 days, henceforth referred to as the reference period. A 10-day period of intake measurements was then recorded on the sorghum faffa diet and the bulk-reduced sorghum faffa diet.

### Methods

Duplicate-portions were collected twice from each day of the menu during the sorghum faffa periods. After homogenizing in a food mixer and oven drying, samples were taken for crude protein analysis using the micro Kjeldahl method and for energy measurement using a Gallenkamp Adiabatic bomb calorimeter. Total amino-acid content was determined on a JEOL 5-AH automatic ion-exchange chromatograph after hydrolysis with methane sulphonic acid as described earlier.[12] Cysteine was determined as cysteic acid after performic acid oxidation[13] and tryptophan after hydrolysis in sodium hydroxide.[14]

The statistical significance of differences in daily food intake between different diet periods was determined using Wilcoxon's non-parametric method with the signed rank test.

### Observations

Refusal to eat the meals with sorghum faffa was considered as an indicator of poor palatability. The acceptability of the sorghum faffa diet was evaluated by comparing the food intake in the reference period (ordinary diet) with that in the two-test periods (sorghum faffa diet). Intolerance was judged by noting persistent gastrointestinal upsets, such as loss of appetite, flatulence, vomiting, and diarrhoea.

### Preparation of bulk-reduced sorghum faffa porridge diet

During the first test period, one daily meal was prepared as sorghum faffa porridge with 20 g sorghum faffa flour mixture per 100 g porridge. During the second test period, we increased the amount of sorghum faffa flour to 25 g per 100 g porridge. After cooking, this resulted in a very thick and stiff porridge not suitable for child-feeding. By adding a small amount of germinated (48 hours) sorghum flour viz. 'power-flour' (about 1 g per 100 g porridge) to the stiff porridge, the viscosity could be decreased within a few minutes to an acceptable eating consistency. This method has been described in detail elsewhere.[10]

The preparation of a bulk-reduced porridge at the children's home was in practice done as follows: water and flour were mixed together and heated with continuous stirring. After reaching cooking temperature the porridge was set aside to cool to about 80°C, when an appropriate amount of germinated sorghum flour (5 per cent of the total amount of flour) was thoroughly mixed into the stiff porridge. After 5–10 minutes, the porridge had acquired an almost liquid consistency. It was then boiled again for 10 minutes. When served to the children, this bulk-reduced porridge had about the same consistency as the sorghum faffa porridge served during the first test period (20 g flour per 100 g porridge).

TABLE 2
*The average daily food intake (g) for each child during the three test periods*

| Child No. | Reference diet* | Sorghum faffa diet† Ordinary | Sorghum faffa diet† Bulk-reduced |
|---|---|---|---|
| 1. | 912 ± 68 | 934 ± 249 | 914 ± 280 |
| 2. | 1017 ± 175 | 1115 ± 137 | 1056 ± 124 |
| 3. | 1100 ± 212 | 1165 ± 74 | 1066 ± 111 |
| 4. | 1087 ± 230 | 1103 ± 97 | 1037 ± 140 |
| 5. | 1153 ± 220 | 1175 ± 122 | 1130 ± 152 |
| 6. | 1063 ± 213 | 1273 ± 131 | 1137 ± 116 |
| 7. | 1029 ± 129 | 1248 ± 97 | 1140 ± 113 |
| 8. | 1046 ± 182 | 1089 ± 182 | 1062 ± 182 |
| 9. | 1027 ± 146 | 1177 ± 96 | 1114 ± 168 |
| 10. | 1027 ± 165 | 1214 ± 161 | 1157 ± 133 |
| 11. | 1049 ± 115 | 1234 ± 171 | 1203 ± 178 |
| 12. | 1077 ± 159 | 1312 ± 127 | 1222 ± 123 |
| 13. | 1036 ± 132 | 1286 ± 121 | 1218 ± 166 |
| 14. | 1038 ± 164 | 1244 ± 98 | 1231 ± 101 |
| 15. | 1060 ± 231 | 1255 ± 121 | 1176 ± 132 |
| 16. | 1139 ± 256 | 1283 ± 103 | 1247 ± 153 |
| 17. | 1120 ± 161 | 1222 ± 137 | 1152 ± 192 |
| 18. | 1132 ± 165 | 1238 ± 125 | 1264 ± 136 |
| 19. | 1143 ± 236 | 1327 ± 144 | 1312 ± 231 |
| 20. | 1182 ± 242 | 1367 ± 169 | 1331 ± 133 |
| $\bar{X}$‡ | 1072[a] | 1213[b] | 1148[c] |
| Range | 912–1182 | 934–1367 | 914–1331 |

* Mean ± SD, 5 days.
† Mean ± SD, 10 days.
‡ Mean values followed by different superscripts are significantly different ($P \leqslant 0.01$).

### Results

The daily intake of food (including liquid) averaged 1072 g for all children in the reference period, compared to 1213 g in the sorghum faffa period and 1158 g in the bulk-reduced sorghum faffa period, Table 2. The differences are statistically significant ($P \leqslant 0.01$). Table 3 shows the average daily liquid intake for each child with an overall mean of 399, 374, and 400 ml, respectively, for the three diet periods.

The daily intake of solid foods was thus 673 g in the reference period, compared to 839 and 758 g, respectively, in the two sorghum faffa periods. The intake of sorghum faffa porridge, ordinarily prepared or bulk-reduced, served either at breakfast or at supper during the two sorghum faffa periods, averaged 272 g per meal in both periods (Table 4).

Table 5 shows the crude protein content (Kjeldahl-N × 6.25) and amino-acid pattern of the sorghum faffa diets measured on duplicate portions. The mean protein content was 41.5 g (range 35.0–43.0), with an amino acid score of 0.68, lysine being the limiting amino-acid, followed by threonine (0.82) and the sulphur-containing amino acids (0.85). The low lysine value reflects the sorghum content of the diet.

The energy density of the sorghum faffa diets (including liquids), evaluated from duplicate portions and bomb calorimetry measurements, was about 1.15 kcal/g, which means that the average energy intake was about 1400 kcal per day during the two sorghum faffa periods.

During the whole study, only two children had mild infections and had a poor appetite for 8 days and 1 day, respectively.

Gastrointestinal symptoms were rare during the three diet periods: only two children vomited once after eating the faffa porridge in the first study period.

### Discussion

The sorghum-based supplementary weaning food faffa used in this voluntary intake study was well accepted by a group of preschool children in a children's home when prepared as porridge, bread, or pancakes and mixed into a traditional Ethiopian diet so as to contribute about 50 per cent of the daily protein intake.

A bulk-reduced sorghum faffa porridge was ingested in equal amounts compared to the ordinary

TABLE 3
*The average fluid intake (g) for each child during the three test periods*

| Child No. | Reference diet* | Sorghum faffa diet† | |
|---|---|---|---|
| | | Ordinary | Bulk-reduced |
| 1. | 424 ± 117 | 376 ± 93 | 401 ± 82 |
| 2. | 407 ± 84 | 375 ± 93 | 401 ± 82 |
| 3. | 405 ± 85 | 371 ± 94 | 401 ± 82 |
| 4. | 405 ± 85 | 371 ± 95 | 401 ± 82 |
| 5. | 404 ± 86 | 374 ± 91 | 401 ± 82 |
| 6. | 403 ± 87 | 367 ± 98 | 401 ± 82 |
| 7. | 401 ± 89 | 372 ± 92 | 401 ± 82 |
| 8. | 421 ± 120 | 372 ± 93 | 401 ± 82 |
| 9. | 403 ± 87 | 369 ± 94 | 401 ± 82 |
| 10. | 407 ± 84 | 375 ± 89 | 401 ± 82 |
| 11. | 405 ± 85 | 367 ± 97 | 401 ± 82 |
| 12. | 369 ± 77 | 378 ± 92 | 401 ± 82 |
| 13. | 404 ± 86 | 379 ± 90 | 401 ± 82 |
| 14. | 401 ± 89 | 377 ± 92 | 401 ± 82 |
| 15. | 372 ± 75 | 381 ± 88 | 393 ± 79 |
| 16. | 432 ± 132 | 370 ± 94 | 401 ± 82 |
| 17. | 372 ± 75 | 368 ± 95 | 391 ± 83 |
| 18. | 402 ± 88 | 377 ± 89 | 401 ± 82 |
| 19. | 372 ± 75 | 380 ± 92 | 390 ± 84 |
| 20. | 373 ± 75 | 375 ± 95 | 401 ± 82 |
| $\bar{X}$‡ | 399[a] | 374[b] | 400[a] |
| Range | 369–432 | 367–381 | 390–401 |

* Mean ± SD, 5 days.
† Mean ± SD, 10 days.
‡ Mean values followed by different superscripts are significantly different ($P \leqslant 0.01$).

TABLE 4
*Average daily intakes of porridge (g) from one meal during the two sorghum faffa periods*

| Child No. | Sorghum faffa diet* | |
|---|---|---|
| | Ordinary | Bulk-reduced |
| 1. | 226 ± 37 | 295 ± 71 |
| 2. | 217 ± 49 | 251 ± 71 |
| 3. | 260 ± 49 | 211 ± 60 |
| 4. | 249 ± 31 | 254 ± 55 |
| 5. | 270 ± 54 | 254 ± 61 |
| 6. | 295 ± 66 | 237 ± 53 |
| 7. | 294 ± 71 | 233 ± 53 |
| 8. | 294 ± 86 | 282 ± 60 |
| 9. | 287 ± 73 | 246 ± 64 |
| 10. | 291 ± 40 | 235 ± 54 |
| 11. | 271 ± 46 | 245 ± 60 |
| 12. | 301 ± 50 | 269 ± 62 |
| 13. | 294 ± 86 | 287 ± 84 |
| 14. | 288 ± 57 | 338 ± 73 |
| 15. | 276 ± 89 | 292 ± 67 |
| 16. | 271 ± 69 | 322 ± 93 |
| 17. | 256 ± 69 | 256 ± 51 |
| 18. | 213 ± 71 | 246 ± 79 |
| 19. | 271 ± 62 | 355 ± 76 |
| 20. | 311 ± 51 | 323 ± 89 |
| $\bar{X}$† | 272[a] | 272[a] |
| Range | 213–311 | 211–355 |

* Mean ± SD, 10 days.
† Mean values followed by different superscripts are significantly different ($P \leqslant 0.05$).

sorghum faffa porridge. The bulk-reduced faffa porridge contained 25 per cent more faffa flour than the ordinary faffa porridge within the same volume, but had the same consistency as a result of addition of germinated sorghum flour to the preparation. The intake of nutrients and energy was thus 25 per cent higher in meals with the bulk-reduced faffa porridge compared to ordinary faffa porridge meals. However, the mean daily intake of solid foods was significantly lower in the bulk-reduced sorghum faffa period (758 g) compared to the ordinary sorghum faffa period (839 g), resulting in about the same average daily energy intake during the two sorghum periods. This finding suggests that the children in this study were able to adjust their energy intakes by modifying their intake of solid foods.

Our findings in this study on total food intake are in agreement with other studies on food intake of preschool children on traditional low-fat, starch-rich diets[15,16] and thus confirm the high acceptability of the sorghum faffa diets.

The energy density of the sorghum faffa porridge was 1.00 kcal/g and of the bulk-reduced sorghum faffa 1.20 kcal/g (0.3 kcal/g from added fat in both). The energy desity of the total sorghum diets (including liquids), measured on duplicate portions, was 1.15 kcal/g. It was obviously possible to obtain an energy density of the bulk-reduced sorghum faffa porridge comparable to that of the daily diet with a consistency which was accepted by the children. The energy density of the diet has also been shown to be strongly correlated to the energy intake of preschool children. Some recent data are available from nutritional surveys.

In Tanzania[17] an average energy density of about 1.25 kcal/g of prepared food was needed in order for preschool children to ingest the estimated daily requirements. In India,[16] preschool children with heights and weights comparable to those of international standards consumed a diet with a mean energy density of 1.17 kcal/g while low-weight children consumed a diet with significantly lower energy density, 0.74 kcal/g.

An adequate energy intake by the children in this study could therefore be expected on both sorghum faffa diets with an energy density of about 1.15 kcal/g. The ordinary prepared faffa porridge with an energy density of 1.0 kcal/g must, on the other hand, be con-

TABLE 5
*Protein content and amino-acid pattern in daily portions of the sorghum faffa diets*

| | mg/gN* | Score† |
|---|---|---|
| Lys | 230 | 68 |
| His | 139 | |
| Trp | 72 | 120 |
| Arg | 258 | |
| Asp | 499 | |
| Thr | 204 | 82 |
| Ser | 234 | |
| Glu | 1187 | |
| Pro | 411 | |
| Gly | 214 | |
| Ala | 296 | |
| Val | 326 | 105 |
| Cys | 108 | 85 |
| Met | 79 | |
| Ile | 274 | 110 |
| Leu | 565 | 128 |
| Tyr | 208 | 137 |
| Phe | 313 | |
| Crude protein, g (Kjeldahl-N × 6.25) | 41.5 | |
| Range | 35.0–43.0 | |

* Mean of six samples.
† FAO/WHO provisional amino-acid scoring pattern (11).

sidered low while the bulk-reduced faffa porridge had an energy density of 1.2 kcal/g, which is closer to the level found in intake studies where the energy requirement is covered.

In order to evaluate the protein adequacy of the sorghum diets, their protein levels should be compared with the 'safe level of protein intake' for the age-group concerned.[11] However, the safe level of protein intake is expressed in terms of egg or milk protein, i.e. high-quality protein, and adjustment of this figure is necessary to assess diets of low-quality protein. The 1973 joint FAO/WHO expert committee on energy and protein requirements has proposed methods to correct the protein quality of a diet: the predicted daily requirements of low-quality protein equal the safe levels of intake of egg or milk proteins divided by the amino-acid score and digestibility. In this study, the duplicate portions from the sorghum diets were taken from 4-year-old children and the safe level of high-quality protein for this age-group is stated to be 18 g per day. The amino-acid score was 0.68 and the true digestibility of a similar diet was estimated to be 0.78 in a nitrogen balance study on preschool children.[1] Thus, the safe level of protein intake of the sorghum diets should be $18/(0.68 \times 0.78) = 34$ g per day. The protein contents in all the duplicate portions showed higher values (range 35–43 g per day), which suggests a satisfactory protein content in the sorghum diets.

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