

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

Proceedings



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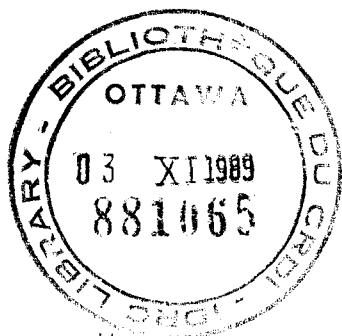
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Improving Young Child Feeding in Eastern and Southern Africa

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Editors: D. Alnwick, S. Moses,
and O.G. Schmidt



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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 período 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 señales 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 para 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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FERMENTATION OF CEREAL- AND LEGUME-BASED WEANING FOODS

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Abstract This paper reviews some common traditional methods in the preparation of predominantly cereal- and tuber-based weaning foods in Tanzania. The common observation is that most of these foods are of thin and watery consistency and are low in nutrient content. To meet the nutrient requirements of the growing child, therefore, the foods must be eaten in large quantities. Legumes are rarely used. The need is identified for the introduction of household-level techniques in the improvement of the nutritive value of weaning foods; methods for achieving this are reviewed. Results are given of preliminary investigations on the preparation and use, for preschool age children, of foods based on cereals, legumes, or both. Available information indicates that there exists the possibility of an improvement of the quality of cereal- and legume-based weaning foods through the use of simple, spontaneous fermentation.

In most African countries including Tanzania, babies are fed exclusively on breast milk, breast milk substitutes, or both up to the age of 4-6 months. From this point to the age of 2-3 years, various forms of foods, semiliquid to solid, are introduced. At some time within this period, the children will be weaned off liquid milk altogether and will depend on foodstuffs prepared from root crops (cassava, sweet potatoes, yams) or from cereals (maize, sorghum, millet, rice) - rarely from legumes such as beans, green gram, or soybeans.

These foods are usually given in the form of gruels or boiled, semiliquid preparations. To achieve the desired free-flowing consistencies (FFC), slurries containing about 10% flour are used in the preparation of the gruels (Mosha and Svanberg 1983). The energy and nutrient concentrations of such preparations are usually too low; attempts have been made to reduce the viscosity of the gruels and to increase their concentration of dry matter. Mosha and Svanberg (1983) developed a simple technique of pregerminating sorghum grains to produce an amylase enzyme that hydrolyzes the starch in the grains.

This technique reduces the water-binding capacity of the flour, making it possible for gruels of suitable FFC to be made from slurries containing as much as 25% flour. Alternative technologies to improve the nutritive value of gruels for child feeding include the use of legume seed flours mixed with cereal flours. Further improvements in the consistency, flavour, and nutritive value may be achieved through the use of simple, spontaneous fermentation techniques. Such techniques have been in use for a long time in Asia (Herseltine and Wang 1972). The purpose of this article is to examine, in the context of Tanzania, both the potential and the limitations of fermentation technology in household-level preparation of weaning foods.

Preparation of Cereal Gruels

Cultural and ecological diversities in Tanzania lead to a varied use of weaning foods; these weaning foods may be classified into four groups:

- "single mix" is a weaning food composed of a single foodstuff, usually a cereal flour, made into porridge or gruel;
- "double mix" is a mixture either of cereal or of root crop flour or of bananas, prepared as mash with a little milk or animal fat;
- "triple mixture" contains starch sources, fruit, and vegetable mash; and
- "multimix" includes the varieties already mentioned, with the addition of any other food that the mother finds palatable and presentable.

Traditional Processing Techniques for Cereal "Uji"

"Uji" is the Kiswahili word used to describe a boiled liquid preparation of cereal grain flour. In Tanzania, the common practice is to boil a slurry of either maize, sorghum, millet, or cassava flour. Sugar and lemon juice are often added to bring out the flavour. When used for newly delivered mothers, butter or fermented milk is often used to enhance the flavour and the nutritive value. In certain parts of the country, particularly in the Tarime District bordering Kenya, it is common practice to prepare "uji" from a previously fermented slurry of maize and sorghum or millet flour. In Kenya, this practice is said to be quite common (Mlingi 1988). For the feeding of infants 4-6 months old, maternity and child health care (MCH) clinics recommend to mothers that the "uji" be prepared from cereal and groundnuts, in proportions of 1:1 (Semoka, personal communication).

The use of additives such as butter, milk, groundnuts, lemon juice, or fermented milk clearly indicates that traditional practice has taken care of the need to improve the nutritive value and flavour of "uji" made from cereals or tubers. We shall now address the question of whether or not fermentation can contribute to this improvement.

Fermentation of Cereal and Starchy Foods

The preparation of "gari," a cassava-based Nigerian foodstuff serves as an example of the "grass roots" application of fermentation technology in sub-Saharan Africa (Ketiku and Omololu 1988). In Tanzania, cassava is fermented at the household level by one of two methods: either it is soaked in water for 3-6 days, or it is chopped and covered with straw for the same length of time. It is then dried and pounded into a flour (Mlingi 1988). In certain areas, a covering of freshly cut grass or banana leaves is preferred and is believed to hasten fermentation to within 3 days, particularly when the cassava has not been left in the sun for too long after peeling.

Natural, spontaneous fermentation is also applied in the preparation of the maize starch cake food "ogi" and of a sour maize beverage known variously as "mahewu" in Southern Africa and "uji" in East Africa (Schwegart and Fellingham 1963; Akinrele 1970; Mbugua 1984). In West Africa, the processing of maize into "ogi" in Nigeria, or "akasa/koko" in Ghana, involves fermentation of the grain by the following method: the maize is soaked in water overnight, then wet-milled; the resulting paste is then mixed with water; this is followed by the filtration and decantation of the supernatant water. The remaining paste, mostly starch, contains the raw materials used in the final cooking of the "ogi" or "akasa" (Ketiku and Omololu 1988; Orraca-Tetteh 1988). Similar processing of maize is common in most urban areas in Tanzania. This type of flour (vividly white and starchy) has no common Swahili name, as opposed to "sembe" and "dona," prepared from dehulled maize and whole maize grain, respectively. Where this practice is used, the flour from the family pot would normally be used in the preparation of "uji" for infant feeding.

According to Mbugua (1984) in Kenya, "uji" is prepared predominantly from maize flour or meal; a mixture, however, of maize and millet or sorghum flours is sometimes preferred. The flour mixture is slurried with water and allowed to ferment at room temperature for 1-3 days, after which it is diluted to the desired consistency, then boiled and sweetened with sugar. The final pH of most "uji" preparation in Nairobi is more than 4.5. Typical "uji" samples have been prepared by making a 30% flour slurry mixture composed of 80% maize and 20% sorghum or millet in tap water and fermenting at 25°C (Mbugua 1984). To achieve a consistency suitable for the feeding of children at a temperature of about 40°C, the final dilution before boiling should bring the final flour content in the slurry to 8-10% (Mosha and Svanberg 1983; Mlingi 1988).

Fermentation of Cereal/Legume Mixtures

Fortification of cereal weaning foods with legumes is a widely recommended and practiced method in Tanzania. As mentioned earlier, a mixture of groundnut to cereal flour in proportions ranging from 1:1 to 1:2 is common (Semoka, personal communication). In Tanzania, the provision of at least one meal of cereal "uji" mixed with a legume or with milk is standard practice in nearly all preprimary nursery schools for children 3-6 years of age. At the Livestock Training Institute (LITI), Morogoro, the "uji" given to preschool children contains 3 parts maize meal and 1 part soybean flour, with the addition of sugar.

We investigated the fermentation characteristics of maize flour supplemented with increasing proportions of soybean flour. The flour mixtures were slurried in potable water at the rate of 10%, then left to ferment at room temperature. The pH development of duplicate determinations during a period of 48 h is shown in Table 1. Table 1 also indicates the stability of the heated gruels, and gives one person's judgment of their consistency and flavour. The inclusion of soybean flour in maize slows the pH development considerably: acidification is impaired with the inclusion of more than 50% soybean; at such levels, the water will separate out during the heating and cooling of the gruels. These preliminary results show that to produce an acceptable fermented product within 48 h, the quantity of soybean flour in the mixture should not exceed 40%; levels between 20 and 30% give a product with optimum consistency and flavour. A 70/30 mixture of maize/soybean is reported to give maximum improvement in the protein quality of weaning foods (Mitzer et al. 1984).

Legume Food Fermentations

Because they are widely available and contain quantities of protein and B vitamins, legumes are extremely important from a nutritional point of view. They provide excellent supplementation for the predominantly cereal- and root crop-based weaning foods in Tanzania. When pulses and cereals are mixed, they supply protein that contains adequate quantities of all the amino acids and is, therefore, of high quality (Latham 1965). It has also been found that the nutrient density of fermented cassava is increased through supplementation with legumes (Mlingi 1988). Some high-protein legumes, however, such as soybean (*Glycine max*) and winged bean (*Psophocarpus tetragonolobus*) are yet to gain popularity in Tanzania: intense beany odour and bitter taste are among the characteristics that have impeded their consumer acceptability.

In the Orient, soybeans have been eaten for centuries. The food prepared from these beans can be divided into two categories - unfermented and fermented. The preparation of fermented soybeans is perhaps the most common application of fermentation technology at the household level in the Orient. The major unfermented foods are soymilk, "tofu" or soymilk curd, yuba, kinako sprouts, and green soybeans. Many types of fermented foods or flavourings are prepared; some examples are "sufu," "natto," soysauce, and "tempeh." The general description of these products is given by Harris and Karmas (1975) among others. In Indonesia, pulverized "tempeh" combined with cereal-based porridge, salt, fish, or "tofu" is widely used as a weaning food.

Fermentation technology has also been used at Morogoro as a means of increasing the acceptability of the winged bean and its products. Winged bean mash was fermented separately with various proportions of cereal flours, such as rice, wheat, maize, and cassava. Yeasts and *Pediococcus* predominated among the ferments. It was found that products fried in oil, similar to Indian "dosa" made from these ferments, were preferred to plain winged beans; winged beans and rice flour in 1:3 proportions produced the favoured "dosa" (M. Seenappa et al., unpublished).

Table 1. Fermentation characteristics of soybean/maize meal mixtures (10% mixed flour in water).

	% soybean flour										
	100	90	80	70	60	50	40	30	20	10	0
pH at 0 h	5.5	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.8	6.2
pH at 24 h	5.4	5.2	5.1	5.1	4.8	4.4	4.5	4.3	4.2	4.1	4.1
pH at 48 h	4.6	4.6	4.5	4.4	4.3	4.1	4.1	4.0	3.9	3.7	3.5
Stability on heating ^a	---	---	--	-	+	+	++	+++	+++	+++	+++
Viscosity at 40°C ^b	TTT	TTT	TT	TA	TA	A	AA	AAA	AAA	AAA	AAA
Flavour ^c	ppp	ppp	ppp	G	G	G	GG	GG	GGG	GGG	GGG

a---, water separation at 40°C, very high; --, water separation at 40°C, high; -, water separation at 40°C, moderate; +, no water separation at 40°C; ++, stable gruel at 40°C; +++, normal gruel at 40°C.

bTTT, too thin; TT, thin; TA, thin but acceptable; A, acceptable; AA, good; AAA, very good.

cppp, very poor; G, acceptable; GG, good; GGG, very good.

Influence of Fermentation on the Consistency of "Uji"

It should be expected that the presence of starch-hydrolyzing microorganisms will reduce the water-binding capacity of the slurries; a less viscous "uji" can therefore be obtained at higher levels of dry matter content. Studies, however, of the microbial flora of spontaneously fermented cereal "uji" or of "uji"-like products showed that amylolytic microorganisms were only a small proportion of the total flora (Akinrele 1970; Mbugua 1984; Mlingi 1988). To achieve sufficient starch hydrolysis, optimal conditions for the activity of the starch-hydrolyzing enzymes must be provided. Table 2 shows the principal starch-hydrolyzing enzymes and their optimal cultural conditions.

Both alpha- and beta-amylase have an optimal pH of 4.5 (Van Veen and Steinkraus 1970); below pH 4, their activity is greatly reduced (Mlingi 1988). Our own laboratory experience is that the pH of 10-30% maize slurry drops from about pH 6 to pH 4.1-4.4 within a 24-h incubation at room temperature (24-28°C). Amylases of germinated cereals (malt) in particular seem to be substantially active over a wide range of temperature (20-70°C). Beyond 70°C, their activity is greatly reduced (Mitzer et al. 1984). The duration of time of action does not seem to be critical.

Significant reduction of viscosity of gruels has been achieved within 5 min of the addition of alpha amylase or of germinated flour to starchy gruels (Karlson and Svanberg 1982; Mosha and Svanberg 1983). Were the type of spontaneous fermentation described by Mbugua (1984) producing sufficient quantities of amylases, neither the pH, nor the incubation temperature, nor the time duration would be

Table 2. Optimal conditions of amylolytic enzymes.

Enzyme	Principal source	Optimal pH	Temperature (°C)	Effect on starch
α -amylase	Pancreas, malt microorganisms (<u>Candida tropicalis</u>)	4.5-7	60-70	Breaks down starch to oligosaccharide with 6 or 7 glucose residues. Rapid decrease of starch viscosity.
β -amylase	Higher plants, cereals, malt, soybeans	4.5	50-60	Breaks down starch to maltose. Slow decrease of starch viscosity.
Amyloglucosidase	Bacteria, yeast, moulds (<u>Aspergillus niger</u>)	2.5-4.4	60	Breaks down starch to glucose. Industrial production of glucose from starch.

Source: Solms (1978).

limiting factors in the reduction of viscosities in such gruels. Available evidence (Table 3) indicates that fermentation by soaking in water does not favour amylase-producing microorganisms sufficiently to effect a noticeable reduction in viscosity.

On the other hand, air-dry fermentation of cassava seems to produce a marked amylolytic activity: this presumably is due to the presence of yeasts and fungi in larger quantities than would result from wet fermentation (Mlingi 1988). It would be interesting to investigate the possibility of enhancement of starch hydrolysis through the fermentation of moist doughs of cereal flours; conditions would need to favour the growth of yeasts, fungi, or both, and particular attention would have to be paid to the possibility of a growth of toxin-producing fungi and black moulds that could discolour the flours. On the basis of available information, it seems reasonable to conclude that fermentation of cereal gruels by soaking is not an effective means of reducing their bulkiness.

Effect of Fermentation on the Nutritional Value of Cereal and Legume Foods

Careful interpretation is required of studies on fermentation and the nutritive value of cereals: conflicting results may arise from differences in the assay techniques employed and in the microorganisms involved. Van Veen and Steinkraus (1970) concluded from various studies carried out in their laboratory that fermentation does not seem to improve the nutritive value of the protein; results of Akinrele (1970) did, however, show slight increases of 8 and 25% in total nitrogen and amino acid nitrogen, respectively, during traditional fermentation of "ogi." Earlier studies (Rajalakshmi and Vanaja 1967; Akinrele 1970; Van Veen and Steinkraus 1970) and more recent ones (Hamad and Fields 1979; Aliya and Geervani 1981; Kazanas and Fields 1981; Murdock and Fields 1984; Nanson and Fields 1984; Dhankar and Chauhan 1987) all seem to agree that fermentation increases the content of certain vitamins, particularly thiamine, riboflavin, and to a lesser extent, niacin. At the same time, a decrease in some vitamins, particularly pantothenic acid, has been recorded (Akinrele 1970; Van Veen and Steinkraus 1970).

Improvements in nutritive value have also been shown to occur during the fermentation of legume foodstuffs; an example is provided

Table 3. Effect of fermentation techniques on viscosity of gruels.

Treatment	Effect on viscosity	Source
Soaking sorghum flour overnight	No reduction in viscosity	Mosha and Svanberg (1983)
Soaking cassava chips in water for 3-6 days	No reduction in viscosity	Mlingi (1988)
Air-dry cassava chips for 3-6 days	22-50% reduction in viscosity	Mlingi (1988)

by "tempeh," made from fermented soybean (Gyorgy 1962). Such improvements have been attributed to increased digestibility, brought about by proteolysis of the complex proteins to peptides of varying length and amino acids (Smith and Circle 1972). Similar changes have been shown to occur during the fermentation of "idli," an Indian product made by mixing black gram (*Phaseolus mungi*) and rice (Gyorgy 1962). There is, therefore, adequate scientific evidence to show that the chemical changes taking place during the fermentation of legumes enhance their nutritional quality. The processing methods used for the preparation of flours also influence considerably the nutritive value of the cereals produced. The West African method of processing the flour of "ogi" or "akasa" is wasteful of nutrients and has been shown to result in a decrease of protein content by as much as 50% and of fat extract by 27% (Ketiku and Omololu 1988). The best products, from a nutritional point of view, are those prepared from whole grain meals. There is, no doubt, an additional but small improvement in the nutritional value as a result of fermentation. This improvement, however small, should be fully exploited in the feeding of children. Other advantages of traditionally fermented foods include ease of digestibility, better storage capability, enhanced flavour, and reduction in cooking times (Van Veen 1970; Harris and Karmas 1975).

Acceptability of Fermented Cereal/Legume Foods

Whatever the nutritional advantages of a food, the following factors will determine its consumption by the targeted consumer group: relative cost, availability, and organoleptic acceptability (acceptability of its flavour). In this latter respect, fermented foods usually present an improvement over the unfermented (Herseltine and Wang 1972); this improvement has been attributed to the production during fermentation of lactic acid, carbon dioxide, alcohol, various flavour compounds, and changes in texture (Pederson 1971).

The decision was made to test the acceptability of fermented gruels for preprimary nursery school children 3-7 years of age. Forty-five children of the Sokoine University Nursery School were used in the test. Maize flour prepared for normal domestic use (the making of hard porridge) was slurried in water at the rate of 10%. About 5 L of the slurry was incubated at ambient temperature for 48 h, during which the pH dropped to 4. As a control, 5 L of gruel of unfermented flour was prepared on the test day. To both samples, sugar was added at the rate of 4%. The samples were presented to the children in a paired preference test. The same experiment was repeated with unfermented gruel, acidified to the same pH as the fermented control sample. Forty-eight children participated in this test.

The results showed that when fermented "uji" of pH 4 was offered along with unfermented "uji," 58% of the children preferred the former; this preference was not, however, significant at $P \leq 0.05$. In the second trial, the children were asked to choose between "uji" acidified, with lemon juice, to the same pH as the fermented "uji"; 60% of the children preferred the former. It can be inferred from these results that the children did not show a preference for either product. Although these results are only preliminary, they show that because of the improved nutritional quality and flavour of fermented "uji," the provision of this food to preschool children should be encouraged.

Summary and Conclusions

It is clear from the scientific evidence cited in this article and from observations made on traditional practices that several options exist for an improvement of the nutritional value of cereal-based weaning foods. Supplementation with legumes is a practical way of improving the protein quality of cereal gruels and is a practice that is both widely recommended and widely followed in Tanzania. Traditional fermentation techniques do not appear to cause sufficient starch hydrolysis to influence significantly the dietary bulk of the gruels; such is not the case with germinated flours. Modifications that favour the growth of amylolytic microorganisms and lactic acid producing bacteria would have to be developed to enable the production of gruels with higher nutrient densities. Results of preliminary investigations showed that fermentation did not impair the acceptability of gruels among preschool children tested. It is concluded, therefore, that fermented gruels can, to some extent, be used to improve the nutrition of children.

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