Improving Young Child Feeding in Eastern and Southern Africa

Household-Level Food Technology

Proceedings of a workshop held in Nairobi, Kenya, 12-16 October 1987
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Editors: D. Alnwick, S. Moses, and O.G. Schmidt

Cosponsored by the International Development Research Centre, the United Nations Children's Fund, and the Swedish International Development Authority
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UNICEF, New York, N.Y. US
Swedish International Development Authority, Stockholm SE


UDC: 613.22(6) ISBN: 0-88936-516-4

A microfiche edition is available.

The views expressed in this publication are those of the authors and do not necessarily reflect those of the sponsoring organizations. Mention of proprietary names does not constitute endorsement of the product and is given only for information.
Abstract

The weaning period, that is the period in a young child's life when supplementary foods are introduced to complement breast milk, poses great nutritional risk to children in developing countries. By the end of the second year of life, one-third of children in eastern and southern Africa are chronically malnourished. The following factors contribute to the growth faltering commonly observed in weaning-age children: low nutrient intake, high incidence of diarrheal disease (often caused by contaminated weaning foods), and recent declines in duration and intensity of breastfeeding.

Food scientists, nutritionists, and health planners working in Africa and South Asia met in an international workshop to examine household-level food technologies that hold promise for improving nutrition of infants and young children. After reviewing current knowledge of breastfeeding and weaning practices in eastern and southern Africa, participants discussed the use in weaning diets of fermented foods and germinated flour, for both improved nutrient intake by young children and decreased risk of food contamination. Research that should be conducted into the effectiveness of the food technology was identified and its diffusion at the community level discussed.

This publication contains the proceedings, conclusions, and recommendations of the workshop. It is directed at scientists and health planners who are involved in nutrition research and developing programs to improve feeding of infants and young children in developing countries.

Résumé

Le sevrage, c'est-à-dire la période où l'on commence à donner des aliments solides à un jeune enfant en complément du lait maternel, présente de graves risques nutritionnels pour les enfants dans les pays en développement. Dès la fin de leur deuxième année, le tiers des enfants en Afrique orientale et australe souffrent de malnutrition chronique. Les facteurs suivants sont à l'origine du retard de croissance que l'on retrouve couramment chez les enfants en âge d'être sevrés : carence nutritionnelle, forte prévalence des maladies diarrhéiques (qui s'expliquent souvent par la contamination des aliments) et diminution récente de la durée et de l'intensité de l'allaitement maternel.

Des spécialistes des sciences de l'alimentation, des nutritionnistes et des planificateurs de la santé travaillant en Afrique et en Asie du Sud se sont réunis dans le cadre d'un atelier international afin d'examiner des technologies alimentaires applicables au niveau des ménages qui semblent prometteuses pour améliorer la nutrition des nourrissons et des jeunes enfants. Après avoir examiné les connaissances actuelles en matière d'allaitement au sein et les pratiques de sevrage en Afrique orientale et australe, les participants ont discuté de l'utilisation, au cours du sevrage, d'aliments fermentés et de farine germée, tant pour améliorer l'apport nutritionnel chez les jeunes enfants que pour diminuer les risques de contamination des aliments. Ils ont également discuté des recherches qu'il y aurait lieu d'entreprendre sur l'efficacité des technologies alimentaires et sur leur diffusion dans la collectivité.
Cette publication fait un compte rendu des discussions de l'atelier et présente ses conclusions et ses recommandations. Elle s'adresse aux scientifiques et aux planificateurs de la santé qui participent à des recherches en matière de nutrition et à l'élaboration de programmes visant à améliorer l'alimentation des nourrissons et des jeunes enfants dans les pays en développement.

Resumen

El período de destete, es decir, aquel periodo en la vida de un niño en que se introducen en su dieta alimentos suplementarios para complementar la leche materna, representa un gran riesgo nutricional para los niños de países en vías de desarrollo. Hacia el final de su segundo año de vida, un tercio de los niños en África oriental y del sur muestran síntomas de malnutrición crónica. Los siguientes factores contribuyen al crecimiento vacilante que se observa comúnmente en los niños que se encuentran en edad de dejar la lactancia materna: baja ingestión de nutrientes, alta incidencia de diarrea (a menudo causada por alimentos en el destete contaminados), y nuevas disminuciones en la duración e intensidad de la alimentación proveniente del pecho de la madre.

Científicos del campo de los alimentos, especialistas en nutrición y planificadores de la salud que trabajan en África y en el Sur de Asia se reunieron en un taller internacional para examinar las tecnologías de alimentos que se utilizan en el hogar y que prometen buenos resultados en el mejoramiento de la nutrición de lactantes y niños pequeños. Después de analizar el conocimiento que existe actualmente sobre la alimentación recibida a través del pecho de la madre y las prácticas que se utilizan para el destete en el oriente y sur de África, los participantes discutieron el uso en dietas para el destete de alimentos fermentados y harina germinada para que los niños puedan ingerir nutrientes mejorados y haya una disminución en el riesgo causado por la contaminación de los alimentos. Se identificó la investigación que se debe realizar sobre la efectividad de las tecnologías de alimentos y se discutió su difusión en el seno de la comunidad.

Esta publicación contiene las actas, conclusiones y recomendaciones del taller. Está dirigida a científicos y planificadores de la salud que participan en la investigación nutricional y en programas de desarrollo para mejorar la alimentación de lactantes y niños en los países en desarrollo.
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DIETARY BULK IN WEANING FOODS AND ITS EFFECT ON FOOD AND ENERGY INTAKE

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Abstract The dietary bulk problem in weaning diets has recently attracted much attention, both because of its clear association with malnutrition in young children, and because of the practical solutions that have been proposed. The two characteristics that determine dietary bulk are volume (or energy density) and consistency. Dietary bulk properties appropriate to young children would be high energy density (low volume) and semiliquid consistency. "Ugali" has a high energy density but stiff consistency, whereas "uji" has a liquid consistency but low energy density; the ideal porridge would combine the positive aspects of each. The use of traditional household technologies offers a potential solution to this problem. Flour from germinated sorghum or millet is known as "kimea," or "power flour" (P.F.); when this P.F. is added during cooking, thick porridges with adequate energy density can be liquefied within a few minutes. Food intake studies at the village level in Tanzania investigated the extent to which the consistency and energy density of a diet would influence actual food intake in young children. In the age group 12-36 months, the children were able to consume about 35% more of the semiliquid diets ("uji" and P.F.-treated "ugali") than of the stiff "ugali" diet. The total food intake in kcal per meal was 2-4 times more of the P.F.-treated "ugali" than of the ordinary "uji," and about 30% more than of the stiff "ugali." Children over 3 years of age were able to consume equal amounts of the stiff "ugali" and of the P.F.-treated liquid porridge.

Nutritionally, there are two biological revolutions in a human life. The first occurs at birth, with the change from intrauterine nutrition to breastfeeding. The second occurs with the initiation of weaning; the "weaning period" has come to mean that period during which an infant gradually becomes accustomed to foods supplementary to

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1These studies have been carried out in collaboration with the Tanzania Food and Nutrition Centre and funded by the Swedish Agency for Research Cooperation with Development Countries.
breast milk. The first of these transitional periods may involve some problems but no real risk, even under unhygienic and poor social conditions. Under such circumstances, however, the second phase becomes one of high risk: the dietary system of the infant is no longer under the biological control of the mother's body, but depends on the knowledge and resources of the family.

We know that under good social and economic conditions, when milk-based weaning foods can be given under medical supervision, the risks can be diminished. Such conditions do not, however, exist in most parts of the world, and nutrition problems during the weaning period are, therefore, widespread. The child must become accustomed to consuming and digesting new foods of often inferior nutritional quality, while being highly susceptible to numerous infections of the intestinal canal that are likely to be introduced as a result of unclean hands and utensils. This situation constitutes the greatest emergency facing the world's children today.

According to UNICEF (1987), covering 64 developing countries representing a population of over 2 billion, more than 30% of children under 5 years of age are suffering from moderate malnutrition, and about 5% are severely malnourished. Malnutrition is at its height during the weaning period - in many developing countries, the time between 6 months and about 2.5 years of age (Gordon et al. 1967). Earlier generations recognized the risks, and breastfeeding and weaning practices are, therefore, usually regulated by cultural and religious tradition (Jelliffe 1955). The best-known and most important tradition is that of prolonged breastfeeding beyond 4-6 months, supplemented by softer portions of the family diet (Cameron and Hofvander 1982).

In most cultures, traditional weaning foods are nonmilk family foods, based on the local staple - usually a cereal, such as corn, sorghum, millet, or rice. Noncereal staples, such as potatoes, cassava, and plantains, are sometimes used. When a staple is prepared as a weaning food, it is usually made either into a thick porridge, or into a soft or liquid gruel. Prepared as a liquid, these staples will hold large amounts of water, and thus become voluminous with a low energy and nutrient density. (Energy density is defined as the amount of energy per gram of food; nutrient density is the amount of nutrients per gram of food.) The flour concentration can be as low as 5%; this would give only 0.2 kcal/g of prepared gruel. To be able to meet his or her daily energy requirements, a young child would have to consume between 3 and 5 L of such a thin gruel, and that is clearly impossible. The high energy requirements of young children, together with their limited stomach capacity, make it impossible for them to eat enough of the food, particularly if the number of meals per day is low.

The term "bulk" is derived from the old English word "bulke," meaning magnitude or volume, and also mass or aggregate, especially that which is large. "Dietary bulk" can be produced in either of two ways. In the first, the energy density of the thin gruel ("uji") is too low, and the required volume therefore too large. The second characteristic of dietary bulk manifests itself when food volume is diminished by a reduction in dilution; in this case, the result is a stiff porridge ("ugali"). The amount of flour in such a porridge is about 30%; this gives an energy density of 1.0 kcal/g. This is the
type of food that is preferred by adults; children from about 2 years of age are introduced to it. The stiff and sticky consistency of the "ugali" makes it more difficult to consume, especially for young children who may not have developed their full capacity to masticate and to swallow stiff and solid foods. Although the energy density is acceptable, the consistency may therefore be a major constraint in providing young children with enough food. It would obviously be desirable to be able to combine the good properties of each (the high energy density of the "ugali" and the semiliquid consistency of the "uji") into one food item.

To evaluate the influence of dietary bulk properties on the nutrition of young children, one must first consider those factors that determine daily energy and nutrient intake (Ljungqvist et al. 1981): number of meals per day, amount of food consumed at each meal, energy and nutrient density of the food consumed, and bioavailability of energy and nutrients in the food. Of these factors, the 2nd and 3rd are the ones most closely related to the dietary bulk properties of the food.

**Dietary Bulk and Protein Energy Malnutrition (PEM)**

Dietary bulk is often mentioned as a possible or even probable factor in the etiology of malnutrition (PAG 1973; Waterlow and Payne 1975; Payne 1976). Two original descriptions of infant feeding in West Africa were given by Cicely Williams, first in 1933, in her classical account of kwashiorkor, and later in her 1938 survey of the general child-health situation in the Gold Coast. She vividly describes the ill effects of the bulky, spiced carbohydrate foods given to older infants. In East Africa, Trowell and Muwazi emphasized as early as 1945 the bulky, indigestible nature of the food on which infants are weaned. These researchers state that the 1200 calories required daily by a child 2 years of age must be obtained from the consumption of bulky vegetable foods.

Very few attempts have been made, however, to study systematically the importance of the problem of dietary bulk in child feeding. Some authors have observed that starch-based diets have a very "bulky appearance" (Jones and Pereira 1972; Chamberlin and Stickney 1973; Binns 1975); it is not clear, however, whether they refer to the volume or to the consistency of the diet.

Nicol (1971) was one of the first to make quantitative estimates of the dietary bulk factor, based on studies of food intake in children. He concluded that the volume of starch-based foods required to cover the energy needs of preschool children is between 900 and 1650 mL. The amount of food eaten ranged from 660 to 1250 mL, divided into two meals per day; this was not enough to meet the energy requirements stipulated by FAO/WHO (1973). Even if the food were to be divided into many meals per day, Nicol concluded, it would be impossible to expect a child 1-3 years of age to enjoy 1450 mL of thick, sticky yam porridge. For cereal-based diets, however, it was considered possible for a child to consume a sufficient volume of porridge (900-980 mL) to meet his energy requirements if the food were divided into four servings per day. The consistency of this diet was not measured, but can be assumed to have been similar to that of a thick porridge.
Rutishauser (1975) compared energy density, feeding frequency, and "appetite" (depending on the presence of illness), with regard to the energy needs of preschool children; she concluded that energy density is the most decisive factor. Another interesting point arises from her data: in cases of discontinued breastfeeding, milk was the only food to provide full compensation; it would appear that milk has desirable dietary bulk properties that distinguish it from other starch-based foods.

Studies have been conducted on the feeding of preschool children in areas where starchy staples are the main foods and where PEM is prevalent. Researchers seem to agree that the "bulkiness" of the diet is a major constraint in providing children with enough food. This experience has, however, resulted in little investigation of means to alleviate the problem. More quantitative data are needed to show the importance of the dietary bulk factor.

**Eating Capacity Related to Dietary Bulk**

The food intake required to cover the energy needs of children of various ages with diets of different energy densities can be calculated from energy requirement data (FAO/WHO 1973). If the maximum intake level for a particular food is known, then we can determine the energy density needed to meet a child's energy requirement. From quantitative estimates on daily food intake, reported above, it can be assumed that young children would be able to satisfy their energy needs on a diet with an energy density of about 1 kcal/g.

Few studies have been devoted to measuring children's actual quantitative intake of different foods. Most studies relate to infants, either breastfed or bottle-fed with varieties of milk formulas. In studies of voluntary intake in preschool children, it is also difficult to avoid the influence of external factors, such as supervising personnel and altered meal patterns.

**Studies of Food Intake in Infants**

Fomon et al. (1969, 1971, 1975) carried out a series of studies on food intake in infants given, ad libitum, milk formulas with different energy concentrations. In spite of the greater quantity of food consumed by infants fed the low-calorie formula, their mean calorie intake (107 kcal/kg per day) was considerably less than that of infants fed the high-calorie formula (126 kcal/kg per day).

After the age of 4 months, the mean quantity of food consumed was 939 mL/day for the low-calorie group, and 582 mL/day for the high-calorie group; this resulted in an equal intake of calories/kg per day and in weight gain for all infants. All these studies, however, refer to milk-based formulas; the relevance for starch-rich weaning foods is not clear.

**Studies of Food Intake in Preschool Children**

Rutishauser and Frood (1973) studied the food intake in 19 Ugandan children aged between 1 and 3 years attending a rural child
welfare clinic. All the children had early clinical signs of malnutrition. Ten of the children were fed a traditional family diet (a mixture of plantain and sweet potato, combined with either beans, groundnuts, or meat) five times daily, along with 500 mL of tea with 25 g sucrose. Nine children were given a milk-based diet (full-cream milk powder, sucrose, and cotton seed oil) at a rate of 100 mL/kg body weight per day. These children were allowed to supplement this diet with as much plantain or sweet potato as they wished. The experimental diets were offered for periods of 7-22 days. The mean total daily intakes were essentially the same for both diets - about 1200 g. The amount of solid foods in the family diet was slightly over 700 g/day; the authors concluded that this was near the maximum capacity of children aged 1-3 years.

Svanberg et al. (1987) report similar intake figures in a food intake study from an orphanage in Ethiopia. Twenty children aged 2-5 years were served a traditional Ethiopian diet, divided into 3 meals per day, and 1 meal consisting of a porridge. The range of daily food intake, liquid, and solid foods, over a period of 25 days, was 912-1367 g for the whole group of children. In a large study of English preschool children (Ministry of Health 1968), the average intake of foods, excluding milk, in children up to the age of 5 years, was 540 g/day, and with milk 900 g/day.

![Energy intake of young children as a percentage of requirements (FAO/WHO 1973) in relation to the energy density of the diet.](image-url)
In conclusion, the data on food intake in preschool children (1-5 years) indicate a maximum capacity of about 900-1400 mL/day. If energy requirements are to be satisfied, these intake figures must be met by an energy density of about 1.2 kcal/g (FAO/WHO 1973). This estimation accords with data obtained from surveillance in villages and in nutrition rehabilitation centres in Tanzania (TFNC 1978; Mellander and Svanberg 1984). Figure 1 shows the actual intake, in percentage of requirements (FAO/WHO 1973), in relation to the energy density of the diet. A significant correlation was found between the daily energy intake and the energy density of the food. On average, an energy density of about 1.25 kcal/g of prepared food was needed to provide the estimated daily requirements; more than 70% of the children were eating meals with an energy density lower than this figure.

Church (1979) has compiled the data from Rutishauser and Frood (1973) in Uganda, and Binns (1975) in Papua, New Guinea. Figure 2 shows the results of these two studies. Even with very good appetites, these children had difficulty eating enough food to cover their energy requirements (Waterlow and Rutishauser 1974). The

![Figure 1](image1.png)

**Fig. 1.** Food intakes of children on a traditional, staple diet compared with the intake of foods with higher energy densities (ED) needed to meet the local standard for energy intake (see Rutishauser and Frood 1973; Waterlow and Rutishauser 1974; Binns 1975; Church 1979).
pattern of low food intake is characteristic and is strikingly exaggerated on days of poor appetite (in the Uganda study, on average, every 3rd day).

Using a 24-h oral recall method, Susheela and Narasinga Rao (1983) investigated the food intake of children in rural and urban areas of India. Children with heights and weights comparable to those of international standards consumed a diet with a mean energy density of 1.17 kcal/g; low-weight children, however, consumed a diet with the significantly lower energy density of 0.74 kcal/g. Svanberg et al. (1987) made sure of an energy density of 1.15 kcal/g in their study of experimental diets in Ethiopia; by Swedish standards, all the children were normal in weight-for-height.

With regard to satisfactory infant growth, the energy density of human milk should be considered optimal. Average values of 0.70 kcal/g have been reported for mature breast milk (Macy and Kelly 1961; Department of Health and Social Security 1977). We can conclude that in a mixed weaning diet in which liquids of lower energy density are consumed with solid food, the latter should have an energy density exceeding 0.7 kcal/g.

In conclusion, it is reasonable to assume that preschool children can satisfy their energy requirements on a diet with an average energy density of over 0.7 kcal/g; this holds true, however, only if the children are healthy and possess good appetites, and if their food is divided into more than three meals per day.

No data seem to be available on the influence of diet consistency on the eating capacity of children of various ages; the results mentioned above indicate no difference in the total daily intake between a more solid family diet and a liquid, milk-based diet (Rutishauser and Frood 1973). In a study at two orphanages in Ethiopia, however, it was observed (Svanberg, unpublished observation) that when a dry-blended weaning food (thick porridge) was used in the diet instead of an amylase-treated variety (liquid gruel), it was necessary to distribute the portions equally over the meals, otherwise the children would have had difficulty in eating their daily provisions.

An interesting contribution has been made by Church (1979), who discusses the consistency of weaning foods, particularly in relation to age and development as well as to diseases in children. The preference for more liquid foods is greater in younger children and increases with the increasing severity of an illness. When the diet is based on starchy staples, however, a higher liquidity in the weaning food means a decreased energy density.

**Physiological Factors Related to Dietary Bulk**

The factors regulating hunger and satiety in human beings are very complex and to a large extent have not yet been defined (Davidson and Passmore 1975). The present discussion is therefore limited to the probable effects of the energy density/volume and the consistency of a meal, in relation to the three basic phases of the digestive system: chewing and swallowing, gastric emptying, and intestinal digestion and absorption.
Chewing and Swallowing

Thicker foods necessitate more effort in chewing and in passing the chewed food on to the stomach. It is possible that this increased effort can limit food intake in young children who have not fully developed their abilities in these respects. Liquid foods, of course, require very little effort to be passed on to the stomach. At the same time, however, there will probably be less amylase (an enzyme needed to break down starch) from the saliva; this reduction in amylase may delay further digestion. None of these factors seem to have been studied adequately with different types of food.

Gastric Emptying

Hunt and Stubbs (1975) have carried out a large number of studies with regard to gastric emptying in adults; these studies cover a wide range of energy densities. The gastric emptying of a meal has been found to have an exponential shape (Hunt and Knox 1968): in other words, the total volume of the meal affects the rate of emptying. More important, however, is the fact that this rate is regulated by the energy density of the food: a meal of high energy density will be emptied more slowly than will one of low energy density. The regulation mechanisms seem, therefore, to be equally sensitive to all energy units, whether the origin of these units be fats or carbohydrates. These regulating mechanisms will not, however, fully equalize the differences between meals of different energy densities: a meal with a higher energy density will still release more energy into the intestines per unit of time than will a meal of lower energy density.

The viscosity of a meal also seems to exert a profound effect on gastric emptying. Gel fibres such as pectin and guar gum have been found to delay gastric emptying considerably in adults (Holt et al. 1979). It is not known whether this effect on gastric emptying can be achieved by the provision of highly viscous gruels of digestible carbohydrates, such as amyllose or amylopectin, or both; these carbohydrates might be partly hydrolyzed by saliva amylases, resulting in a reduced viscosity.

Because of the ethical and practical problems involved in studying children, the information on gastric emptying rates in these age groups is scarce. There are, however, recent studies of small infants given adapted cow's milk (Singer and Fridrich 1975). These studies indicate that here also the emptying pattern is exponential. Gastric emptying time for half the given volume was found to be $87 \pm 29$ min (mean $\pm$ SD, $n = 24$) - a significantly longer time than that found in adults (Griffith et al. 1968).

Digestion and Absorption

The final digestion and absorption of the food components are usually concentrated to the proximal parts of the intestines (Johansson 1975). These processes may be extended to more distal parts of the intestines as a result of high rates of gastric emptying, or of a high content of unavailable carbohydrates (McCance et al. 1953). It is difficult to assess the possible influence of different rates of absorption with regard to dietary bulk as a limiting factor for nutrient intake.
Some further comments on the role of unavailable carbohydrates may, however, be pertinent. The important functions exercised by unavailable carbohydrates or "dietary fibre" are now being recognized. They constitute a source of unavailable energy, and they may also affect the availability of proteins and minerals (Southgate 1973). Furthermore, the undigestible carbohydrates bind large amounts of water and therefore contribute to dietary bulk: an example of this is pectin, carrying five times its own weight in water. Finally, emphasis must be laid on the profound effects of various diseases (in particular, those of the digestive tract), acute malnutrition, and various parasites, on appetite, digestion, and absorption (Latham 1975).

Reducing the Dietary Bulk

Traditional food-handling technologies have been shown to be able to reduce the water-holding capacity of cereals and legumes, and thus make it possible to prepare gruels with acceptable energy and nutrient densities but with semiliquid consistencies. We shall discuss two examples of such traditional, bulk-reducing methods: the first is sprouting (malting or germination) of cereals (Brandtzæg et al. 1981; Mosha and Svanberg 1983) and of legumes in Asian and African countries; the second is fermentation, used especially in Africa to make edible the cassava and other starchy plants and roots.

The bulk-reducing effect of these processes depends on their formation of amylases. Enzymatic activity increases rapidly in germinating seeds; in some cereal varieties (barley, sorghum, and millets) the amylolytic activity is especially high. The alpha-amylases are synthesized in the cell within the aleurone layer; from here, they migrate into the starchy endosperm, where hydrolysis of the starch granules begins. These starch granules will therefore not swell to the same extent during cooking, and the amylase chains supposed to form the gel network will be broken down. The alpha-amylase activity developed during germination will thus reduce the water-holding capacity of gruels prepared from germinated flours. Sorghum (white varieties) and millets have been shown to develop significant amylolytic activity after 48 h of germination; other cereals and brown sorghum varieties may need more than 96 h of germination. (Figure 3 shows the dramatic effect on the bulk properties of a millet variety after germination.) At least three times as much germinated flour can be mixed into the same volume of water while maintaining the same consistency of gruel.

Furthermore, after germination, certain varieties contain amylolytic enzymes that are both soluble and so active that they can be used to degrade the starch gel network in gruels prepared from ungerminated flour. This means that, with the addition of a small amount of germinated flour, a sticky porridge of about 20% flour concentration will become a semiliquid gruel (Mosha and Svanberg 1983).

Many microorganisms participate in fermentation; some of these have been shown to produce amylases that could influence the bulk properties of, for example, cassava flour. Of particular importance are the acid-producing microorganisms. It is usually lactic acid that is produced; the pH of the product can be as low as 4.0 - a pH in which the starch component may lose its water-holding capacity.
Fig. 3. Effect of cooking method on the viscosity of gruels prepared from unmalted and malted dehusked ragi flour. --- flour mixed directly with boiling water and cooked for 3 min; --- flour mixed with cold water and heated slowly. Viscosity was measured at 40°C in a Brookfield viscometer.

Table 1 summarizes in quantitative terms the effect of different bulk-reducing measures that can be carried out at the household level. It lists the energy densities of various weaning gruels that have been prepared with a semiliquid consistency. A proposed adequacy level (adequate for a 2-3 year old child) of 1.15 kcal/g is obtained from the average requirement for energy given by FAO/WHO (1973), and assumes a total daily food intake of about 1200 g for children in this age group.

When ungerminated cereals are used as a starch base in the gruel preparation, the energy density is around 0.30 kcal/g - as high as 0.50 kcal/g, if waxy varieties with favourable types of starch granules are used (Hellstrom et al. 1981). The addition to a nonwaxy cereal and cooking oil or a mixture of cowpeas and groundnuts (4:1) also results in energy densities of about 0.50 kcal/g. To reach the minimum desirable energy density of 0.70 kcal/g, it is necessary to mix cereal and groundnuts in a 3:1 ratio. When germinated sorghum (white) and millets are used to prepare a semiliquid gruel, it is possible to reach energy densities of 1.0 kcal/g or even higher (up to
Table 1. Energy densities of weaning gruels prepared to a semiliquid consistency measured against a proposed adequacy level of 1.15 kcal/g for a 2-3 year old child.

<table>
<thead>
<tr>
<th>Weaning gruel</th>
<th>Energy density (kcal/g)(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ungenerated cereals</strong></td>
<td></td>
</tr>
<tr>
<td>Nonwaxy</td>
<td>0.24 - 0.47 (0.37)</td>
</tr>
<tr>
<td>Waxy</td>
<td>0.28 - 0.58 (0.45)</td>
</tr>
<tr>
<td>Starch granule</td>
<td>0.41 - 0.54 (0.45)</td>
</tr>
<tr>
<td>With cooking oil</td>
<td>0.37 - 0.68 (0.51)</td>
</tr>
<tr>
<td>With cowpeas (4:1)</td>
<td>0.35 - 0.51 (0.43)</td>
</tr>
<tr>
<td>With groundnuts (4:1)</td>
<td>0.41 - 0.66 (0.52)</td>
</tr>
<tr>
<td>With groundnuts (2:1)</td>
<td>0.55 - 0.77 (0.65)</td>
</tr>
<tr>
<td><strong>Germinated cereals</strong></td>
<td></td>
</tr>
<tr>
<td>White sorghum and millets</td>
<td>0.68 - 1.02 (0.81)</td>
</tr>
<tr>
<td>Brown sorghum</td>
<td>0.31 - 0.81 (0.46)</td>
</tr>
<tr>
<td>Maize</td>
<td>0.39 - 0.86 (0.56)</td>
</tr>
<tr>
<td>Sorghum/millet with groundnuts (4:1)</td>
<td>0.82 - 1.15 (0.98)</td>
</tr>
<tr>
<td>Sorghum/millet with cowpeas (4:1)</td>
<td>0.53 - 0.81 (0.64)</td>
</tr>
<tr>
<td>Any cereal/root with &quot;power flour&quot;</td>
<td>0.82 - 1.15 (0.97)</td>
</tr>
<tr>
<td><strong>Fermentation</strong></td>
<td></td>
</tr>
<tr>
<td>Cereal/root</td>
<td>0.33 - 0.86 (0.45)</td>
</tr>
</tbody>
</table>

Note: Minimum acceptable energy density = 0.70 kcal/g.

\(^a\) Mean values are shown in parentheses.

1.15 kcal/g, by mixing with groundnuts or by using the germinated flour as a "power flour," or P.F.).

**Intake of Bulk-Reduced Weaning Foods**

We have, in collaboration with the Tanzania Food and Nutrition Centre, conducted studies on dietary bulk in weaning foods; as part of these investigations, we have been able to carry out controlled food intake studies on young children at the village level with weaning foods of different dietary bulk properties.

In the Luganga village study, three different diets were prepared from the same double-mixture of maize flour and groundnuts (95/5). Diet 1 was a liquid "uji" with 5% flour concentration. Diet 2 was prepared as thick porridge with 20% flour concentration. Diet 3 was as diet 2, but liquefied by the addition of germinated sorghum flour (P.F.). The participating 32 children were served each diet on 3 consecutive days per month, over a period of 6 months. Table 2 shows a summary of the food intake data, with the children divided into four age groups. Eighteen children, 12-48 months old, consumed significantly more of the liquid gruels than of the thick porridge. Children over 48 months of age showed no significant difference in food intake with the three diets.

We can conclude, therefore, that for children between 12 and 48 months of age, it is the viscosity (consistency) and not the energy
Table 2. Average food intake (g) in young children of gruels of different dietary bulk properties.a

<table>
<thead>
<tr>
<th>Children's age (months)</th>
<th>5% (liquid)</th>
<th>20% (without P.F. - thick)</th>
<th>20% (with P.F. - liquefied)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-12 (n=4)</td>
<td>154 ± 77a</td>
<td>153 ± 72a</td>
<td>163 ± 106a</td>
</tr>
<tr>
<td>12-24 (n=8)</td>
<td>330 ± 188b</td>
<td>277 ± 93a</td>
<td>346 ± 94b</td>
</tr>
<tr>
<td>24-48 (n=10)</td>
<td>491 ± 201a</td>
<td>405 ± 141b</td>
<td>445 ± 172a</td>
</tr>
<tr>
<td>48-65 (n=10)</td>
<td>544 ± 90a</td>
<td>517 ± 107a</td>
<td>565 ± 99a</td>
</tr>
</tbody>
</table>

aMean values within the same group followed by a different letter are significantly different at P = 0.05 (the Wilcoxon signed rank test for paired samples).

density of the gruels that will affect food intake. This accords with the results of studies by Svanberg et al. (1987) on Ethiopian children fed the sorghum-based weaning food "faffa," bulk-reduced by the addition of 5% germinated sorghum flour. In that study, two weaning gruels of nearly the same viscosity but with different energy densities were consumed in equal amounts at single meals. Children between 1 and 2 years of age were the most sensitive to the consistency of the diet. This is the age group for which supplementary feeding is supposed to cover a large part of the energy and nutrient requirements, and the group in which the malnutrition problem reaches its peak.

The intake figures obtained in this study could be used to estimate the quantities of different weaning gruels needed per day to meet the energy requirements of preschool children. Table 3 compares gruels with different dietary bulk properties, showing the levels of

Table 3. Estimated consumed volume of gruels with different dietary bulk properties needed to supply 60% of daily energy needs for a child 1 year of age.a

<table>
<thead>
<tr>
<th>Flour concentration in gruel</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% (liquid)</td>
</tr>
<tr>
<td>Volume to supply 60% of daily energy needs (mL)</td>
</tr>
<tr>
<td>Actual intake per meal (mL)</td>
</tr>
<tr>
<td>Number of meals needed per day</td>
</tr>
</tbody>
</table>

aEnergy requirements for children 1 year of age - 1180 kcal/day.
bGerminated sorghum flour added (5% of total amount).
gruels with different dietary bulk properties, showing the levels of food intake needed to cover 60% of the daily energy requirements for a child 1 year of age. It is assumed that breast milk will cover the rest of the requirements. Over 3500 mL/day of the 5% maize/groundnut gruel is needed; this is obviously impossible for a child of 1 year to ingest. Of the 20% thick gruel, about 870 mL/day will be needed. This could be divided into three meals, according to the observed average intake of 277 mL/meal. Using the P.F. technique, it is possible to have flour concentrations of up to 20-25%. The requisite amount of such gruels would be in the range of 710-870 mL/day; 60% energy coverage could therefore be reached with only 2 or 3 meals a day. The importance of a weaning food of such high energy density is further emphasized by the fact that in Tanzania, children under 5 years of age are usually fed only two or three times a day.

References


