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Vitamin A reduces the inhibition of iron absorption by phytates and polyphenols

Miguel Layrisse, María Nieves García-Casal, Liseti Solano, María Adela Barón, Franklin Arguello, Daisy Llovera, José Ramírez, Irene Leets, and Eleonora Tropper

Abstract

In searching for an explanation for the rapid response to iron-fortification programmes, we focused on the interaction of vitamin A and inhibitors of iron absorption from a basal breakfast containing bread from either pre-cooked maize flour or wheat flour plus cheese and margarine. These breads were labeled with either ^{59}Fe or ^{55}Fe. These experiments demonstrated that vitamin A prevented the inhibiting effect of polyphenols and phytates on iron absorption. It was also demonstrated that vitamin A had the same effect on iron absorption as phytase.

Introduction

The project for fortification of pre-cooked maize flour and white wheat flour with iron and vitamins (vitamin A, thiamine, riboflavin, and niacin) on a national scale was initiated in Venezuela in 1993 (table 1).

One year after the fortification was begun, a survey was conducted on schoolchildren of both sexes 7, 11, and 15 years of age, living in Caracas under low socio-economic conditions. Comparison between a survey conducted in 1992, before the fortification programme was begun, and a 1994 survey of children of the same age and socio-economic stratum showed that the prevalence of iron deficiency had been significantly reduced from 37% to 16% and the prevalence of anaemia from 19% to 10%. This was confirmed by the iron reserve values, as measured by the serum ferritin concentration of all subjects tested, which increased from a median of 15 μg/L in 1992 to a median of 21 μg/L in 1994 [1].

Such results were impressive and provocative, since iron fortification usually takes a considerably longer time to produce favourable results [2]. These results motivated the authors to begin iron absorption studies to determine if the changes could be explained by characteristics of the fortified flours.

TABLE 1. Enrichment of food vehicles in Venezuela

Nutrient	Pre-cooked maize flour	White wheat flour
Vitamin A (IU/kg)	9,500	–
Thiamine (mg/kg)	3.1	1.5
Riboflavin (mg/kg)	2.5	2.0
Niacin (mg/kg)	51.1	20.0
Iron[a] (mg/kg)	50.0	20.0

a. Ferrous fumarate.

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Materials and methods

The first study was performed with a basal breakfast composed of bread made from either pre-cooked maize flour or wheat flour tagged with either ^{59}Fe or ^{55}Fe, plus 50 g of cheese and 10 g of margarine (table 2). In the first iron absorption test, the subjects received only the basal breakfast. In the other tests, they received the basal breakfast with various concentrations of coffee. The basal breakfast alone was administered on the first day after an overnight fast. The second meal was given on the afternoon of the same day.

The administration of food labelled with ^{59}Fe or ^{55}Fe in the morning after an overnight fast and on the afternoon of the same day was based on experiments previously published. Four-hour intervals between meals are sufficient for iron absorption studies [3]. Blood was drawn 15 days later to determine the haematological profile and measure the radioactivity. Blood was drawn again on the 30th day to measure the ^{59}Fe or ^{55}Fe and the ferritin concentration. Methods of measurement of radioactivity and haematological variables have been published previously [1, 4].

TABLE 2. Iron absorption in children 7 to 15 years of age given a basal breakfast with coffee[a]

Subjects and sex	Haemoglobin (g/dl)	Serum transferrin saturation (%)	Serum ferritin concentration (μg/L)	Iron absorption (%) from breakfast consisting of[b]:				
				A	B	C	D	E
Basal breakfast of maize bread, cheese, and margarine								
4M, 3F	11.9 ± 0.2	20 ± 0.5	17 ± 1	5.1 ± 1.4	7.7 ± 1.4	8.2 ± 1.4	7.8 ± 1.3	
1M, 9F	14.3 ± 0.4	27 ± 1	26 ± 1	4.4 ± 1.3	5.3 ± 1.3	4.6 ± 1.5		3.1 ± 1.5
Average of above 2 groups	13.3 ± 0.4	24 ± 2	22 ± 1	4.7 ± 1.3	6.1 ± 1.5	5.8 ± 1.5		
Basal breakfast of white wheat bread, cheese, and margarine								
2M, 8F	12.9 ± 0.8	29 ± 1	28 ± 2	6.8 ± 1.2	1.2 ± 1.4[c]	0.4 ± 1.4[c]		0.7 ± 1.2[c]

a. The basal breakfast consisted of bread made from either pre-cooked maize flour or commercial white wheat flour fortified with ferrous fumarate, plus 50 g cheese and 10 g margarine. Values are means ± SEM.
b. A, Basal breakfast alone; B, basal breakfast + 2 g American coffee; C, basal breakfast + 4 g espresso coffee; D, basal breakfast + 4 g cappuccino coffee; E, basal breakfast + 4 g espresso coffee.
c. Significantly different from absorption from breakfast A ($p < .05$).

In the first experiment, the bread was prepared from enriched, pre-cooked maize flour. The percentage of iron absorbed was practically the same when the breakfast was given alone and when it was given with various concentrations of coffee. When the breakfast was prepared from wheat flour, the percentage of iron absorbed decreased from 6% when the breakfast was given alone to less than 1% when it was given various concentrations of coffee (table 2).

The only vitamin present in pre-cooked maize flour and not in wheat flour was vitamin A. This difference encouraged the authors to perform further studies using pre-cooked maize flour fortified only with 5 mg of iron (as ferrous fumarate) per 100 g of flour.

In the next experiment, the basal breakfast was given alone in test A, with 1,000 IU of vitamin A in test B, and with 1,000 IU of vitamin A and 8 g of coffee in test C (table 3). Finally, the basal breakfast was given with coffee only in test D.

Results

The percentages of iron absorbed in tests A and C were not significantly different, indicating that vitamin A prevented the inhibitory effect of the polyphenols contained in coffee. This effect was not evident in test D, in which the breakfast was administered with coffee only. Iron absorption from the breakfast given alone (test A) was then compared with iron absorption from the breakfast enriched with 1,000 IU of vitamin A (test B)(table 3). The percentage of iron absorbed in test B was almost twice that absorbed in test A. All flours contain phytate, which is another inhibitor of iron absorption. In this experiment, vitamin A prevented the binding of phytate to iron.

The next experiment was designed to find out if the effect of phytase was similar to the effect of vitamin A on iron absorption. Table 4 compares iron absorption from the breakfast prepared with 50 g of pre-cooked maize flour (test A) with iron absorption from the same breakfast enriched with 1,000 IU of vitamin A (test B), and with iron absorption from the same breakfast in which the flour was mixed with 304 U of phytase, which reduced the phytate content of the flour from 150 to 40 mg/100 g. In this experiment, iron absorption in tests B and C was more than three times that in test A, when the breakfast was given alone, thus demonstrating that vitamin A has the same effect as phytase on the absorption of iron from cereals.

The incorporation of 1,000 IU of vitamin A in the basal breakfast made from commercial wheat flour was ineffective, because 50% of the vitamin A was denatured by the effect of yeast in the dough. Moreover, after baking it was further reduced to about 100 IU. This can be compensated for by dissolving 1,000 IU of vitamin A in water and drinking it slowly while eating the breakfast, or by incorporating 2,000 IU of vitamin A in the basal breakfast made with wheat flour.

Discussion

The same effects of vitamin A—to increase nonhaem iron absorption and to prevent the inhibitory effect of phytates and polyphenols—have also been demonstrated with β-carotene [5]. Vitamin A is an essential nutrient for vision, bone growth, cellular differentiation, and the integrity of the body's immune system [4]. It has been suggested that it is also essential for erythropoiesis [6–10].

This unexpected behaviour of vitamin A in reducing

TABLE 3. Iron absorption from a basal breakfast enriched with vitamin A and/or served with coffee[a]

Subjects and sex	Haemoglobin (g/dl)	Serum transferrin saturation (%)	Serum ferritin concentration (μg/L)	Iron absorption (%) from breakfast consisting of[b]:			
				A	B	C	D
1M, 17F	12.5 ± 0.2	25 ± 1	13 ± 1	5.8 ± 1.1		8.5 ± 1.2	2.0 ± 1.2[c]
4M, 8F	14.6 ± 0.3	28 ± 2	52 ± 1	2.7 ± 1.1	5.1 ± 1.1[d]		

a. The basal breakfast consisted of bread made from pre-cooked maize flour fortified with ferrous fumarate, plus 50 g cheese and 10 g margarine. Values are means ± SEM.
b. A, Basal breakfast alone; B, basal breakfast + 1,000 IU vitamin A; C, basal breakfast + 1,000 IU vitamin A + 8 g espresso coffee; D, basal breakfast + 8 g espresso coffee.
c. Significantly different from absorption from breakfast C ($p < .05$).
d. Significantly different from absorption from breakfast A ($p < .05$).

TABLE 4. Iron absorption from a basal breakfast with added vitamin A or phytase[a]

Subjects and sex	Haemoglobin (g/dl)	Serum transferrin saturation (%)	Serum ferritin concentration (μg/L)	Iron absorption (%) from breakfast consisting of[b]:		
				A	B	C
4M, 9F	12.3 ± 0.4	26 ± 2	19 ± 1	3.6 ± 1.1	10.6 ± 1.1[c]	15.4 ± 1.1[c]

a. The basal breakfast consisted of bread made from 50 g pre-cooked maize flour with 2.5 g ferrous fumarate added, plus 50 g cheese and 10 g margarine. Values are means ± SEM.
b. A, Basal breakfast alone; B, basal breakfast + 1,000 IU vitamin A; C, basal breakfast + 304 U phytase.
c. Significantly different from absorption from breakfast A ($p < .05$).

the inhibition of iron absorption by phytates and polyphenols is apparently a newly discovered property of vitamin A. The results suggest that vitamin A binds iron during the digestive process and forms a complex that acts as a chelating agent, thus blocking the effect of hydroxyl radicals present in phytates and polyphenols [4].

Present and future food fortification programmes should consider adding vitamin A to the enrichment mix for the control of iron deficiency.

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Maternal preferences for consistency of complementary foods in Guatemala

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Abstract

Increasing the nutrient density of complementary food mixtures is a common strategy for improving child nutrition in developing countries. Such modification, however, typically increases the viscosity of the mixtures, which may not appeal to caretakers or children. To assess maternal preference for complementary food consistency, 46 rural Guatemalan mothers, each of whom had a child between 6 and 14 months of age, were interviewed by trained data collectors and participated in focus group discussions. Strong opinions regarding consistencies of complementary foods were identified, which varied according to the child's age and health status. Mothers preferred thinner complementary foods for children less than one year old and thicker foods for children more than one year old. When the child had a cough or fever, most mothers preferred thin, liquid complementary foods. When the child had diarrhoea, about half of the mothers believed thinner complementary foods would replace the water the child lost with diarrhoea, whereas other mothers believed that thicker complementary foods would harden the stool or stop diarrhoea. This information will help guide efforts to develop improved complementary foods, particularly those for use during illness in underprivileged populations of developing countries.

Introduction

The World Health Organization (WHO) recommends that children begin complementary feeding in addition to breastmilk between four and six months of age in order to ensure adequate growth and nourishment [1]. In many developing countries, however, traditional complementary food gruels are based on starchy staple foods, such as wheat, rice, maize, or sorghum, that produce viscous porridges that are difficult for children to consume [2, 3]. As a result, mothers commonly dilute the porridge with water to reduce its viscosity [4, 5]. Such dilution, however, also reduces the energy density of the mixture [3]. Since young children have small gastric capacities, they are unable to consume enough of the diluted porridge to meet their energy requirements and consequently may become malnourished. This problem of high viscosity, low energy density, or both in complementary food is often referred to as "dietary bulk" [3]. Children consuming these foods grow poorly [6] and have higher mortality rates [7].

Increasing the nutrient density of complementary foods is a strategy commonly recommended for improving child nutrition [5, 8]. However, increasing the nutrient density of a complementary food may change its consistency from liquid or easily spoonable to thicker and dough-like. It is commonly suggested that foods of higher viscosity are less acceptable to the mother or to the child [9–12], although no published studies could be identified that specifically attempted to quantify this perception. The inadequacy of the information in this area is particularly striking, because a great deal of effort has already been invested in strategies to reduce the viscosity of complementary foods of high nutrient density, most commonly with the use of amylase-rich flours [5, 9, 13–16].

Qualitative research carried out in the same community where the current study was conducted found that indigenous Cakchiquel-speaking Guatemalan mothers displayed unexpectedly well-defined and detailed notions of food consistency (personal communication, E. Hurtado, 1992). Table 1 summarizes these classifications and provides examples of foods associated with various local terms for consistency. The objective of the current study was to measure more accurately, both qualitatively and quantitatively, the maternal preference for consistency of complementary foods in relation to the age and health status of the

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TABLE 1. Classification of foods according to consistency by mothers in Santa María de Jesús, Guatemala

Cakchiquel term	Literal meaning of Cakchiquel term	Spanish term	Foods reported as belonging to Cakchiquel category
Ya', pura ya'	Water or like water	*Liquida*	Coffee, broths, *topogigio, fresco,* incaparina (if it is thin)
Ma can ta ya' ya', Ya' yoj	Not like water, not thick	*Rala/liquida*	Thin gruels (*atol*) and sauces like *pepian, hilachas*
Co ru ya'	Has its water	*Rala*	Green leafy vegetables that are cooked in water, *caldo,* or broth
Cuor	Soft and can be mashed	*Media*	Avocadoes, bananas, squash
Tzapor, ja'roch	Thick foods	*Espesa*	Bread soaked in coffee, ground beans, pieces of tortilla soaked in bean broth, noodles, eggs, *puliques,* tomatoes, radishes, other vegetables and fruits, thick gruels, *atol* (incaparina and pap offered by INCAP)
Chak'ej, chie'	Dry or hard	*Duro, seco*	Tortillas, rice, beans, fish, meat, eggs, hard-boiled eggs, whole beans, cheese

Source: E. Hurtado. Qualitative research on infant and child feeding in Santa María de Jesús. Unpublished manuscript. Guatemala City: Institute of Nutrition of Central America and Panama (INCAP), 1992.

child, and the maternal preference for two improved gruels of different known viscosities.

Methods

Study site

The study was conducted in August 1995 in the community of Santa María de Jesús, which is located in the central highlands of Guatemala on the slope of Agua Volcano, 55 km south-west of Guatemala City and 10 km south of Antigua, in the department of Sacatepéquez. It is a traditional rural community with approximately 15,000 inhabitants, most of whom are descendants of the Mayan Indians and speak Cakchiquel, one of the 23 indigenous languages spoken in Guatemala. Many Santa Marienses, especially the men, also speak Spanish. The primary religion is Catholicism, but Evangelism is becoming increasingly present in the community. The male heads of households are predominantly (82%) subsistence farmers; the main crops are corn, black beans, peas, tomatoes, and coffee. Women are seldom formally employed, although many women sell food or crafts in the marketplace. The majority of adults, especially women, have had little schooling. The literacy levels among people over 10 years of age are 77% for males and 39% for females.

The socio-economic, health, sanitary, and nutritional characteristics of the community have been described in detail elsewhere [17–19]. Briefly, the housing quality is poor, as most homes have cornstalk walls, tin roofs, and dirt floors. Pit latrines are the most common means of human waste disposal. Most homes have electricity but no piped water; consequently, women must gather water daily from centrally located wells. The basic diet of adults and older children is composed largely of maize tortillas and black beans. Children typically are breastfed from birth up to the age of about two years. Complementary foods are commonly introduced at around six months of age. Foods most often used to complement breastmilk include locally produced cereal-based gruels and porridges (*atols*), coffee with sugar, tortillas and bread dipped in coffee, bananas, and broths. These foods are generally fed to children by cup or spoon. Between the ages of one and three years, the growth of these children is poor, and by the age of three, over 50% of the children are stunted (height-for-age Z score < -2 relative to the WHO reference).

Data collection

The study employed a series of individual interviews and focus group discussions with the mothers of 46 children (aged 6–14 months) who were participating in a study on amylase-complemented foods [20]. Individual interviews and focus group discussions were conducted by bilingual (Cakchiquel–Spanish) women from the local community who visited the study participants at home and spoke with the participants in their native language, Cakchiquel.

The individual questionnaire addressed the maternal preference for consistency of complementary foods in relation to locally available foods that were commonly consumed by weaning-age children. For certain questions related to preferences, mothers were given a

choice of five answers: thick, like corn dough (Spanish: *espeso como masa de maiz;* Cakchiquel: *tzapor*); thin, like a liquid drink (Spanish: *ralo como atol;* Cakchiquel: *ya' yoj*); medium, semi-liquid consistency, thinner than corn dough but thicker than a liquid (Spanish: *medio;* Cakchiquel: *cuor*); no preference; or other. The foods associated with the terms "thick" and "thin" (*masa de maiz* and *atol*, respectively) were well known in the community, and there was minimal variation in their preparation. *Masa de maiz* is maize dough used to make tortillas and is similar in consistency to cookie or bread dough. *Atol* is a liquid drink made with water, cereal grains, and sugar and is similar in consistency to cream or thin gravy.

The first part of the individual questionnaire addressed maternal preference for the consistency of locally provided complementary foods according to the following categories: in general (without specifying age or health status); according to specific age categories (six months to one year [the early weaning period] and older than one year [mid to late weaning period]); and according to the health status of the child (healthy, cough or fever, diarrhoea). The second part of the interview questionnaire asked about the consistency of two experimental complementary food gruels of known viscosity that were being used in the larger intake study (table 2). The mothers were shown the two experimental gruels and instructed to stir them with a spoon, comment on their differences, judge their consistency, and select the preferred gruel, in response to specific questions.

Upon completion of the individual questionnaire interviews, four focus group discussions were conducted, with the objective of soliciting additional qualitative information on preferences. All 46 mothers who were interviewed were invited to participate in the focus group discussions; 39 (85%) of the mothers participated. They were randomly assigned to focus groups in accordance with their work schedules. The questions asked by the moderator mirrored those asked during the individual interviews. The focus group discussions were tape-recorded and translated into Spanish by the moderator.

Results

The participant mothers ranged in age from 16 to 39 years (mean, 28.8 years), had had a mean number of 5.1 pregnancies (range, 1–12), and had completed a mean of 1.3 grades (range, 0–6) in primary school. Thirty-three (72%) of the mothers spoke Spanish fluently. The children ranged in age from 6 to 14 months (mean, 9.1 months). The questionnaire results revealed that most mothers (77%) preferred to spoon-feed their children, 15% preferred to use a cup or bottle, and 8% preferred to feed by hand.

Age of the child

Table 3 shows the results of the individual questionnaires on maternal preference of complementary food consistency based on the age of the child. In general, mothers preferred to feed younger children thinner foods and older children thicker foods. A majority of the mothers (63%) stated that they preferred to feed an easily spoonable, semi-liquid gruel when the child was less than one year old. When the child was one or more years of age, however, more mothers preferred to feed the child thicker complementary food gruels, ranging from an easily spoonable, semi-liquid consistency (33%) to a thick, dough-like consistency (48%).

The focus group discussions confirmed these results and provided qualitative insight into them. Nearly all women participating in the focus groups felt that the consistency of the complementary food should change according to the age of the child. Many commented that children one or more years of age needed a thicker complementary food that would "fill their stomachs"

TABLE 2. Characteristics of experimental complementary foods

Food	Energy density (kcal/100 g)	Viscosity (cps)[a]	Consistency
Traditional (control)	100	14,500	Semi-solid, spoonable, like pudding or mayonnaise
Low-viscosity[b]	100	4,200	Semi-liquid, easily spoonable, like cream or thick gravy

a. Viscosity measurements were made with a Brookfield viscosimeter, spindle no. 6 (50.0 rpm), at 30°C.
b. Maize malt was added (0.2 g/100 g gruel) to reduce the viscosity.

TABLE 3. Number (percent) of mothers preferring different consistencies of improved, energy-dense complementary food gruels, according to age of child (n = 46)

Preferred consistency of food	Age of child	
	< 1 yr	≥ 1 yr
Thick, like corn dough *(espeso como masa de maiz)*	8 (17)	22 (48)
Medium (semi-liquid, easily spoonable, thinner than corn dough and thicker than a liquid)	29 (63)	15 (33)
Thin like a liquid drink *(ralo como atol)*	7 (15)	6 (13)
No preference	2 (4)	3 (7)

because their "stomachs are large and they normally eat very little." Notably, in Cakchiquel the same expression, *ni nim rupan*, means "large stomach" and "big appetite." Other mothers reasoned that "older children could take hold of the complementary food and eat it if it was thick." The following are examples of responses to the question "Do you believe that the consistency of a complementary food mix should change according to the age of the child?":

» Yes. Depending on the age of the child, the consistency of the food will change. As the child grows, he wants very thick complementary food so that it will sustain him. If it is thin, it is the same as breastfeeding or nursing, and that is not going to fill him.

» Yes. The consistency of complementary food should change, because large children are not the same as small children. When children are small, I give them complementary food that is a little thin so that they can eat it, but when they are large, I give them complementary food that is thick so that it sustains the stomach, because the stomach is already large.

Health status of the child

The results of the individual questionnaires and the maternal preferences for complementary food consistency, based on the child's health status and age, are presented in table 4. Mothers exhibited no overwhelming preferences for particular complementary food consistencies for healthy children. Rather, when the children were well, the mothers would feed them foods of all types of consistencies, but felt that the food should be "smooth" so that the child could "swallow it quickly" and so that it would "fill the stomach."

If a child was sick, however, strong beliefs about complementary food consistencies emerged. Almost all mothers (78%) preferred to feed children thin complementary foods when they had a fever or cough (table 4). Focus group discussions provided insight into the beliefs behind these results. An overriding concern expressed in the focus groups was that "children don't want to eat at all when they are sick." For most women, this concern about illness-induced anorexia was more important than the consistency of the complementary food during illness. If a feverish child did eat anything, however, most women thought that the food should be of a thin, liquid, or semi-liquid consistency, so that the child "can swallow it" and so that it "can go down the throat easily." One woman said, "When my child is sick, he is thirsty," and stated that if she gave him thick complementary food he would not eat it. If it was too thick, she said, "It sticks in the child's mouth and he doesn't swallow it." The following are other representative responses to the question "What consistency of complementary food do you prefer to feed your child when she/he has cough or fever?":

» The complementary food should be very thin so that the child will eat it and so that it will go down the throat easily.

» When my child has cough or fever, I give him thin food because it helps with his thirst and nausea.

For a child with diarrhoea, two opposing opinions emerged in both the individual interviews and the focus groups, particularly for younger children (six months old). In the interviews, about half of the mothers preferred to feed younger children thinner, liquid-like foods, whereas about one-third preferred to give foods of a thick consistency (table 4). In the focus groups, qualitative insights into these two opposing schools of thought regarding the optimal consistency of the complementary food were obtained. Mothers who preferred to give thinner foods to children with diarrhoea did so in order to replace the water that the child lost. For example, they said:

» When they have diarrhoea, they are thirsty, and because of this they will take a little food if it is thin. With diarrhoea you should only give liquid food to help soothe the thirst and replace the liquid that is lost.

» I prefer to feed liquid complementary food because it helps to replace the liquid that is lost in diarrhoea. On the other hand, mothers who preferred to give

TABLE 4. Number (percent) of mothers preferring different consistencies of complementary foods, according to age and health status of child (n = 46)

Preferred consistency of food	Age and health status of child					
	6 mo			12 mo		
	Healthy	Cough or fever	Diarrhoea	Healthy	Cough or fever	Diarrhoea
Thick	13 (28)	2 (4)	16 (35)	16 (35)	3 (7)	12 (26)
Medium	6 (13)	3 (7)	4 (9)	11 (24)	2 (4)	10 (22)
Thin/liquid	14 (31)	36 (78)	22 (48)	3 (7)	36 (78)	19 (41)
No preference	13 (28)	0 (0)	2 (4)	16 (35)	0 (0)	2 (4)
Child won't eat or mother doesn't feed child	0 (0)	5 (11)	2 (4)	0 (0)	5 (11)	3 (7)

children with diarrhoea thicker complementary foods did so because they felt it hardened the stool and stopped the diarrhoea:

» I give him thick food because it helps to plug up the child and stop the diarrhoea. If I give liquid food it makes the child worse. I also give thick food during diarrhoea because it helps to calm him and alleviate the diarrhoea.

» I prefer to feed my child thick food because it hardens the stomach. If I give him liquid food I think that it could make him worse because it loosens the stomach.

Finally, when the mothers were shown the two semi-liquid complementary gruels used in the energy-intake study (table 2), 22 (48%) reported they would prefer to feed their well children the thicker of the two gruels, 17 (37%) said they would prefer the thinner, and 7 (15%) had no preference. Unfortunately, the mothers were not asked which of the foods they would prefer to give their sick children.

Discussion

This study was conducted to better understand maternal preferences for consistency of complementary foods and to determine if and how maternal preference varied according to the age and health status of the child. The results suggested that indigenous mothers in this rural Guatemalan community made clear distinctions among food consistencies and had strong preferences for different consistencies according to the age and health status of their children. The mothers preferred to feed older children thicker foods because they felt that these foods better filled the stomachs of larger, older children. When a child was well, food consistency was not a major concern. When a child was ill, however, the mothers had strong opinions regarding food consistency according to the type of illness. When a child had cough or fever, the mothers consistently preferred to give thinner foods. When a child had diarrhoea, some mothers preferred to give thin foods to replace the water lost, whereas others preferred to feed thicker foods to harden the stool or "stop up the child." The lack of apparent preference for either of the two experimental foods may be due to the similarity in their consistency: both were semi-liquid, differing in viscosity by only 10,000 cps.

Few published studies specifically report maternal preferences for complementary food consistency. A few studies have some anecdotal information on maternal preferences [10, 11, 13] but it is difficult to draw conclusions about maternal preferences on the basis of these studies. For example, the terms used to describe various consistencies of complementary foods (e.g., thick, thin, or smooth) are often ambiguous and poorly defined, and often no measurements of viscosity are given. Additionally, the classification of consistency and viscosity is not standardized across studies; for example, gruels of similar viscosity are described as "thick" in one study and "thin" in another. In one of the few quantitative studies identified [9], the mothers of 78 severely malnourished children five to eight months of age recovering from diarrhoea in a nutrition rehabilitation unit in Bangladesh were asked whether complementary foods should be "liquid" or "semi-solid." Approximately 60% of the mothers said that the consistency should be "liquid," but no viscosity measurements were reported, nor were mothers asked to explain the reasons for their preferences. In Peru, Creed de Kanashiro et al. [10] found that "mothers had very definite ideas about the required thickness for each type of complementary food preparation," and during recipe trials "mothers were reluctant to prepare complementary food mixes with a thicker consistency than customary." These mothers gave their children mostly soft, smooth complementary foods, such as soups or puddings, because they were easy to swallow. Bentley et al. [11] reported that Nigerian mothers who commonly "hand feed" preferred thin, liquid foods for children up to 35 months of age because they felt that a child "could not swallow foods of a solid or semi-solid consistency." In India, Gopaldas et al. [13] reported that mothers preferred gruel (830 cps) thinned with amylase-rich flour, a malted flour, because it was "smooth and fairly free-flowing," whereas the gruel without amylase-rich flour (2,800 cps) was perceived by mothers to be "lumpy."

The age effects seen in the current study are consistent with reports by Gopaldas et al. [12, 21] who reported that Indian mothers preferred to give older children (10 months of age or older) thicker porridges of spoonable consistency (2,000–6,000 cps) rather than thin, free-flowing gruels (1,000 cps) like those fed to younger children.

The effect of a child's health status on maternal preference for complementary food consistency found in the current study is also consistent with other reports. In Peru, mothers preferred to give children with diarrhoea mashed rather than fried potatoes, toasted or roasted cereals and legumes rather than the coarser fresh, dried, or whole-grain forms, and hard foods that had been peeled or ground [10]. In Nigeria, Bentley et al. [11] found that maternal encouragement as well as child acceptance increased when children with diarrhoea were given "liquid or semi-solid food" rather than "solid food."

The significance of the current study relates to ongoing efforts to improve the dietary quality of complementary foods in developing countries [22]. A great deal of effort has been invested in trying to increase the nutrient density of such foods without increasing their consistency to a point that is unacceptable to mothers or children [5, 9, 14–16]. The potential importance of such organoleptic characteristics of foods has been noted [23], but few studies have been done

on maternal or child preferences for such characteristics. The current study suggests that these preferences are strong and vary according to the age and health status of the child. To permit comparisons across studies to be made, future studies of the consistency of complementary foods should try to standardize terms and laboratory methods, since measured viscosity depends on temperature, spindle reading, speed, and other factors.

Our results are specific to one rural Mayan community in Guatemala, and preferences will be different in other settings. Moreover, the results are based on the mothers' reported preferences, and more studies are needed to confirm these reports by observation.

In conclusion, the results of this study will increase the likelihood that efforts to develop improved complementary foods will not be contradictory to the mothers' preferences. They are particularly relevant for ongoing efforts to improve feeding during illness [24–26]. Improved effectiveness of such efforts will contribute to better growth and health status of children in developing countries.

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Yearly household record of food from the forest for home consumption by rural villagers in north-east Thailand

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Abstract

Forests provide food and resources that are used in the daily life of the rural villagers who live nearby. This study explored the contribution of forest food to household nutrition and food security of these people. The study focused on the frequency, varieties, and amounts of forest food gathered for consumption in the household, and the reduction in food expenditure resulting from using forest food. Seven households in a village near a forest in north-east Thailand were selected for a one-year study of forest food consumption using household food records. The data were collected from May 1988 to April 1989. Forest food was gathered for consumption an average of three days a week. One hundred twenty-six kinds of forest food were gathered. The amount gathered for consumption was highest in May and lowest in December, with an average of 126.6 kg per household per year. The use of forest food could reduce food expenditure for the rural villagers.

Introduction

In the past, forests were very important to rural villagers. They were sources of foods and resources that were used daily. They provided animal foods, vegetables, fruits, medicines, household building materials, household equipment, wood for fuel, and products for cash sale [1, 2]. Food from the forest was particularly important for the villagers, some of whom went to the forest frequently to collect food [1].

Food from the forest supplied nutrients. Wild animals provided protein and were good sources of iron, vitamin A, and vitamin B. Wild leaves and fruits contained vitamins and minerals. Seeds, nuts, roots, and tubers supplied fats, carbohydrates, and minerals. Mushrooms provided protein and minerals [2–4]. Forest food provided supplemental, seasonal, and emergency contributions to household food supplies [2].

In earlier times, villagers who lived near the forests of north-east Thailand were engaged in a self-subsistent economy, with a stable crop of paddy rice, supplemented by hunting wildlife and gathering food and wood from the forests surrounding the settlements. Any surplus from household production and collection was shared among villagers or bartered with outsiders [1, 2]. In the past 40 years, the growing population has resulted in an increased demand for food, including forest foods, as well as more land for cultivation. Some households that did not have enough land for cultivation moved to the forest for cash crop cultivation. This was one of the events that contributed to the decrease in forest area [5, 6]. From 1961 to 1985, the forest area in Thailand decreased from 53% to 29% of the total area of the country [7]. Because of the rapid decrease in forest area, in 1987 the Thai Government enacted a forest-closing law that prohibited cultivation in the forest but still allowed the villagers to collect forest food.

This study was conducted in a village located near a forest in north-east Thailand. It began a few months after the prohibition of cultivation in the forest. The objective was to study the use of food from the forest for home consumption by the rural villagers during one year by focusing on the kinds of foods gathered from the forest for consumption in the household, the frequency with which they were gathered, the amounts gathered, and the reduction in food expenditures resulting from using forest food.

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Methods

Village selection and characteristics

The criteria for village selection were that it be near a forest and be classified as a poor, remote, rural village with insufficient rice production and crop land.

The selected village was small, with only 59 households in 1987. Most of the population was Thai-Laos and Buddhist. Most families were nuclear families with approximately five or six persons in a household. The village was situated in a valley in Khon Kaen Province in north-east Thailand. It was located near a forest area and was approximately 14 km from the district centre. The village was isolated from others in the valley. Clusters of households were located on the high land surrounded by rice fields (most of which belonged to other villages) and mountains. It was difficult to travel to or from the village, because no minibus passed through the village, and the gravel road was muddy during the rainy season. Normally, the villagers took a minibus from a neighbouring village about 2 km away, and there were two or three minibus trips to the district centre each day. At the beginning of the study, there was no electricity in the village.

Compared with other villages in the valley, the studied village was poor, with low income and the least agricultural land per household. Rice was cultivated only for home consumption, and even this amount was insufficient for the people's needs because their rice fields were too small. The main source of cash income was cassava. Before the forest was closed, most of the villagers encroached on the forest reserve to grow cassava. In 1987 the Government banned cultivation in the forest, although villagers could still collect food from the forest.

Household selection and characteristics

Land tenure was taken as a measure of economic status. Thus, a landless household was classified as poor. At the beginning of the study, there were 59 households in the village, 15 of which were landless. According to the village headman, no household had sufficient land or other property to be classified as rich. Households with some of their own land or their parents' land were considered households of moderate economic status. The village headman was asked which households belonged to these categories. Then, members of households from different categories were asked if they would like to cooperate in the study and keep household food records. Seven households (two landless and five of moderate economic status) were selected for the study. The characteristics of the studied households are summarized in table 1.

Data collection and analysis

The seven households were given forms for recording daily household food consumption (including menus and ingredients) and weighing scales. One member of the household was trained in food-weighing techniques and asked to keep daily food consumption records for every meal in the house. The varieties, amount, prices, and sources of foods were recorded from May 1988 to April 1989. Only data on food from the forest were analysed. The data were edited, coded, and entered into a computer to make a food database using the FoxBase programme. The varieties, amounts, prices, and sources of foods and the number of days when the data were recorded were counted for each month. Since there were some days when the data were not recorded, consump-

TABLE 1. Characteristics of the studied households

House-hold no.	No. of members	Depen-dency ratio	Economic status	Land in use	Remarks
1	6	0.67	Poor	Landless	Often unemployed
2	5	0.20	Moderate	Sharecropping	
3	5	0.60	Moderate	3 rais paddy field 3 rais upland not used	
4	6	0.33	Moderate	6 rais paddy field 24 rais upland not used	
5	9	0.12	Moderate	4 rais paddy field	
6	6	0.67	Poor	Landless	Employed transplanting, planting, and harvesting in rice fields and gathering forest food for sale
7	4	0.25	Moderate	6 rais paddy field 4 rais not used	

tion for that month was calculated proportionally to the amount of food consumed on the recorded days.

Definition of forest food

Forest food consisted of all the kinds of food that could be found in the deep forest (*dong* in Thai), on the hillsides or hilltops (*khok*), or in the shrublands (*lon*). Some kinds of forest food came from trees, and others were found in or near ponds or streams in the deep forest.

Results

Frequency of gathering of forest food for consumption

On average, households living near the forest gathered forest food for home consumption three days a week. The poor, landless households whose members were frequently unemployed gathered forest food an average of five days a week, as compared with households of moderate economic status, which gathered food two or three days a week. The poor, landless households whose members were employed gathered forest food as frequently as those of moderate economic status. The average frequency of gathering forest food for home consumption was highest in May and lowest in December (table 2).

Varieties of forest food gathered for consumption

A total of 126 kinds of forest food were gathered. There were 49 kinds of animals (39%), 16 kinds of mushrooms (13%), 6 kinds of bamboo shoots (5%), 43 kinds of other vegetables (34%), and 12 kinds of fruits (9%)(fig. 1). Table 3 lists some of these forest foods.

Amount of forest food gathered for consumption

The average amount of forest food gathered for consumption was 127 kg per household per year. The three peak months for the total amount of food gathered were May, August, and November. The consumption of animal food was highest in May, bamboo shoots in August, mushrooms in November, and other vegetables in May (table 4).

Reduction of food expenditure from gathered forest food

The average reduction of food expenditure from consuming forest food was 2,946 baht (26 baht = US$1.00 in 1985–1992) per household per year. The highest reduction of food expenditure was in May, about 595 baht per household, and the lowest was in January, about 141 baht per household (fig. 2).

Discussion

This study was conducted in one year after the forest was closed and the villagers were not allowed to plant cassava in the forest. Their incomes were reduced by one-half, from about 20,000 to 10,000 baht per year. During that period, they had to save their money and borrow from people outside the village. Some households occasionally gathered wild vegetables, bamboo

TABLE 2. Average number of days per week spent gathering forest food for consumption, according to month and household

Month	Household no.							Mean
	1	2	3	4	5	6	7	
Jan	ND[a]	3.5	1.6	0.7	1.8	1.0	2.3	1.8
Feb	4.4	3.0	1.6	0.0	2.0	0.0	4.5	2.2
Mar	4.9	4.7	3.2	0.5	2.0	2.9	4.4	3.2
Apr	ND	4.7	4.7	1.0	6.3	2.9	ND	3.9
May	5.1	5.4	6.5	2.5	5.6	5.4	2.9	4.8
Jun	5.4	2.7	5.0	2.8	2.1	2.3	2.5	3.3
Jul	6.5	3.5	2.0	2.8	1.5	2.5	1.9	3.0
Aug	6.1	3.8	2.7	4.1	3.2	2.7	0.2	3.3
Sep	5.4	3.7	0.6	2.1	2.6	4.0	1.4	2.8
Oct	4.7	2.6	3.0	2.1	2.9	4.3	1.3	3.0
Nov	6.1	5.6	3.8	4.0	2.1	3.5	0.7	3.7
Dec	ND	2.3	1.6	0.5	0.2	0.5	1.3	1.1
Mean	5.4	3.8	3.0	1.9	2.7	2.7	2.1	3.3

a. No data.

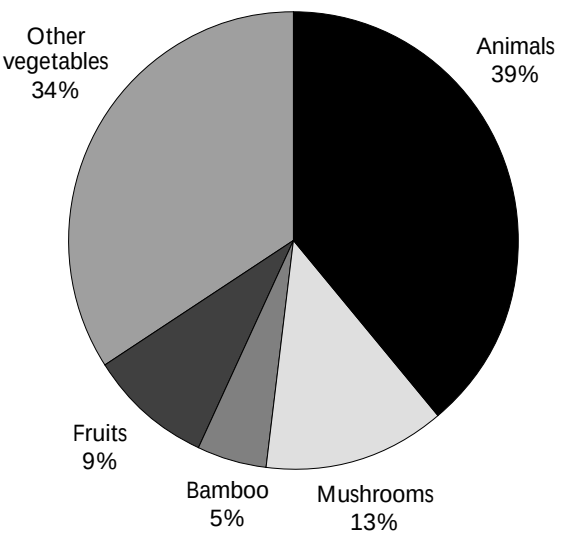

FIG. 1. Percentage of kinds of forest food gathered for consumption by the studied households in a year

TABLE 3. Local, common, and scientific names of some food plants and animals from the forest

Local name	Common name	Scientific name
Mangda	Giant water bug	*Lethocerus indicus*
Khai Ja-kajan	Cicada egg	*Magicicada* spp.
Mim	Little honey bee	*Apis florea*
Khai Mod-dang	Ant eggs	—
Kung	Freshwater prawn	*Macrobrachium lanchesteri*
—	Shrimp	—
Hoi-Joob	Pond snail	*Sintaia ingallsiana*
Pla Ta-pean	Small carp	*Puntius gonionotus*
Pla Ngarm	Small carp	—
Pla Khow	Jullien's mud carp	*Cirrhina jullieni*
Pla E-Thai	Small carp	*Osteochilus* spp.
Pla Chon	Snakehead fish	*Ophicephalus striatus*
—	Rasbora	*Rasbora* spp.
Pla Duk	Freshwater catfish	*Clarias* spp.
Pla Nin	Nile tilapia	*Tilapia nilotica*
Pla Lai	Swamp eel	*Fluta alba*
Kob	Frog	*Rana* spp.
Ngod	Frog	*Rana* spp.
Kaet	Small toad	*Oocidozyga lima*
Ung	Bullfrog	*Kaloulan* spp.
Dtow	Tortoise	—
Yar	Ground lizard	*Liolepis belliana*
Lan	Tree monitor	*Varanus nebulosus*
Kee-kra-porm	Tree lizard	*Calotes* spp.
Nok-kao	Dove	*Macropygia ruficeps*
Kai-pah	Jungle fowl	*Gallus gallus*
Kra-jaun	Chipmunk	*Menetes berdmorei*
Kra-rauk	Squirrel	*Callosciurus* spp.
Kra-tae	Tree shew	*Tupaia* spp.
Bang	Flying lemur	*Cynocephalus variegatus*
Noo-na	Field rat	*Rattus rattus*
Noo-wai	Field rat	*Leopoldamys sabanus*
Moo-pah	Boar	*Sus scrofa*
E-hen	Palm civet	—
Lin	Pangolin	*Manis* spp.
Ma-muang	Mango	*Mangifera indica* Linn.
Mak-mee	Ripe jackfruit	*Artocarpus heterophyllus* Lamk.
Mak-waa	Java plum	*Syzygium cumini* Druce
Ma-kang	Ma Kue Phuang	*Solanum torvum* Sw.
Mak-ben	Small thorn tree	*Flacourtia indica* Merr.
Mak-keng	Kleng	*Dialium cochinchinense* Pierre
Het Kradang	Het Khan	*Lentinus praerigidus* Berk.
Het Ghaw	—	*Lentinus edodes*
Het Takai	—	*Russula delica* Fr.
Het Teenhad	—	*Russula nigricanus* Fr.
Het Plorg	—	*Termitomyces fuliginosus* Heim
Het Pung	—	*Boletus edulis* Bull.
Het Pungkam	—	—
Het Ra-ngok	—	*Amanita vaginata* Fr. Var. alb (Fr.) Gill
Het Larp	—	—
Het Hoo-noo	—	*Aurecularia auriculasis* (S. F. Gray) Martin
Het Po	—	*Astreaus hygrometricus* (Pers.) Morg.
Het Ploag-dong	—	*Termitomyces fuliginosus* Heim.
Pak Kra-jeaw	—	*Curcuma* sp.
Pak Kra-don	—	*Careya arborea* Roxb.
Pak Karn-trong	—	*Ottelia alismoides* Pers.
Pak Kaaw	Paracress	*Spilanthes acmella* Murr.
Pak Ngoo-haa	Ivy gourd	—
Pak Tiu	—	*Cratoxylum formosum* Dyer
Pak Lin-laen	—	*Naravelia Zeylanica* DC.
Neem	Pag Sadao	*Azadirachta indica* Juss.
Pak Sarb	—	*Adenia viridiflora* Craib.
Pak Nam	Thorny vegetable	*Lasia spinosa* Thw.

TABLE 3. Local, common, and scientific names of some food plants and animals from the forest (*continued*)

Local name	Common name	Scientific name
Pak Waan	—	*Melientha suavis* Pierre
Pak E-lert	—	*Piper sarmentosum* Roxb.
Pak Mek	—	*Sysygium gratum* (Wight) S. N. Mitra
Wai		Rattan leaf top *Calamus* sp.
Naw Jod	—	*Arundinaria ciliata* A. Camus
Bong	—	*Bambusa tulda* Roxb.
Sweet	—	*Bambusa* sp.
Hurk	—	*Bambusa* sp.
Phai	—	*Bambusa* sp.
	Banana stalk	*Musa acuminata* Colla
Toa	Freshwater algae	*Spirogyra* spp.
E-log-e-ngorm	—	*Thomsonia sumawongii* Bogn.
Pak Lin-fah	—	*Oroxylum indicum* Vent.
Mafai	—	*Baccaurea ramiflora* Lour.

shoots, or mushrooms to sell to people living near the village. At that time some households sold fruit, such as bananas, from their own gardens at the market. In this way, they could get about 40 to 50 baht per day. The villagers were more dependent on forest foods, especially the poor families who were often unemployed and who gathered forest food five days per week, as compared with the families of moderate income, who

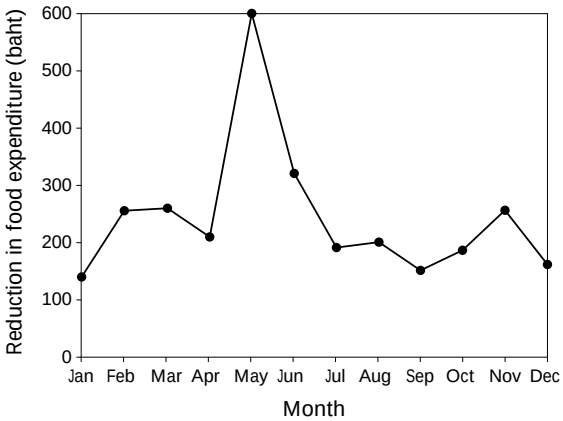

FIG. 2. Reduction in household food expenditure as a result of gathering forest food for consumption, according to month. 26 baht = US$1.00 in 1985–1992

gathered forest food two or three days per week.

Thailand has three seasons: summer, rainy, and winter. The rainfall starts in May and continues to September. It rains again during the first fortnight of November. In May wild vegetables and wild animals, such as toads, can be found easily. During the rainy season local people can gather bamboo shoots and mushrooms for home consumption. At the beginning of November mushrooms (*Het Kradang*) can be found easily and gathered for sale and home consumption.

The kinds of foods gathered from the forest for consumption in the household, the frequency with which they were gathered, and the amounts gathered depended not only on seasonal variation but also on the amount of time that was available to the villagers. From May to June, the rainy season, there was a lot of forest food. The villagers had free time to gather forest food because this period, following the seeding of the paddy fields, was one of waiting before transplanting the young rice plants. The forest food gathered during this period included ground lizards, tree lizards, bamboo

TABLE 4. Average amount of forest food (kilograms fresh weight) gathered for consumption per month by all households, according to month and type of food

Type of food	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Animal food	3.9	4.9	5.2	4.0	11.6	3.4	1.2	0.7	0.8	1.4	2.1	3.0	42.2
Vegetables													
Mushrooms	0.1	0.0	0.5	1.6	3.4	3.1	3.0	1.4	2.0	4.3	9.5	0.4	29.3
Bamboo shoots	0.1	0.0	1.2	1.1	5.4	5.0	5.7	9.6	5.9	2.5	1.4	1.7	39.6
Other	0.2	1.0	1.4	1.5	2.1	0.9	0.7	0.3	0.4	0.6	0.7	0.0	3.8
Fruits	0.7	1.2	0.0	0.1	0.4	0.1	0.0	1.5	0.0	0.8	0.9	0.0	5.7
Total	5.0	7.1	8.3	8.3	22.9	12.5	10.6	13.5	9.1	9.6	14.6	5.1	126.6

shoots, *E-log-e-ngorms* (vegetable), morning glories, *Pak Nam* (vegetable), and *Het Po* (mushroom).

From July to September, a lot of forest foods, such as bamboo shoots, mushrooms, *Het Takai*, *Het Ra-ngok*, fish, snakehead fish, and swamp eel, were available. However, since this was the time to transplant the young rice plants, some family members would gather or catch forest food, while others continued with their farm work.

During October and November, forest foods such as bamboo shoots, mushrooms, and *Het Kradang* were available. In this period the farmers were busy harvesting rice, so only some members of the family gathered forest food for home consumption or for sale.

December to February was the cold and dry season. The farmers who did not migrate to work outside the village had free time to go to the forest, but less forest food was available during this period. They could find some animals, such as *Ngod* (frogs), fresh-water prawns, ant eggs, minnows, and some kinds of fish.

March and April were dry and most of the natural ponds had no water. At this time it was difficult to find forest food. Although the farmers had free time, very few people went to the forest during this period because of the hot weather and the difficulty of finding forest food. They might find some kinds of mushrooms, bamboo shoots, toads, and frogs, but the amounts were less than during the rainy season. Other forest foods found in this period were ant eggs and *Pak Waan* (vegetable).

Since the villagers earned an average of only 45 baht per day, the use of forest food could substantially reduce food costs. Consumption of forest food by the villagers is traditional. If they cannot gather forest food themselves, they have to buy it in the market, where the prices are very high. Some villagers, especially the poor families, may not be able to buy forest food for home consumption.

Forest food was important for rural villagers living near a forest. The study conducted in this village from January to September 1988 found that except for rice, the staple food, the forest was the main source of household food. In terms of kilograms, 31% of all household food came from the forest, 22% was produced by the household, 31% came from the paddy fields, 13% was purchased, and 3% came from gifts [1].

During the study period, the villagers were allowed to collect forest food. In the future the forest will be closed completely, and collecting many kinds of forest food will not be allowed, especially hunting wild animals. The villagers may be faced with food and economic problems that the Government should help alleviate. The assistance that should be given in the villages is as follows:

» Raising animals such as fish for protein should be promoted.
» The village committees and women's groups should be trained to run food-production programmes at the village level, since many poor households are landless.
» Disease prevention and treatment of animals, such as chickens, ducks, and fish, should be initiated in the villages, as should the cultivation of fruits and vegetables.
» Food produced at the village level should be provided to village households first and the surplus should be sold, with the money going into the village fund.
» The villagers should be allowed to gather forest foods, such as mushrooms, bamboo shoots, and vegetables, for home consumption and sale. Naturally, these forest foods will have new plants every year. It would be a pity for the forest food to die without being used as a food source. It would be better if the villagers were allowed to continue to collect those forest foods for home consumption in order to reduce their food expenditure and allow them to spend their money for other necessities. At the same time, campaigns for preserving the forest should be conducted on a continual basis.
» Villagers should be encouraged to preserve the forest for their own benefit as well as that of the country as a whole. Schoolchildren, especially those living near the forest area, should be educated and stimulated to take care of the forest for the benefit of the country and rural villagers in the future.
» Villagers living near the forest and far from the sea seldom consume seafood. This leads to goitre. Thus, information about food intake and health should be provided to the villagers.
» Income-generating projects that are suitable and acceptable should be promoted in the villages or the local areas.

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Food aversions and cravings during pregnancy: Prevalence and significance for maternal nutrition in Ethiopia

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Abstract

A cross-sectional study of the nutritional significance of food aversions and cravings during pregnancy was conducted on 295 women in southern Ethiopia between February and May 1995. A questionnaire was used to collect data on dietary practices. Mid-upper-arm circumference (MUAC), triceps skinfold thickness (TSFT), and weight measurements were used to assess nutritional status. Slightly fewer than three-quarters (71%) of the women craved one or more foods, whereas about two-thirds (65%) avoided at least one food. Cereal foods, despite being staple foods in the area, were avoided by more women (41%) than any other foods. Livestock products, which were scarce at the time of the study, were craved by more women (55%) than any other foods. Comparisons using various anthropometric indicators revealed that women who avoided foods had significantly higher MUAC and TSFT than those who did not ($p < .05$*), whereas there was no difference in nutritional status between women who craved foods and those who did not. However, those craving women who managed to get the desired foods had significantly higher weight gain (*$p < .05$*), but not significantly higher MUAC or TSFT, than those who did not. Aversion and craving were positively associated (*$\chi^2 = 10.66$*, $p < .001$; odds ratio, 2.36). Thus, women who avoided foods were 2.4 times more likely to crave foods than those who did not avoid foods. This implies that aversion and craving are complementary processes geared towards ensuring optimal nutrition during pregnancy. Aversion results in the avoidance of monotonous diets, whereas craving calls for varied and nutritious foods. More research, however, is needed before such a conclusion is warranted.*

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Introduction

It is common to hear pregnant women complain about changes in their appetites. Whereas some women report a dislike of or total aversion to specific foods, others report a strong craving for specific foods and non-food items, which are usually not readily accessible. Food aversions and cravings during pregnancy are known all over the world [1, 2], but despite their ubiquity, neither their causes nor their ultimate effects on maternal nutrition have been well established scientifically. The opinions that have been documented so far are speculative, contradictory, or inconclusive.

Some researchers argue that aversions and cravings are idiosyncratic, learned behaviours, which therefore should be considered extrinsic, exogenous phenomena [2]. Other researchers attribute aversions and cravings to intrinsic physiological processes geared towards ensuring the optimal growth and development of the foetus [1]. According to the latter opinion, aversions are a physiological mechanism that protects the foetus either from nutrient deficiencies (by prompting mothers away from low-quality and monotonous foods) or from excess foeto-toxic substances present in the foods; thus, aversion would be beneficial [3, 4]. The evidence that the most commonly avoided foods or substances are staple foods, alcoholic beverages, coffee, and cigarettes appears to support this opinion.

Several studies have observed that women usually avoid staple or commonly consumed foods [2]. Studies also indicate that relatively high proportions of pregnant women avoid alcoholic beverages. In a study in the United States, 21% of pregnant women avoided alcoholic beverages and 13% avoided cigarettes [5]. Similarly, in Ethiopia almost 20% of the women studied showed an aversion to coffee and 35% showed an aversion to alcoholic beverages [F. Alemu and Z. Wolde-Gabreil, personal communication, 1995]. These findings appear to support the opinion that aversions are intrinsic and beneficial.

Some researchers, however, believe that aversions play a negative role in maternal nutrition because they re-

duce the mother's food options [1] by causing her to decrease her intake of certain foods. Thus, opinions on the importance of aversion to maternal nutrition are contradictory.

Researchers who believe that craving is physiological argue that it is a mechanism to protect the foetus and the mother from nutrient deficiencies [6] and suggest that craving is triggered when a deficiency in one or more nutrients arises. Hence, they argue that women who experience cravings increase dietary intake [1]. This opinion appears to be supported by the observation that, in general, women crave nutritious foods that are lacking in their diets. In an Ethiopian study, about 43% of the women craved milk and meat [F. Alemu and Z. Wolde-Gabreil, personal communication, 1995]. Similarly, in the United States 47% of the respondents craved fruits and 34% craved dairy products [7].

The literature on aversion and craving clearly indicates that knowledge of these behaviours, especially aversion, is far from complete. Since aversions and cravings are closely linked to the dietary intake of pregnant women, understanding these behaviours is important in addressing the issue of maternal nutrition. This paper is intended to contribute to the understanding of the role of aversion and craving during pregnancy, to identify foods commonly avoided or craved, and to determine the relationship of aversion and craving to maternal nutrition, using the Hadiya Zone in Ethiopia as a case study.

Materials and methods

Study site

The Hadiya Zone was selected as the study site on the basis of the opinions of nutritionists regarding the occurrence and magnitude of qualitative changes in foods consumed during pregnancy and the presence of the facilities necessary to carry out the study. In this site, a single Mother and Child Health Clinic was randomly selected.

Study respondents

The study enrolled all of the healthy pregnant women who came to the clinic for antenatal checkups between February and May 1995. A total of 295 women (using a prevalence of 45% for both aversion and craving) were studied.

Study instruments and procedures

A questionnaire was designed to gather demographic and socio-economic data, information on the women's dietary modifications (aversion and craving), and the reasons for them. Nurses working in the clinic were trained to use the study instruments and tools. A pilot study was conducted, and the questionnaire was modified appropriately.

Body weight measurements were taken to the nearest 100 g following standard procedures, using a beam scale. In addition to the body weight measured during the interview session, one other recent body weight measurement for each subject was retrieved from clinic records. Mid-upper-arm circumference (MUAC) and triceps skinfold thickness (TSFT) measurements were taken using the standard methods described by Gibson [8]. A non-stretchable tape, calibrated to the nearest 0.1 cm, was used to measure MUAC, and a Holtain caliper, calibrated to the nearest 0.2 mm, was used to measure TSFT.

Data analysis

The data were processed and analysed using SPSS statistical software. Food types were divided into major food categories: staples, legumes, vegetables and fruits, and livestock products. Weight gain per week was calculated by subtracting the weight measurement taken from the patient's clinic records from the measurement taken on the date of interview.

Results

Demographic and reproductive characteristics of the women

Table 1 shows the demographic and reproductive characteristics of the study women. Almost equal numbers of women from rural and urban communities (51% and 49%, respectively) participated. Nearly all of the women (92%) were housewives; 6% were civil servants, and only 2% were self-employed. The majority (88%) of the women were Protestant Christians of various denominations; the remainder belonged to other religions, such as the Eastern Orthodox and Roman Catholic Churches or Islam.

None of the women came from the upper-income class. About two-thirds (65%) were from the lower-income group, and the rest were from the middle-income group. About a quarter (24%) had not attended school, close to a half (46%) had completed some level of elementary school, and about a third (30%) had gone beyond elementary school.

The low mean age (25 years) and gravidity (3.6) indicate that the respondents were mostly young women. Only about 13% of the women were over 30 years of age. There were no respondents in their first trimester, whereas 30% and 71% were in their second and third trimesters, respectively. Women go for antenatal check-

TABLE 1. Demographic and reproductive characteristics of the women (n = 295)

Characteristic	No.	%
Residence		
Rural	150	51
Urban	145	49
Education (yr)		
0	70	24
1–8	136	46
≥ 9	89	30
Income (Ethiopian birr)[a]		
Low (< 250)	193	65
Medium (250–1,000)	102	35
High (> 1,000)	0	0
Religion		
Protestant	260	88
Muslim	18	6
Other	17	6
Occupation		
Housewife	272	92
Civil servant	17	6
Other or self-employed	6	2
Age (yr)[b]		
< 24	135	46
24–30	122	41
> 30	38	13
Gestational age[c]		
1st trimester	0	0
2nd trimester	87	30
3rd trimester	208	71

a. 1 birr = US$0.16.
b. Mean age = 25 ± 2.6 years.
b. Mean gestational age = 7 ± 1.5 mo.

TABLE 2. Percentages of pregnant women who habitually consumed various foods during pregnancy and who had consumed them during the preceding 24 hours

Food	% habitually consuming	% consuming in preceding 24 hours		
		Breakfast	Lunch	Supper
Injera	70	35	56	59
Wheat bread	48	29	12	12
Roasted wheat	11	18	7	4
Enset bread (*kocho*)	35	10	11	14
Coffee/tea	100	45	11	9
Shiro wot	67	24	44	41
Meat	0	0	7	6
Lentils	0	0	4	4
Kale	17	0	5	9
Potatoes	0	0	0	3

ups mostly during their third trimester, as they approach delivery. The mean gestational age of seven months is evidence of this pattern.

Food consumption, aversion, and craving

Table 2 shows the proportion of women who reported consuming various foods during the recent months of their pregnancy. Over two-thirds of the women (70% and 67%, respectively) reported consuming *injera* (a cake made from fermented *teff* [*Erastus teff*] dough) and *shiro wot* (a legume flour sauce for consumption with *injera)*. Nearly half (48%) reported commonly consuming wheat bread, and slightly over one-third (35%) reported commonly consuming *kocho* (a bread made from fermented *enset* root flour). Cereals and legumes dominated the women's diet, whereas root crops, mainly *kocho,* also played a significant role in the diet.

The pattern of frequency of food consumption during the preceding 24 hours was similar to the women's usual food consumption pattern (table 2). About one-third (35%) of the women reported that they had consumed *teff injera* for breakfast, and about equal numbers (56% and 59%) had consumed it for lunch or supper, respectively. The consumption of *shiro wot* for breakfast was reported by 24%, and for lunch or supper by almost equal numbers of women (44% and 41%, respectively). About an equal but relatively small number of women also reported that they had consumed *kocho* for breakfast, lunch, or supper (10%, 11%, and 14%, respectively).

About two-thirds (65%) of the women avoided at least one food during the course of their pregnancy, with 27% avoiding more than one food (table 3). Nearly three-quarters (72%) craved at least one food, and 28% craved more than one food.

Table 4 shows the major foods avoided, along with the percentage of women avoiding them. The most commonly avoided foods were roasted wheat, coffee, wheat bread, meat sauce, *kocho,* and *injera,* which were avoided by 34%, 21%, 17%, 12%, 9%, and 9% of the women,

TABLE 3. Prevalence of aversion and craving among pregnant women

Dietary practice	Prevalence (%) (n = 295)
Aversion	
No food avoided	35
At least one food avoided	65
More than one food avoided	27
Craving	
No food craved	28
At least one food craved	72
More than one food craved	28

TABLE 4. Number (percentage) of pregnant women with aversion to or craving for specific foods or food categories

Food	Aversion (n = 182)	Craving (n = 212)
Specific foods		
Injera	17 (9)	17 (8)
Wheat bread	30 (17)	4 (2)
Roasted wheat	62 (34)	1 (1)
Linseed	0 (0)	1 (1)
Cheese	5 (3)	39 (18)
Milk	5 (3)	27 (13)
Enset bread *(kocho)*	17 (9)	4 (2)
Potato	13 (7)	1 (1)
Meat sauce	21 (12)	100 (47)
Fatty meat	2 (1)	1 (1)
Kale	1 (1)	18 (9)
Coffee	38 (21)	1 (1)
Banana	0 (0)	6 (3)
Orange	0 (0)	14 (7)
Food categories		
Cereals	109 (60)	22 (10)
Legumes	13 (7)	5 (3)
Roots	30 (16)	5 (3)
Livestock	24 (13)	117 (55)
Vegetables	4 (2)	23 (11)
Fruits	1 (1)	17 (8)
Beverages	29 (16)	9 (4)

respectively. With the exception of meat, these foods are widely consumed in Ethiopia. When the foods were divided into major food categories, cereal foods were found to be avoided by the largest proportion of women (60%). These were followed by root crops and beverages, which were avoided by about 16% each, whereas other food categories (e.g., legumes and livestock products) were avoided by a smaller proportion of the women.

The women were clear about the distinction between aversion and taboos (abstinence due to beliefs). The main foods that 81 (28%) of the women abstained from were milk and cheese (avoided by 44% each), linseed (16%), fatty meat (11%), and bananas (9%). All of the foods that the women mentioned as having been avoided (except *enset* bread, kale, and coffee, which none of the women abstained from) were also abstained from by 1% to 3% of the women. The reasons given for abstinence were fear that food would stick to the foetus, causing discolouration to the body, and fear that the baby would become too large to deliver easily.

The majority of the women (90%) did not have reasons for their food aversions. A few believed that aversions were caused by a dislike of the food by the foetus.

The most widely craved foods were meat sauce, cheese, and milk, which were craved by 47%, 18%, and 13% of the women, respectively (table 4). When craved foods were aggregated, livestock foods were found to be craved by the largest proportion of women (55%). Livestock foods, as stated above, were also among the least commonly avoided foods. About 10% of the women craved vegetables and fruits.

Slightly less than two-thirds (60%) of the women did not have reasons for their cravings. Almost an equal proportion (62%) said they did not know what would happen if they did not obtain the craved foods. Slightly more than a third (36%) considered craving to be a call ("demand") by the foetus, whereas an almost equal number (31%) believed that a mark would develop on the foetal body.

With respect to the relationship between food aversion and craving, well over three-quarters (78%) of the women who experienced food aversions also craved at least one food (table 5). A slightly smaller proportion (60%) of women who did not experience food aversions also craved foods. The results of our observations showed that aversion and craving were highly associated ($\chi^2 = 10.66$; $p < .001$; odds ratio, 2.36; 95% confidence interval, 1.4 to 3.98). Women who experienced aversions were 2.4 times more likely to crave foods than women who did not experience aversions.

Nutritional status of the women

The results show that the women who experienced aversions had better nutritional status than those who did not (table 6). The MUAC and TSFT of women who avoided certain foods were significantly higher than those of women who did not avoid any foods ($p < .05$). The data on weight gain, however, did not show any significant difference between the two groups, although the scores for women who experienced aversions were higher.

The anthropometric characteristics of craving and non-craving women are presented in table 7. There was no statistically significant difference between the two groups. Women who had been able to consume craved foods had significantly higher weight gain than those who had not ($p < .05$) (table 8). The differences in the other anthropometric indicators, i.e., MUAC and TSFT, were not significant. However, women who consumed their desired foods also had higher values for both indicators.

TABLE 5. Relationship between the numbers (percentages) of women experiencing aversion or craving

Experienced aversion	Experienced craving	
	No	Yes
No	41 (40)	62 (60)
Yes	42 (22)	150 (78)

Odds ratio, 2.36; $\chi^2 = 10.66$; $p < .001$.

Discussion

The relatively high prevalence of aversion found in this study (65%) is comparable to the prevalences reported by other researchers, which ranged from 50% to 80%. The high prevalence of aversion to cereal foods (which are the most commonly consumed foods in the area) supports the widely held view that pregnant women avoid staple foods. Coronios-Vargas et al. [2], in an extensive study that covered four ethnic groups in the United States, observed that women avoided staple foods. Similar results were reported in a study in Ethiopia [F. Alemu and Z. Wolde-Gabreil, personal communication, 1995]. Pregnant women in areas where *enset* foods were usually consumed avoided more of these foods, whereas those in areas where cereal foods were usually consumed avoided more cereal foods. This supports the observation that aversion to commonly eaten foods is an inbuilt mechanism to diversify the types of food consumed by avoiding monotonous diets. It is important to note that the significance of such a mechanism would depend on the mothers' ability to substitute other foods for the foods they avoided.

The fairly high prevalence of aversion to coffee in this study is comparable to that found in other studies [3, 4]. It remains to be established whether the assumption is valid that aversion to coffee is aimed at protecting the foetus against the stimulant and bitter qualities of caffeine. If the assumption is true, then the physiological nature of aversion is unlikely to be refuted. It is also to be noted here that it is difficult to establish the view held by most anthropologists that aversion is mainly due to nausea (morning sickness), since, as we observed earlier, most women did not have a reason for their aversion and therefore did not associate it with overt nausea.

The reasons given here for abstaining from food (fear that the baby would become too big to deliver or have

TABLE 6. Anthropometric characteristics of women who did or did not experience aversion

Characteristic	Aversion		No aversion		t
	n	Mean ± SD	n	Mean ± SD	
MUAC (cm)	184	25 ± 2.1	103	23 ± 2.7	3.25[a]
TSFT (mm)	184	13 ± 4.5	103	12 ± 4.6	2.35[b]
Weight gain (kg/wk)	81	0.2 ± 0.02	41	0.12 ± 0.01	0.21

a. $p < .01$.
b. $p < .05$.

TABLE 7. Anthropometric characteristics of women who did or did not experience craving

Characteristic	Craving		No craving		t
	n	Mean ± SD	n	Mean ± SD	
MUAC (cm)	208	24 ± 2.6	79	24 ± 2.2	0.74[a]
TSFT (mm)	208	13 ± 4.5	79	13 ± 5.0	1.24[a]
Weight gain (kg/wk)	92	0.2 ± 0.06	31	0.2 ± 1.2	0.72[a]

a. Difference not significant.

TABLE 8. Anthropometric characteristics of women according to frequency of consumption of craved foods

	Mean (± SD) number of times per week that a craved food was consumed		
Characteristic	0 (n = 36)	< 7 (n = 111)	≥ 7 (n = 61)
MUAC (cm)	23 ± 1.7	24 ± 2.3	24 ± 2.4
TSFT (mm)	12 ± 3.9	13 ± 4.5	13 ± 4.7
Weight gain (kg/wk)	0.13 ± 0.07	0.25 ± 0.04[a]	0.18 ± 0.03[a]

a. $p < .05$ as compared with women not consuming craved foods.

discolouration on its body) have been reported by others [9, 10].

The high prevalence of craving found in the study (72%) was also not unexpected, since other studies in both developed and developing countries have also observed a high rate of craving among pregnant women, ranging from 43% to 98%. This indicates that poverty and underdevelopment are not the only determinants of the incidence of craving. The high prevalence of craving for livestock foods and vegetables that were largely unavailable at the time of the study appears to support the commonly held view that women crave scarce and nutritious foods. This appears to support the observation by the Canadian Federal Committee on Nutrition that craving is a mechanism geared towards augmenting nutritional deficiencies [6]. This also appears to support the hypothesis that craving is induced by intrinsic (endogenous) biological processes rather than by exogenous factors [1]. These hypotheses, however, have yet to be confirmed by in-depth studies.

The data cannot be used to establish whether the women craved status foods (a view held by many anthropologists), because the issue was not addressed directly. Because scarce and nutritious foods are likely to be considered status foods in this community, it is important to distinguish between the determining factors in craving. Specific studies should be undertaken to establish whether high-status foods, *per se*, are craved by pregnant women in this community.

The absence of a difference in nutritional status between the craving and non-craving groups can probably be explained by the fact that most of the craving women were able to consume what they desired. The significantly higher weight gain of women who obtained their craved foods compared with those who did not get them seems to support this observation. The former group could have been of marginally better nutritional status. Most of that group could also have been in the group of women who experienced food aversions, who have been observed to enjoy better nutritional status than the group that did not experience aversions. The absence of statistically significant differences between craving and non-craving women (who, as observed above, could have been in a position to obtain the craved foods) also supports the view, held by many authors, that craving could be an intrinsic mechanism set by the body to correct nutrient deficiencies. These observations underscore the importance to maternal nutrition of fulfilling cravings.

Many authors assume that aversions decrease food choices and, thus, lead to reduced dietary intake, which would obviously affect nutritional status negatively. However, this assumption runs contrary to this study's finding that women who experienced food aversions were better nourished than women who did not. Similar observations were made in the Ethiopian study by F. Alemu and Z. Wolde-Gabreil [personal communication, 1995], who observed higher birthweights in infants born to mothers who had experienced food aversions than in infants born to mothers who had not. Because the available information is so limited, more arguments are required in support of observations of the better nutritional status of women who experience food aversions. One explanation is that, although pregnant women may dislike a specific food, whether or not they avoid it depends on the other food options available. Poor women with few food options are unlikely to avoid specific foods as commonly as women who have more choices. This would imply that women who avoid foods are better off economically and nutritionally. Another possible explanation based on the results of this study is that the correlation of food aversion with food craving (which was also observed by Coronios-Vargas et al. [2] and Alemu and Wolde-Gabreil [personal communication, 1995]) might account for the better nutritional status of those women who avoided specific foods.

The positive relationship suggests that women who experience food aversions also crave more, not only to compensate but to diversify their diets and to consume higher-quality foods. This suggestion is supported by the findings that more women avoided cereal foods and craved livestock products, which implies that monotonous staple diets are avoided, whereas nutritious and less common foods are desired. What becomes important in this scenario is the women's ability to avoid the foods they dislike and to obtain the foods they crave.

Since most of the women in this study claimed that they received what they desired, it is quite logical to expect better nutritional status in the women who experience aversions.

Conclusions and recommendations

Although aversions and cravings are considered undesirable, the few data available and the results obtained in this study strongly indicate that this view may have to change. The two should always be studied together in any community in order to establish whether they have complementary or similar effects on the nutritional status of pregnant women. Aversions and cravings should be investigated during antenatal follow-up, and advice should be offered.

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Weaning foods in West Africa: Nutritional problems and possible solutions

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Abstract

Weaning practices and the problems of weaning foods in West Africa are reviewed. The low nutrient density and high bulk of the weaning foods, early introduction of solid foods, and unhygienic practices predispose infants to malnutrition, growth retardation, infection, and high mortality. Multi-approach strategies, involving the development of improved recipes and processing, nutrition education, access to safe water, good sanitation, economic empowerment of women, reduction in workload, and promotion of breastfeeding, are recommended solutions to the problems.

Introduction

In many West African countries, exclusive breastfeeding is usually adequate up to three to four months of age, but after this period it may become increasingly inadequate to support the nutritional demands of the growing infant. Thus, in a weaning process there is always the need to introduce soft, easily swallowed foods to supplement the infant's feeding early in life.

The weaning process may be gradual, lasting for months until the infant is finally introduced to the family diet. On the other hand, in abrupt weaning, the infant is introduced straight into the family menu. This latter option creates a problem, as the child may not be able to eat enough of the adult diet to meet his or her nutritional needs.

In West African countries, weaning can be a period of problems and vulnerability for the survival of a child. We looked at the conventional or traditional weaning foods and weaning practices in some West African nations. The nutritive values, nutritional problems, and possible solutions are presented.

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Weaning practices and weaning foods in West Africa

According to the available literature, West African mothers usually breastfeed for 12 months. Many urban poor and rural women breastfeed for up to 18 to 24 months [1, 2]. These reports indicate that there is early supplementation with solid foods or early weaning. Although the majority of women start weaning their infants at the age of three to four months, a few begin within the first two months of life. The first solid food and the most popular weaning food is a thin cereal gruel that is called by different names depending on the type of cereal or the West African country.

In Nigeria the usual first weaning food is called pap, *akamu*, *ogi*, or *koko* and is made from maize (*Zea mays*), millet (*Pennisetum americanum*), or guinea corn (*Sorghum* spp.) [3–6]. In Anambra State most mothers introduce the thin gruel at three to six months of age [3]. The baby is fed on demand with a spoon or a cup, although in certain parts of the country, a few mothers use the traditional forced hand-feeding method [6].

After the successful introduction of cereal gruel, other staple foods in the family menu are given to the child. These foods include yam (*Dioscorea* spp.), rice (*Oryza sativa*), *gari* (fermented cassava grits), and cocoyam (*Xanthosoma sagittifolium*), which may be eaten with sauce or soup [7, 8]. These foods are usually mashed, thinned, or pre-chewed. As soon as a child can chew, he or she is given pieces of food from the family pot. Some authors observed that in certain communities the low-income families do not make a special effort to prepare weaning foods for the infants, who are fed modified or unmodified food from the family pot [9, 10].

People from low-income groups seldom feed meat, eggs, or fish to their infants, because of socio-economic factors, taboos, and ignorance [11–13]. Cherian reported that people from high-income groups used these foods more often and tended to add variety to their weaning foods [5].

Legumes are rarely used for weaning and are introduced much later (after six months of age) because of

the problems of indigestibility, flatulence, and diarrhoea associated with their use [14, 15]. However, Uwaegbute and Nnanyelugo noted that 67% of their study population satisfactorily used cowpea products for weaning [15].

Most Ghanaian mothers start weaning by the third month of life [2]. A few mothers, however, start after one month. On the basis of interviews with breastfeeding Ghanaian mothers, Armar-Klemesu and Wheeler reported that the main weaning food for infants up to six months of age was a traditional fermented maize porridge (*koko*) [16]. From six months onwards, the infants were given the family diet with complementary breastfeeding. The family foods on which the infants were weaned included dishes made from cereal, starchy tubers, legumes, and vegetables.

Ogi, prepared from maize or sorghum (couscous *ogi*), is a popular weaning food in Sierra Leone [17]. Other staple foods include yam, *gari*, *foofoo*, and legumes.

The weaning foods and practices in other West African countries are similar to these. Table 1 shows the traditional weaning foods in some West African countries and the ages at which the foods are introduced.

Nutritive value and nutritional problems of weaning foods in West Africa

Traditional weaning foods in West Africa are known to be of low nutritive value [18, 19] and are characterized by low protein, low energy density, and high bulk. Maize pap or *koko* has been implicated in the aetiology of protein–energy malnutrition in children during the weaning period [8, 20] Cereal-based diets have lower nutritional value than animal-based ones. Cereals form the primary basis for most of the traditional weaning foods in West Africa. The protein content of maize and guinea corn is of poor quality (table 2), low in lysine and tryptophan. These two amino acids are indispensable to the growth of the young child [23].

In Anambra State, Nigeria, Agu observed that pap contained only 0.5% protein and less than 1% fat, as compared with 9% protein and 4% fat in the original corn [24]. Indeed, Akinrele and Edwards concluded that the protein content of *ogi* or pap (corn gruel) was too low even to support the growth of rats [25]. Another report noted that corn gruel can provide some energy, but not other nutrients needed for the growth of the baby [26].

Guiro et al. similarly noted that the traditional millet gruel used for weaning Senegalese children was not energy dense and was insufficient to cover all the nutrient needs of the infant [18].

Cereal gruel processing methods have resulted in the loss of nutrients other than protein. Makinde and Lachance reported a 98% loss of the original tryptophan in maize during the processing of *ogi* [27]. Large losses of niacin during the processing of *ogi* were reported earlier [28], which could account for the high incidence of pellagra in the area.

The family diets to which some infants are weaned

TABLE 1. Summary of traditional weaning foods fed by West African mothers

Country	Food[a]	Age of introduction (mo)	Description
Nigeria	*Ogi*, pap, *akamu*, *koko*	3–6	Fermented cereal from maize, sorghum, or guinea corn
Ghana	*Koko*, *kenkey*	3–6	Fermented corn porridge
Sierra Leone	*Ogi*, couscous *ogi*	4–6	Cereal gruel from fermented maize or sorghum
Benin	*Ogi*	3–6	Cereal gruel from fermented maize, sorghum, or millet

Source: ref. 2.

a. Starchy grains, roots, and tubers (yam, *gari*, rice, and cocoyam + sauce) are also given.

TABLE 2. Nutritive value of traditional weaning foods as compared with commercial weaning products

Food	Energy (kcal)	Ash (g/100 g dry weight)	Protein (g/100 g dry weight)	Carbohydrate (g/100 g dry weight)
Traditional weaning foods				
Guinea corn pap	415	0.5	4	92
Maize pap	417	0.2	6	91
Millet pap	419	0.5	7	88
Millet pap + soya bean milk	420	1.8	19	74
Guinea corn porridge	412	1.0	5	91
Millet porridge + soya bean milk	413	2.2	23	70
Commercial products				
Lactogen	463	4.8	22	52
Similac	517	3.0	11	56
Cerelac	412	3.3	16	67

Source: refs. 15, 21, 22.

are also low in nutritional value. Indeed, many investigators [23, 25, 29] have reported that these traditional foods are low in protein and that other nutrients are lost due to poor processing. Bulk is a major problem of the traditional West African weaning foods [8, 20, 30]. For adults and older children, it is usually possible to achieve an adequate protein–energy intake by increasing the daily intake of starchy foods of low nutrient density. For infants and small children, however, the volume of the traditional diets may be too large to allow the child to ingest all the food necessary to cover his or her energy needs. A baby aged four to six months would need 920 g of corn gruel to meet daily needs of energy (740 kcal) and protein (13 g) [31]. This is an impossible task, considering the size of an infant's stomach. However, the use of foods of high nutrient density and frequent feeding schedules can help provide adequate food for growth and activity.

The problems inherent in the traditional West African weaning foods and feeding practices predispose the infant to malnutrition, growth retardation, infection, and high mortality. Guiro et al. rightly observed that one major cause of weaning-age malnutrition is complementation of breastmilk with cereal gruels that are of low energy density [18]. Thus, protein–energy malnutrition is a common problem among infants and children in the poor socio-economic groups of developing countries [32].

Severe protein–energy malnutrition results in kwashiorkor and marasmus. The inadequate growth or stunting produced as a result of poor supplementation is best described as hidden malnutrition. This is because the child may appear healthy while being severely malnourished.

According to the 1987 Ghanaian National Survey, 58% of the children were below 80% of the National Center for Health Statistics (NCHS) weight-for-age, 8% suffered from severe malnutrition, 40% were wasted, and 52% were stunted [33]. Amar-Klemesu and Wheeler observed that 30% of the infants who were fed cereal porridge and adult foods as weaning foods were malnourished [16]. They attributed this to inadequate complementation with breastmilk. In Nigeria, Akinele and Omotola investigated the energy and protein intake of infants and children of the low-income group [34]. They reported that about one-third to one-half of the infants suffered varying degrees of malnutrition and 10% were wasted and stunted. A more recent Nigerian National Survey conducted by the Demographic and Health Survey (DHS) in 1990 placed the proportion of underweight children under five years of age (those below –2 SD weight-for-age) at 36%, including 12% severely underweight (below –3 SD). The prevalence of stunting (below –2 SD height-for-age) was 43%, including 22% severe stunting (below –3 SD), while the levels of wasting and severe wasting were 9% and 2%, respectively [35].

An earlier 1986 DHS survey of children aged 6 to 36 months in Ondo State, Nigeria, found a 28% prevalence for underweight, 32% for stunting, and 7% for wasting. It is therefore clear that during the period of weaning, children in West Africa are very vulnerable to malnutrition, and one of the major factors that causes stunting or what makes some children appear stunted can be traced to inadequate food intake.

Children in West Africa are at high risk of infection during weaning. Malnutrition increases susceptibility to infectious diseases and affects child mortality from diseases such as diarrhoea, whooping cough, and acute respiratory infection [36]. It reduces the capacity of the host to resist the consequences of such infection, making death inevitable for some. As solid foods are introduced, infection with germs that cause diarrhoea or other diseases is more likely to occur [37]. The food is often contaminated because of poor handling, use of dirty water and utensils, and poor storage by rural and poor urban mothers. The story is similar for working mothers, who leave infants in the care of maids who are usually ignorant and inexperienced, and sometimes very unhygienic. Because of its poor nutritional status, the infant can hardly resist these infections. The frequent occurrence of such infections leads to malnutrition because of increased energy and nutrient requirements coupled with poor absorptive capacity. This in turn affects the nutritional status of the child and further lowers resistance to infection.

According to the available statistics from Nigeria, infant mortality is responsible for almost 50% of all deaths in children up to 14 years of age, and under-five mortality accounts for 93% of these deaths, 70% of which are attributed to preventable diseases [35].

Strategies for solving weaning food problems in West Africa

Many issues need to be addressed to solve the problems of weaning foods in West Africa. These include improving the quality of traditional weaning foods, ensuring household food security, providing nutrition education, and improving the income-generating activities of women.

Formulation and development of weaning foods of high nutritive value

Several strategies may be used to improve the nutritive value of weaning foods. The traditional West African weaning foods could be improved by combining locally available foods that complement each other in such a way that the new pattern of amino acids created by this combination is similar to that recommended for infants [21]. Cereals are deficient in lysine but have sufficient sulphur-containing amino acids that are lim-

iting in legumes. Therefore, the combination of cereals and legumes has been found to produce amino acid patterns that adequately promote growth.

Nigerian experience

Many researchers have worked extensively on cereal–legume combinations in Nigeria. For example, Fashakin and Ogunsoola [20] formulated nut–*ogi* (a mixture of corn gruel and peanut), Akinrele and Edwards [25] formulated soya–*ogi* (corn gruel plus soya bean), and the Collaborative Research Support Programme (CRSP) Cowpea Linkage Project at the University of Nigeria, Nsukka, formulated *cerebabe* (corn plus cowpea). Other useful combinations include *ogi* and melon protein (corn gruel plus melon seed) and cowpea–*ogi* [38]. Some of these combinations have been adopted by the food-processing industries and are available in the Nigerian market. Table 3 shows some blends used in West Africa [39].

However, Fashakin et al. observed that no single protein from the above sources was adequate to promote growth or enhance nitrogen retention as well as a milk-based diet [38]. To this end, a mixture of cowpea, melon, soya bean, and *ogi* was found to be superior to any single protein source in protein efficiency ratio, net protein retention, biological value, and net protein utilization [38].

Ghanian experience

Low-cost, nutritious, well-balanced weaning foods rich in protein and energy have been developed from locally available foods in Ghana. One such food is *weanimix*, a blend of legume (groundnut and/or cowpea) and cereal (maize) in the ratio of 1:4 w/w. However, Takyi et al. suggested that alfalfa could be incorporated into the weaning diet of infants [40]. This legume was found to contain higher levels of protein, minerals, and β-carotene and could support child growth better than weanimix.

Fermentation and germination

Fermentation enhances the nutritive value of food by increasing thiamine, nicotinic acid, riboflavin, and perhaps protein content as a result of microbial activity [41, 42].

Fetuga et al. observed that the digestibility, protein efficiency ratio, net protein utilization, and biological value were much higher in fermented beans than in uncooked beans [43]. Lopez et al. also noted that minerals were made more available and phosphorus was released from phytate during fermentation of corn (*Zea mays*) [44].

Fermentation can also reduce the high bulk of the traditional West African weaning foods by reducing the viscosity of the cereal gruel. During cereal fermentation, microbial activity hydrolyses starch granules, resulting in reduced viscosity of the porridge [N. I. V. Mlingi, personal communication, 1985].

TABLE 3. Estimated protein quality of weaning blends containing groundnut, cereal, and legume

Blend	Protein content (%)	Protein score (%)	NPV[a] (%)
10% groundnut + 80% maize			
+ 10% cowpea	13	66	9
+ 10% pigeon pea	13	67	9
+ 10% soya bean	14	70	10
+ 10% winged bean	14	73	10
10% groundnut + 80% millet			
+ 10% cowpea	13	74	10
+ 10% pigeon pea	13	75	10
+ 10% soya bean	15	77	11
+ 10% winged bean	14	81	12
10% groundnut + 80% sorghum			
+ 10% cowpea	14	58	8
+ 10% pigeon pea	13	59	8
+ 10% soya bean	15	63	10
+ 10% winged bean	15	66	10

Source: adapted from ref. 39.

a. Net protein value (net protein utilization × crude protein content).

In addition to fermentation, germination can improve the nutritional value of weaning foods by reducing the water-binding capacity of cereal flour. This allows the porridge to have a free-flowing consistency even with a high proportion of flour [45, 46]. Germination also converts insoluble proteins to soluble components and increases the levels of lysine as well as of vitamins B and C [47].

Dry milling

Dry milling can improve the nutritional value of weaning foods by conservation. As stated earlier, wet milling of cereal results in nutrient loss and allows contamination from dirty water. It is advisable to use dry milling because it is more hygienic and retains the nutrients in cereals.

Addition of sugar and oil

The addition of sugar and oil increases the energy content of cereal gruel.

Nutrition education

Ignorance and food taboos in West Africa can result in weaning foods of poor nutritional quality. Improving the nutritional value of the weaning foods by itself will not eliminate the problems. Training and nutrition education of the mothers is necessary to change feeding practices and provide correct information.

Nutrition education can easily be incorporated into primary health care programmes. Health workers and nutritionists can educate rural mothers about the importance of adequate weaning foods and practices, infant health, host defense systems, home-scale drying, processing, and so on. The importance of varying the baby's diet and practising good hygiene when handling and storing the baby's food can be included as well.

The teaching and training of rural mothers can have a long-term impact on weaning practices and nutritional status of West African children. In the Philippines a weaning education programme led to a reduction in the prevalence of malnutrition from 64% to 42% [48]. In Nigeria the Africare Child Survival Programme yielded similar results. The governments of some West African nations have yet to realize the importance of training and education.

Access to safe water and sanitation

The provision of water is perceived as a government responsibility. The governments of all West African countries should intensify their efforts to provide safe, pipe-borne water and proper sewage disposal in rural communities. These measures would go a long way to reduce the incidence of food contamination and infectious diseases in West Africa.

In 1989 about 70% of urban Nigerian populations, 50% of semi-urban populations, and 22% of rural populations had access to safe water, according to the Federal Office of Statistics [35]. Forty-eight percent of rural populations and 11% of semi-urban and urban populations named the "bush" as their place for waste disposal. Sixty-five percent of urban populations, 84% of semi-urban populations, and 49% of rural populations used pit toilets. Only 18% of urban households, 3% of semi-urban households, and no rural households had water closets. There is a need for improvement in this area, and many West African governments have intensified their efforts, in some cases with external assistance.

Development of recipe books

The development of books of recipes for weaning foods of high nutrient density using locally available foods is useful. Where recipe books are available, they should be properly distributed to mothers. For the rural illiterate mother, nutrition counselling and demonstrations are appropriate. The Nigerian Ministry of Health produced a booklet called "Nigerian Weaning Diets" that contains more than 40 recipes for weaning foods. WHO/UNICEF have produced similar booklets for health and community workers. The University of Nigeria Cowpea Research Project has also developed a book containing recipes for weaning and adult foods.

Improvement of purchasing power of women

The socio-economic status of women should be improved by increasing their purchasing power, which will ensure household food security. This can be achieved by improving income-generating activities for women. When there is enough food at home, some mothers may be able to make blends or mixes that are more nutritious than the conventional weaning foods alone. Improvement can be brought about through skill acquisition. The availability of appropriate ready-to-use flour from a village mill process will increase the use of weaning foods and decrease costs [48].

Appropriate time allocation for women

Rural women spend about three hours a day in meal preparation, as against one hour for child care [49]. Reducing the workload of rural West African mothers would save time and energy for tending the children. A typical rural African woman spends 14 to 18 hours per day (an average of 17 hours) working. African women are the key to household food security and nutrition. They form 47% of the continent's agricultural labour force and account for two-thirds of food production [50]. With such time- and energy-consuming activities, these rural women are not able to prepare nutritious weaning foods. Time- and energy-saving processing methods and equipment are needed for both agricultural and domestic uses in the rural communities.

Breastfeeding promotion

Mothers should practise exclusive breastfeeding for the first four to six months, and complementary breastfeeding should continue into the second year.

Summary and conclusions

Many of the traditional weaning foods used in West African countries are of low nutrient density. Cereal gruels and starchy roots and tubers continue to form the bulk of the weaning foods. Some children, however, are weaned directly onto the family diet early in life. Infant-feeding practices are not fully developed. Infection and malnutrition are problems associated with poor weaning methods.

A number of convenient commercial weaning foods are now available, but they are very expensive and out of the reach of the target populations. A different approach may be developed to offer rural and poor urban women the opportunity to feed their infants properly, perhaps through appropriate household- or village-scale technology. The governments of the West African countries need to address these problems seriously.

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Home gardening and access to animals in households with xerophthalmic children in rural Nepal

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Abstract

This case–control study compares the home garden and animal husbandry practices of households with and without xerophthalmic children in south-central Nepal, focusing on the relationship between these practices and household intake of vitamin A–rich foods. Eighty-one households with a child between the ages of one and six years diagnosed with xerophthalmia (cases) and 81 households with an age-matched, non-xerophthalmic child (controls) were studied. There was little difference between case and control households in the size of their gardens. However, case households were significantly less likely to plant carotenoid-rich vegetables from October to March than were control households (odds ratio, 0.39; 95% confidence interval, 0.16 to 0.96). The mean consumption of non-carotenoid-rich vegetables, but not of carotenoid-rich vegetables, increased linearly with garden size. Case households were significantly more likely than control households to rent domesticated animals from others ($\chi^2 = 5.91$; $p < .05$). Control households were more likely than case households to own chickens and pigeons ($\chi^2 = 6.6–9.2$; $p < .05$). During specific seasons, household meat consumption was significantly lower in case households, regardless of access to animals. Case households appeared to have significantly lower intakes of key vitamin A–rich foods, particularly green leaves and meat, regardless of their socio-economic level (as determined by ownership of material goods), access to animals, or availability of home gardens.

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Introduction

In areas where vitamin A deficiency is a serious public health problem, childhood xerophthalmia is known to cluster at the regional, district, village, and household levels [1]. This clustering is thought to be the result of pockets of relative poverty and/or poor access to vitamin A–rich food sources [2–5]. Despite this, there are a number of households living in these same high-risk clusters that do not experience xerophthalmia. One explanation is that these households have developed strategies that allow greater access to vitamin A–rich foods.

Cultivation of home gardens and ownership of domesticated animals are potential ways of increasing household access to foods rich in vitamin A and carotenoids. Numerous attempts have been made to implement gardening programmes towards such a goal [6, 7]. Indeed, several studies have found that the presence of a home garden is a strong predictor of the quality of child nutrition, particularly during seasons when employment opportunities are few [8–10].

Although home gardens have been shown to provide a number of economic and dietary advantages to poor families, the evidence linking home gardens to reduced vitamin A deficiency in vulnerable household members is equivocal. In Bangladesh, analyses indicate that even a small household garden affords protection against childhood xerophthalmia [4]. More recent work from this region [11] shows that the variety of plants in a garden, and not its size, is associated with reduced risk of xerophthalmia. Other studies, however, show that vitamin A status may not improve despite successful home gardening efforts [12, 13]. In West Java, well-off households (those with home gardens and land) were found to consume more of all nutrients than did poorer households, except for vitamin A and calcium [14].

Household-level interventions directed towards improving vitamin A status have focused on increasing plant sources of vitamin A by encouraging home gardens, which require a relatively small investment and can be a source of abundant carotenoid-rich foods. Domestic animals are an additional source of home

food that intervention studies and programmes often overlook. Domestic animals provide milk, eggs, and meat that may help protect household members from vitamin A deficiency.

In this study we explore the variations in access to domesticated animals and differences in home gardening practices in households with and without xerophthalmic children in rural Nepal. These practices are then examined with respect to the changes in intake of carotenoid- and retinol-rich foods at the household level over a one-year period.

Methods

A community-wide ocular survey was conducted in January 1992 on 3,735 pre-school children living in three Village Development Committees with a population of approximately 15,000 in Sarlahi District in the central lowland region of Nepal. The survey identified 86 households with children aged 12 to 72 months who had clinical signs of xerophthalmia or a current history of night-blindness. Five households were lost because of migration or refusal to participate, resulting in 81 case households participating in the study. Thirty-three of the children had guardian-reported night-blindness alone, 33 had Bitot's spots alone, and 10 children had both night-blindness and Bitot's spots. The remaining five were diagnosed with corneal xerosis alone or with Bitot's spots or night-blindness.

From the pool of neighbouring households (within 5 km of the case), 81 control households were selected that had a child of the same age as the case child (within three months) and a younger sibling of similar age (within four months), if a younger sibling was present in the case household. In control households, there were no clinical signs of xerophthalmia in any child in the household and no reported history of night-blindness in children or their mothers. Both case and control households were studied prospectively from March 1993 to June 1994.

A recall of home gardening practices was obtained from the head of the household, usually a male, three times during the year: April–May 1993 (three-month recall period), August–September 1993 (four-month recall period), and February–March 1994 (five-month recall period). For the purposes of this study, a home garden was defined to include all plants (fruits and vegetables) grown in and around the homestead. We used specific local terms to distinguish home gardens from agricultural plots. During each round of interviews, recall data were collected on which vegetable and fruit plants were grown in the home garden, the quantity grown, and about how much of the produce was consumed in the household. Harvesting and consumption of green leaves associated with gourds (such as pumpkin leaves) were also noted.

The size of the vegetable garden was calculated by summing the total plot sizes used for each type of plant grown. If one plot area was used for two different crops (planted simultaneously or at different times), the total garden size equalled twice the actual land area used by the plants. In addition, individual vines and plants, such as gourds and tomatoes, grown outside a formal plot were counted separately and assigned an average value of 0.5 square feet (464 cm^2) per plant. As a result of varying planting and harvesting intervals during the recall period, the calculation of garden size is not representative of the actual amount of cultivated land.

Only fruit plants and trees that produced fruit during the year surveyed were counted. The informants were asked to recall all vegetables and fruit plants to which their family had access and from which they were able to obtain some produce, such as plants shared with relatives or neighbours. Fruits or leaves found in the wild were not included within our definition of home garden.

Possession of domesticated animals was determined once by a survey conducted with the head of the household in January 1993. In Nepal there are several forms of animal ownership, ranging from outright ownership to renting and raising animals for a pre-determined portion of the meat or milk produced. Ownership of an animal, for this study, means that the owner has access to all milk or eggs produced by the animal and all the meat if the animal is slaughtered. Rental of an animal means that part of the animal products are kept by the owner and part by the household renting the animal. The numbers of animals owned, rented from others, and rented to others were determined for each household.

Household dietary intake was assessed with a previously described seven-day food-frequency questionnaire [15]. The food-frequency questionnaire was administered four times during the year beginning in July 1993: July to September, October to December, January to March, and April to June. Dietary recalls were conducted on individuals knowledgeable about the household and the food intake of the children, usually the mothers. Household intake was defined as foods consumed by any member of the household, focusing on foods consumed during the primary mealtimes.

Fruits and vegetables were classified as carotenoid-rich or non-carotenoid-rich on the basis of regional and international food composition tables [16, 17]. Vegetables classified as carotenoid-rich included dark-green leafy vegetables and ripe pumpkin; fruits classified as carotenoid-rich included papayas, mangoes, and jackfruit.

Matched-pair odds ratios and 95% confidence intervals were derived by conditional logistic regression to compare household characteristics according to xerophthalmia status. All odds ratios were adjusted for socio-economic status, which was a scaled variable based on the number of different types of material possessions not related to either home gardening efforts or the up-

keep of animals. The final scale had eight items in currently usable condition: flashlights (one or more), watches (one or more), bicycles (one or more), armoires (one or more), beds (two or more), number of rooms in the house (two or more), a roof constructed of a material other than straw, and irrigation pump sets. The alpha coefficient for this scale was 0.78 and the mean score value was 3. Those households with a scale score equal to or greater than the mean were classified as having higher socio-economic status (a value of 1 in the regression equation); those below the mean were classified as having lower socio-economic status (a value of 0).

Odds ratios (OR) of less than 1 indicate that case households were less likely than controls to report a practice (e.g., intake of foods). For analyses that required further stratification of the data, unmatched-pair analyses were conducted. Analyses were carried out using SAS (SAS version 6.11, SAS Institute, Cary, NC, USA).

Oral informed consent was obtained from families before participation in the study. This study was approved by the Nepal Health Research Council in Kathmandu and the Committee for Human Research, Johns Hopkins University School of Hygiene and Public Health, Baltimore, Maryland, USA.

Results

Household gardening patterns

Table 1 lists the most common fruits and vegetables grown over the year by case and control households. The types of vegetables and fruits planted and picked differ little between the two groups. An exception, however, is *munga*, a type of long thin gourd, which was planted significantly more frequently in control households. No difference was noted in access to gardens: more than 97% of all study households reported access to some type of home garden during the year, approximately 95% (97% cases, 94% controls) of the households cultivated vegetables, and more than 81% (80% cases, 84% controls) produced fruits. Likewise, no difference was found in the percentage (which averaged 60%) of vegetable and fruit harvests that the household reported were completely consumed.

Garden size varied during the year, with the smallest gardens being planted from June to September and the largest from October to March. Table 2 compares case and control households with respect to garden size and composition according to season. There were no significant differences in garden size between case and

TABLE 1. Percentage of households with access to garden vegetables and fruits during the year, according to case status

Common name	Scientific name	Cases (n = 79)	Controls (n = 77)
Vegetables			
Sponge gourd	*Luffa cylindrica*	84	75
Green chilies	*Capsicum annum grossa*	72	64
Green peas	*Pisum sativum*	66	64
Gourd	*Lagemaria siceraria*	66	62
Potato	*Impomea batas-convulacea*	58	69
Pointed gourd	*Trichosonthes dioica*	58	66
Munga	Gourd, like *Moringa oleifera*	37	55[a]
Eggplant	*Solanum melongena-solonacea*	33	34
Carotenoid-rich vegetables			
Pumpkin	*Cucurbita minima*	68	77
Garlic leaves	*Allium sativum*	57	65
Mustard leaves	*Brassica compestris-cruciferae*	46	51
Dhaniya leaves	*Coriander sativum*	32	34
Thadiya leaves	Name unknown	32	23
Radish leaves	*Raphnum sativus-crucifera*	25	32
Fruits			
Banana	*Musa sapientum*	52	53
White guava	*Psidium guajava*	57	49
Custard apple	*Annona squamosa*	23	28
Carotenoid-rich fruits			
Papaya	*Carica papaya*	71	65
Mango	*Mangifera indica*	52	56
Jackfruit	*Artocarpus integrifolia*	48	49

a. Statistically significant at $p < .05$.

control households over the whole year; however, control households tended to have larger gardens than case households from October to March (OR, 0.41; 95% CI, 0.17 to 1.01). From October to March only, control households were significantly more likely than case households to plant and consume at least one carotenoid-rich vegetable (OR, 0.39; 95% CI, 0.16 to 0.96). This difference is mainly a result of the greater number of garlic leaves and onion greens consumed in control households during this period.

Figure 1 shows the relationship between average cumulative garden size and vegetable consumption for the year for both vitamin A–rich foods and those lacking significant amounts of vitamin A. Pooled data were used for these comparisons, as garden size did not significantly differ between cases and controls. Consumption of non–vitamin A–rich vegetables was found to increase with garden size, whereas consumption of vitamin A–rich vegetables remained low across the observed range of garden sizes. A similar analysis was performed for fruit consumption (fig. 2). In this case, households without gardens had roughly half the mean intake of carotenoid-rich fruits as households with large gardens, although this difference was not statistically significant.

Patterns of animal husbandry

Table 3 compares case and control households with respect to their access to domesticated animals. Nearly all households (90% of cases and 95% of controls) had at least one animal in their home, and nearly 50% of case and control households had a milk-producing animal. However, case households were more likely than controls to have rented animals from others, especially cows. Moreover, nearly twice as many control households as case households had chickens, and three times as many control households as case households had

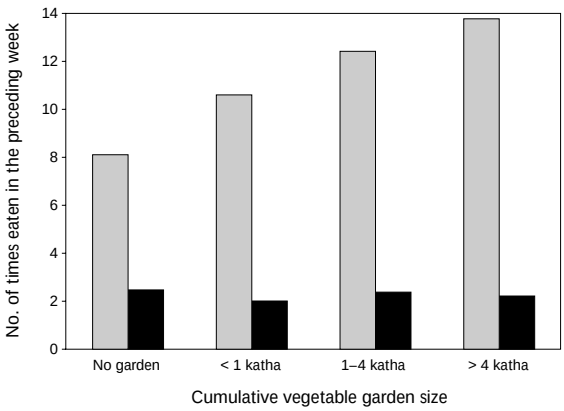

FIG. 1. Average weekly household consumption of low-carotenoid (grey bars) and carotenoid-rich (black bars) vegetables by all study households over the year. according to size of vegetable garden. 1 katha = 0.083 acres = 0.034 hectares

TABLE 2. Matched-pair adjusted odds ratios of garden characteristics for case and control households

	Feb–May 1993			Jun–Sep 1993			Oct 1993–Mar 1994		
Garden characteristic	Case–control pairs (n = 78) (%)	OR[a]	95% CI	Case–control pairs (n = 78) (%)	OR	95% CI	Case–control pairs (n = 77) (%)	OR	95% CI
Cumulative plot size[b] (> 1 katha of land)	63 59	1.49	0.74–3.02	22 16	1.80	0.75–4.32	58 71	0.41	0.17–1.01
> 10 single vines, bushes	44 49	0.84	0.44–1.61	62 58	1.27	0.62–2.62	43 46	0.95	0.47–1.94
> 10 harvesting fruit plants	17 21	0.86	0.36–2.02	33 41	0.87	0.45–1.69	22 36	0.67	0.33–1.35
Carotenoid-rich vegetables harvested and consumed in household	64 71	0.82	0.41–1.65	24 27	0.92	0.45–1.92	72 87	0.39	0.16–0.96[c]
Carotenoid-rich fruits harvested and consumed in household	39 45	0.82	0.43–1.57	39 45	0.70	0.36–1.39	47 42	1.40	0.74–2.65

a. OR, odds ratio; OR < 1 indicates that case households are less likely than control households to report a practice.
b. 1 katha = 0.083 acres = 0.034 hectares. Garden size includes calculation of single vines and bushes with designated plot size of 0.5 sq. ft. (464 cm^2) per plant.
c. $p < .05$.

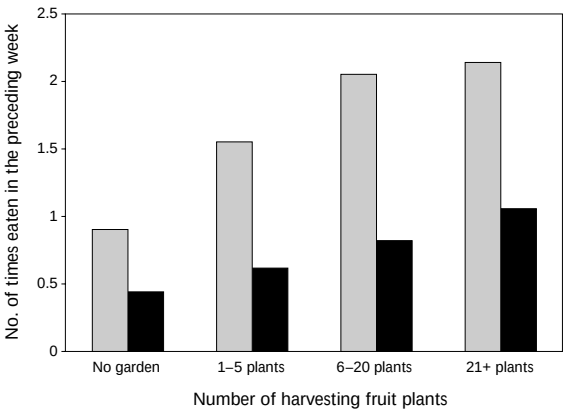

FIG. 2. Average weekly household consumption of low-carotenoid (grey bars) and carotenoid-rich (black bars) fruits by all study households over the year. according to number of fruit plants

pigeons. Chickens and pigeons are both good sources of vitamin A–rich eggs and meat, including liver.

Using household food-frequency data, table 4 examines differences in milk consumption by any household member in the previous week, stratified by access to milk-producing animals. Comparisons are made for three groups: (1) households with no milk-producing animals, (2) households with milk-producing animals (either rented or owned), and (3) households that owned but did not rent milk-producing animals (a subset of group 2). Preliminary unadjusted odds ratios indicated that regardless of access to milk-producing animals (rented or owned), case households were significantly less likely than control households to have consumed milk during the periods from July to September and from October to December (odds ratios ranged from 0.16 to 0.33). However, adjustment for socio-economic status removed any significant differences in milk consumption between case and control households.

Meat (including liver) and eggs are also good sources of pre-formed vitamin A. Animals most likely to be domesticated for consumption include chickens, pigs, goats, and pigeons. Table 5 compares case and control households with and without access to these animals with respect to their consumption of meat and eggs. Among households without access to animals, case households were much less likely to report consumption of meat or eggs in the preceding week than controls (odds ratios ranged from 0.07 to 0.69), with significant differences during the period from January to March. Among households with access to animals, case households were significantly less likely than controls to report consumption of meat or eggs in the preceding week during the period from October to December (OR, 0.41; 95% CI, 0.20 to 0.82).

Discussion

In this paper we differentiate households with a xerophthalmic child from those having a non-xerophthalmic child of the same age, with respect to two factors that could influence the intake of vitamin A–rich foods: home gardens and access to domesticated animals. After controlling for socio-economic status and season, the presence or absence of these factors was related to household intake of vitamin A–rich foods.

Previous dietary analyses from this study indicated that control households consumed more carotenoid-rich vegetables from July to December than case households [15]. The current data corroborate previous find-

TABLE 3. Percentage of case (n = 81) and control (n = 81) households raising animals, renting animals from others, or renting animals to others

	Raising animals		Renting animals from others		Renting animals to others	
Animal	Case	Control	Case	Control	Case	Control
Cows	25	26	11	0[a]	3	7
Bulls and calves	56	58	10	7	3	4
Buffaloes (female)	6	9	0	0	0	0
Buffaloes (males and calves)	21	35	9	9	3	5
Goats (female)	24	25	4	4	1	0
Goats (males and kids)	56	58	23	20	5	12
Pigs	4	6	2	0	0	2
Chickens	26	46[a]	6	5	1	4
Pigeons	6	20[a]	0	0	0	0
Any milk-producing animal (cows, buffaloes, goats)	48	47	15	4[a]	4	7
Any animal	90	95	43	31	11	24[a]

a. $p < .05$ (unmatched pair analyses).

TABLE 4. Non-adjusted and adjusted[a] odds ratios for milk consumption (at least once per household in the past week), based on access to milk-producing animals,[b] for cases and controls, according to year and months

Year and months	No access		Access[c]		Owned animals	
	OR	95% CI	OR	95% CI	OR	95% CI
1993 Jul–Sep						
Non-adjusted	1.25	0.48–3.23	0.32	0.12–0.80[d]	0.33	0.12–0.89[d]
Adjusted	1.07	0.45–2.51	0.73	0.34–1.57	0.61	0.26–1.43
1993 Oct–Dec						
Non-adjusted	1.56	0.62–3.97	0.16	0.06–0.45[d]	0.21	0.07–0.61[d]
Adjusted	1.30	0.53–3.15	0.57	0.26–1.26	0.55	0.24–1.28
1994 Jan–Mar						
Non-adjusted	1.10	0.37–3.30	0.41	0.16–1.02	0.46	0.17–1.23
Adjusted	0.96	0.33–2.78	0.79	0.33–1.90	0.82	0.31–2.15
1994 Apr–Jun						
Non-adjusted	0.47	0.17–1.26	0.69	0.28–1.71	0.90	0.34–2.39
Adjusted	0.41	0.15–1.12	1.41	0.58–3.43	1.78	0.63–5.06

a. Odds ratios adjusted for socio-economic level as determined by a scaled variable of material possessions owned.
b. Female cows, buffaloes, and goats.
c. Households raising animals, either owned or rented.
d. $p < .05$.

ings by showing that control households were more likely to consume carotenoid-rich vegetables from their gardens from October to March as well. The increased intake of carotenoid-rich foods found in the previous analyses may be due in part to the greater access to garden vegetables during certain months of the year.

TABLE 5. Non-adjusted and adjusted[a] ratios for consumption of meat or eggs (at least once per household in the past week), based on access to commonly used animals,[b] for cases and controls, according to year and months

Year and months	No access		Access[c]	
	OR	95% CI	OR	95% CI
1993 Jul–Sep				
Non-adjusted	0.42	0.08–2.33	0.60	0.28–1.26
Adjusted	0.69	0.14–3.29	0.69	0.34–1.38
1993 Oct–Dec				
Non-adjusted	0.19	0.03–1.11	0.31	0.14–0.67[d]
Adjusted	0.34	0.06–1.92	0.41	0.20–0.82[d]
1994 Jan–Mar				
Non-adjusted	0.07	0.01–0.47[d]	0.70	0.32–1.52
Adjusted	0.08	0.01–0.91[d]	0.77	0.37–1.63
1994 Apr–Jun				
Non-adjusted	0.39	0.56–2.73	0.71	0.35–1.48
Adjusted	0.65	0.11–3.91	0.80	0.42–1.51

a. Odds ratios adjusted for socio-economic level as determined by a scaled variable of material possessions owned.
b. Pigeons, chickens, pigs, and goats.
c. Households raising animals, either owned or rented.
d. $p < .05$.

The likelihood of improving consumption of vitamin A–rich foods from the garden, however, is not dependent on garden size. Larger garden sizes were not found to be associated with reported intake of dark-green leafy vegetables and pumpkin. This result supports those of other studies [8, 14] showing that higher economic status may not result in greater consumption of carotenoid-rich vegetables. On the other hand, there was a corresponding increase in the consumption of non-carotenoid-rich vegetables with garden size. As in other areas of South Asia, in Nepal dark-green leafy vegetables are often considered low-status foods, which may explain, in part, why increasing the areas of home gardens does not increase the number of times carotenoid-rich vegetables are eaten.

In this population, access to gardens was high and did not differ significantly between case and control households. Nevertheless, the mean consumption of carotenoid-rich fruits and vegetables was extremely low, averaging less than four times in the preceding week. We also found an increase in the consumption of all fruits as garden size increased. Additional efforts to promote home gardens will likely need to focus on greatly increasing the number of types of carotenoid-rich foods planted and consumed in the household.

Access to domesticated animals is another household strategy that may increase vitamin A intake at the household level but is often omitted from the home-gardening literature. In our sample, both case and control households had access to some type of domesticated animal. However, the form of ownership varied: case households were more likely to rent animals than to own

them. In addition, control households were significantly more likely than case households to own chickens and pigeons. This may be indicative of the slightly better socio-economic status of the control households, a finding consistent with other research in the area [3].

In an effort to control for the effects of socio-economic status on diet, we devised a socio-economic status scale that could serve as a proxy for household income but would not include items on ownership of land or animals. When this variable was included in the regression analysis, we found that socio-economic status did influence the odds ratios of household milk consumption but not those of consumption of meat and eggs. In the case of milk consumption, the odds ratios adjusted for socio-economic status were higher (0.5 to 0.7) than the unadjusted odds ratios (0.2 to 0.3), which implies that although control households had greater reported milk intake than cases, this was probably due in part to the slightly higher economic status of these households.

This was not true with consumption of meat or eggs; case households consumed meat or eggs significantly less frequently than controls in certain seasons, regardless of access to animals or socio-economic status. In households with no access to animals, the odds ratios for consumption of meat or eggs were low (0.07 to 0.69), suggesting that control households, even those without direct access to meat or eggs at home, were still able to obtain and consume meat or eggs more often than case households.

As efforts continue to identify household strategies that increase the intake of vitamin A–rich foods [18, 19], understanding the intricacies of current household practices and their relationship to diet is critical. This study demonstrates that household-level access to home gardens or domesticated animals does not ensure that vulnerable members within the household will be able to obtain a diet adequate to prevent clinical signs of vitamin A deficiency. In addition, the size of a garden did not appear to be related to the intake of carotenoid-rich vegetables in this population. From previous analyses [15] we learned that case households and index children were significantly less likely to consume meat, liver, and eggs. This finding holds true in the current analysis, which indicates that other factors besides household access to domesticated animals or socio-economic level (as determined by ownership of material goods) may influence household intake during critical periods of the year. This study is a first step in examining household strategies and their effect on household intake. Further research to identify other types of household strategies and characteristics important for increased consumption of vitamin A–rich foods is warranted.

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Determinants of the nutritional status of children in a rural African setting: The case of Chobe District, Botswana

Kesitegile Gobotswang

Abstract

*Variations in interdistrict nutritional status have puzzled both social policy makers and health workers in Botswana. A total of 643 households and 898 pre-school children were surveyed to determine factors that are associated with the nutritional status of children below the age of five years in the north-western District of Chobe. Except for those in remote and difficult-to-reach places, all households with a pre-school child were selected for the study. The results showed that the nutritioneal status of the pre-school children had a strong positive correlation with access to a latrine (*r = *0.52) and ownership of cattle (*r = *0.27). Age was negatively correlated with the child's nutritional status (*r = *−0.02).*

Introduction

Botswana has shown impressive improvements in the nutritional status of children below the age of five years. The prevalence of undernutrition declined from 25% in 1985 to about 13% in 1996. However, the western districts, which include Chobe District, have consistently performed poorly in almost all basic health and nutrition indicators. Unlike the other poor and remote desert areas of Gantsi and Kgalagadi, Chobe is endowed with rich natural resources and is one of the attractive destinations for tourists in Botswana. The district also has the highest annual rainfall in the country.

The contradictions between the rich resources and the poor health and nutritional status of children under five years of age in Chobe are a concern to district and central level health workers. Hence there is a need to study some of the underlying factors associated with child undernutrition in this district. The survey was part of a food and nutrition security project supported through a collaborative agreement between the National Institute of Development Research and Documentation (NIR) of the University of Botswana and the Centre for Development and the Environment (SUM) of the University of Oslo. A similar study was conducted in Letlhakeng District. This paper presents findings on the association between selected variables and the nutritional status of children under five years of age.

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Materials and methods

This cross-sectorial study covered eight villages and one "village town" in the north-western District of Chobe. Non-village settlements (areas with less than 500 inhabitants) were excluded from the study. These areas include the underserved and difficult-to-reach places mainly inhabited by the Basarwa (San) people, who are among the poorest in Botswana. For convenience, all households with a pre-school child were selected for the study. A total of 643 households and 898 children under five years of age were surveyed during the study period. According to the 1991 census, 14,126 people lived in Chobe.

Data collection

Structured interviews were conducted using pre-tested questionnaires administered to heads of households. Information was collected on the demographic characteristics of household members and socio-economic factors. Child-related data, such as breastfeeding, child feeding, nutritional status, and sanitary conditions, were also collected. Five female national service participants (Tirelo Sechaba) associated with the National Institute of Development Research and Documentation were used as field assistants. They were trained in basic interviewing techniques and in taking weight measurements. Translations of questions into Setswana, the local language, were agreed upon to ensure consistency.

Anthropometric data

Weight measurements were taken from all children below the age of five years using the Salter hanging scale. Older children who could not fit into the weighing pants were allowed to hang from the scale by their hands. Weight-for-age was used as the main indicator to assess the nutritional status of pre-school children using the National Centre for Health Statistics (NCHS) reference standards. Weight measurements were taken to the nearest 0.1 kg.

Local health workers were informed about the research activities. The respondents were also made aware that the weighing that was taking place was not a substitute for monthly growth monitoring conducted at the health facilities. Before the resumption of the field study, district and local authorities were informed about the study and its objectives.

Timing

Data were collected during June and July 1993, the harvest season. The crop that year was good in comparison with that of the previous year, a drought year. There were occasional outbreaks of malaria before and during the data collection period. At least two of the five field assistants were also affected. For women, who are the main caretakers, the harvest season is one of the busiest periods of the year. Although the food security situation is usually good during harvesting, child care tends to suffer.

Analysis

Data processing was performed on an IBM computer at the National Institute of Research, using the EPI Info (version 5) computer software package. Multivariate analysis was performed to determine independent variables that significantly affected the nutritional status of pre-school children, with weight-for-age as the dependent variable.

Results

Nutritional status

The results in table 1 show that young children up to the age of 10 months have a better nutritional status than older children. By the age of three years, a child in Chobe is more than twice as likely to be underweight as a 10-month-old. The results of the regression analysis further reveal that there is a negative association between age and the nutritional status of the child.

Ethnicity

The main inhabitants of Chobe are the Basubiya, although the Batawana are politically dominant. The Banabjwa, Basarwa (San), and other groups also live in the District. As shown in table 2, ethnicity plays a very important role in the nutrition situation in Chobe. There are significant differences in nutritional status among the main ethnic groups. The percentage of undernutrition ranged from 9% among members of "other" ethnic groups to 30% among the Basarwa children. The rest of the ethnic groups are within the same range (average, 17%) with no significant differences among them.

Sex of head of household

Table 3 shows that children from female-headed households were 1.5 times more likely to be underweight than those from male-headed households ($p < .016$). Women

TABLE 1. Percentage of undernourished children (< –2 SD of reference weight-for-age) according to age group

Age (mo)	% undernourished children
0–10	7.9
11–23	19.8
24–35	20.3
36–47	15.7
48+	20.0
Total	16.7

TABLE 2. Percentage of undernourished children (< –2 SD of reference weight-for-age) according to ethnicity

Ethnicity	% of total sample	% undernourished children
Basubiya	46	16
Batawana	19	16
Basarwa	30	30
Banabjwa	20	20
Others	16	9

TABLE 3. Percentage of undernourished children (< –2 SD of reference weight-for-age) according to the sex of the head of the household

Sex of head	% of total sample	% undernourished children[a]
Female	49	20
Male	51	14
Total	100	17

a. $p < .016$.

constitute the bulk of people living in poverty in Botswana.

Educational level of head of household

Table 4 shows that 23% of children from households headed by a person with no education were underweight, as compared with 15% and 12% of children from households headed by a person with some primary or secondary education, respectively ($p < .0019$). Education is often associated with higher socio-economic status.

Presence of a latrine

An estimated 58% of the children lived in households with latrines. Of those who had no latrine, 28% were underweight, as compared with 25% of children from households with a latrine.

Other factors

The study also considered possible associations of the nutritional status of children under five with the number of people in the household and the number and sex of the working adults in the household. The results showed no significant relation ($p < .276$) between the size of the household and the nutritional status of the children. Ownership of cattle was found to be more important ($p < .015$) in determining the nutritional status of the children. This suggests that the asset base of a household is more important than its size. However, the family size structure can have a positive effect on child nutrition in some instances [1].

A multiple regression model was run to determine the most important factors that affect the nutritional status of pre-school children. Variables considered included ownership of cattle, educational level of the head of the household, presence of a latrine, sex of the head of the household, and age of the child. Table 5 shows a relatively strong positive correlation between nutritional status and the presence of a latrine, followed by ownership of cattle. Age has a negative association with nutritional status: older children are more likely to be underweight than younger children.

Children from households with one or more working adults were less likely to be underweight (table 6).

TABLE 4. Percentage of undernourished children (< –2 SD of reference weight-for-age) according to the educational level of the head of the household

Education of head	% of total sample	% undernourished children[a]
None	32	23
Primary	49	15
Secondary	18	12
Post-secondary	1	0

a. $p < 0.0019$.

Conclusions and discussion

Data from the survey revealed that poor nutrition mainly affects children between the ages of one and three years. The results confirm findings from previous surveys. One of the studies showed that the prevalence of moderate and severe forms of malnutrition was high in children aged 13 to 36 months [2]. A study that looked at the relationship between maternal use of time and children's health and nutritional status found that at two years of age, toddlers begin to receive less intensive care, freeing the principal caretakers, mostly mothers, for economic activities [1]. Participation of the principal caretakers in economic activities outside the household could have a negative effect on child nutrition, depending on the age of the child. Another study, in the Rukwa region of western Tanzania, reported that women spent less time cooking and feeding their children during the peak labour seasons [3]. Although the Chobe study was carried out in a high-activity season, the findings from Rukwa are relevant to this study.

Children in female-headed households were more likely to be malnourished than those in households with a male head. Ownership of cattle was positively associated with better child nutrition. Cattle are the most

TABLE 5. Variables affecting nutritional status of children under five years old

Variable	*B*	95% CI		SE
		Lower	Upper	
Ownership of cattle	0.2700719	0.083527	0.456617	0.95176
Educational level of head of household	0.1072027	–0.033098	0.247504	0.071582
Presence of a latrine	0.5197920	0.315638	0.723946	0.104160
Sex of head of household	0.1500735	–0.037895	0.338042	0.095902
Age of child	–0.0242134	–0.029894	–0.018533	0.002898

TABLE 6. Percentage of undernourished children (< –2 SD of reference weight-for-age) according to the number of working adults in the household

No. of working adults	% undernourished children
0	23
1	20
2	17
3	13

a. $\chi^2 = 3.67$; $p = .30$.

important economic asset in Botswana, in the same way that land ownership is critical in the Medak District of Andhra Pradesh, India [2]. Since women in Botswana generally have a poor asset base, malnutrition is most likely to affect children from female-headed households. The results of the multiple regression model showed an even stronger correlation between the presence of a latrine and the nutritional status of pre-school children. However, households with better socio-economic status are also likely to have latrines.

The educational background of the head of the household had an important influence on child nutrition in Chobe. This is in line with the findings from a study of selected low-income urban areas in Tanzania that showed that mothers with secondary education were about 2.2 and 3.4 times more likely to have adequately nourished normal children than those with 5 to 8 and 0 to 4 years of schooling, respectively [4]. Educational attainment is generally associated with improved socio-economic status.

Improvement of the socio-economic status of the principal child caretakers, who are mostly mothers, could go a long way towards improving the nutritional status of children. However, any intervention that seeks to improve income levels, particularly those of female-headed households, is likely to have a beneficial effect on child health and nutrition.

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Emergency nutrition

Judit Katona-Apte

Abstract

Emergency nutrition is a specialization for strengthening the training and research capacities of developing countries to meet nutritional needs during natural and man-made disasters. Efforts are being made to prevent famines, especially those arising from natural disasters. However, there will be less food available in the future, although new emergency situations are developing constantly and lasting longer. It is important to train nutritionists, administrators, policy and decision makers, and others to be able to prioritize food needs and make the best use of available resources. Methodologies, techniques, expertise, and even theoretical frameworks that can be used in training programmes must be developed and strengthened. The paper discusses four areas where expertise in nutrition is weak and could be strengthened through short courses, workshops, and internships: assessment methodologies, monitoring and evaluation, conflict and post-conflict situations, and advocacy.

Introduction

Institutional capacity-building and training must also include meeting the nutritional needs of populations during disasters. This requires competence in a new specialization, "emergency nutrition." "Emergency" is a relative term: rather than referring to a specific set of conditions, an emergency may be defined as any serious disruption of the functioning of a society that exceeds the ability of an affected people to cope solely by means of its own resources.

There are more than 50 million people in the world who are affected by war or civil conflict and countless others who are affected by floods, droughts, hurricanes, and other natural disasters. A large number of these people depend on external assistance for at least a part of the duration of their displacement. Governments, (national, local, and bilateral), non-governmental organizations, international government organizations, and the United Nations all provide nutritional support to these populations at one time or another. However, without the benefit of appropriately trained nutritional experts, this support is often poorly provided.

Efforts are being made to prevent famines, especially those that result from natural disasters. During the drought in South Africa in the early 1990s, for instance, deaths from famine were averted by a massive shipment of food into the region. At times of conflict, such as the tragedy in the Great Lakes region of Africa, in Somalia, or in the former Yugoslavia, food has been provided to keep populations from starvation.

However, the donor agencies should not become complacent about their ability to provide assistance during emergencies. It is predicted that there will be less food available for such purposes in the future, even though new emergency situations are constantly developing and tend to last longer. These factors present a growing challenge to relief delivery services to provide services both cost-effectively and efficiently. To meet this challenge, it will be necessary to create a critical mass of nutritional experts—administrators, doctors, and others—who are able to assess and prioritize food needs and to make decisions about the best use of available resources. In order to equip nutritionists with the knowledge and skills required to carry out such responsibilities, it is necessary to identify, develop, and strengthen methodologies, techniques, expertise, and even theoretical frameworks that can be used in training programmes.

The first step in positioning ourselves to meet these challenges is to improve existing human resource capacity by initiating specific training opportunities for those already involved in the administration of emergency nutrition services, i.e., policy makers, technical experts, and fieldworkers. Policy and decision makers must be among those targeted for training, because without their informed support, nutritional experts may

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not be included in emergency teams. It is essential that members of emergency nutrition teams be trained in the skills necessary to define objectives, reach consensus, and carry out effective advocacy.

There are four subject areas in which a working body of emergency nutrition expertise should be developed, which could easily be transmitted through short courses, workshops, and internships: (1) assessment methodologies, (2) monitoring and evaluation, (3) conflict and post-conflict situations, and (4) advocacy. This is not to imply that these are the only areas where nutrition expertise is needed. Programme design and project management, for example, are not addressed here. For the sake of brevity, however, only the above-mentioned subjects will be discussed here.

Nor do I wish to imply that the core of professionals needs to be competent in all of these areas, although this would be ideal. Not every emergency requires the same specific expertise. Rather, individuals who work in the field of emergency nutrition should be aware of the importance of each of these perspectives. If individuals could be trained to become proficient in any of these aspects, this would be a step in the right direction.

Methodological needs

During emergencies populations that are dependent on external assistance usually receive food aid. Delivery of appropriate rations is difficult for a variety of reasons (logistics, resource shortages, etc.). Designing those rations in terms of quantities and types of food aid commodities, however, is a task that falls within the domain of nutritionists. There has to be justification for initiating and phasing down food assistance. However, there are currently no training programmes in the methods of assessment for food aid needs or for estimating the levels of food security.

Nutritional requirements, although acknowledged to exist, are not often considered important enough to warrant seeking specific technical input in times of emergency. The number of qualified experts working for United Nations agencies and non-governmental organizations in the area of emergency nutrition is very small. Yet the nutritional well-being of populations during emergencies depends on valid assessments of their food needs and dependence on external food assistance. Such assessments are usually carried out by national governments, United Nations agencies, and non-governmental organizations. These activities, however, do not make use of existing dietary assessment theories, methods, guidelines, or short- or long-term training courses.

The same situation is true of methods for establishing the degree of food security, an indicator for determining when food aid could be phased out. Currently there are no reliable methods or guidelines for these assessments. It is important that these be established, because the availability of food resources is diminishing in comparison to the need for them. Energy experts should be involved in such assessments, but in order to be effective they need to be trained how to design and initiate surveys, analyse the data, and make implementable recommendations.

Monitoring and evaluation

After emergency programmes are implemented, they must be carefully monitored and then evaluated. Emergency nutrition is applied nutrition; we are interested in monitoring the process and the outcome of nutritional intervention as well as the impact on the target population.

In emergencies very large quantities of food commodities are shipped, stored, and distributed. Although it is possible to track the food to distribution points, it is much more difficult to know what happens to the food after it is dispensed: who gets what and how much. It is essential, therefore, to monitor every stage in the movement of food commodities and nutritional outcomes.

Food monitors are often placed in refugee camps to help authorities to be certain that the distributed goods actually reach their targeted destinations. Monitors need to acquire the skills to fulfill the following responsibilities, among others: (1) checking transport and distribution records and other aspects of the food distribution process, (2) determining household-level food availability and consumption, (3) identifying essential inputs for food security interventions, (4) tracking changes in the nutritional status of the population, and (5) identifying those at risk for malnutrition and persuading them to seek assistance. All of these tasks are most efficiently accomplished by persons familiar with the population. Thus, training programmes to improve local capacity (including members of the affected populations) are urgently recommended.

The quantity and type of external food assistance depend on donor perceptions of need and impact. It is important, therefore, to document that training and research programmes, along with proper interventions, do result in reduced malnutrition rates or that they are, at least, successful in the prevention of further deterioration of nutritional status, if that is the objective. Otherwise, future donor response to nutritional needs will decline.

Potential roles for nutritionists in preparedness and post-conflict peace-building

There are important ethical, conceptual, and policy issues to be clarified in the work of nutritionists, who must

be able to translate humanitarian principles into actions appropriate to the needs of the victims. One of the dangers of working in emergency nutrition is a tendency to focus on the immediate needs of the victims—perhaps because so much bureaucracy stands between those entitled to receive assistance and its actual delivery. To do this properly requires support of food as a human right and opposition to the use of food as a weapon.

Nutritionists should be on the forefront of negotiations that affect the availability of food to populations during emergencies. They should be trained in methods of improving disaster preparedness, the early warning indicators of impending crises (such as deterioration of the food supply), the art of negotiating for the safe passage of food (as in Sudan and Bosnia), finding resources for victims of natural disaster (such as are currently needed for North Korea), and designing exemption programmes for government-imposed sanctions. Each of these areas of activity requires special skills—including diplomatic and political adeptness—which are not currently included in nutrition training programmes.

During post-conflict peace-building and reconstruction activities, the objectives are to sustain safe and productive livelihoods as well as lives. This requires a long-term perspective, the opposite of the perspective of emergency relief, which is perceived as temporary. Thus, policy makers and planners may not regard nutrition as a priority in their post-crisis endeavours; after all, the immediate danger of death from starvation has passed. However, the inclusion of nutritional considerations in the design of development programmes is important, as the recovering population is still vulnerable and may not be able to cope with the next crisis.

Nutritionists should be active participants in all stages of planning to ensure that government programmes are created that will assess and correct deficiencies and that safety nets are provided for groups vulnerable to malnutrition. It is highly desirable to train nutritionists to communicate and interact effectively with policy makers and planners in order to make convincing arguments for including nutritional concerns in a country's strategy. In this way they could share the common goal of safeguarding the welfare of the population and improving the quality of life during reconstruction.

Advocacy

It is essential to promote, support, and advance the cause of nutrition if nutrition programmes and considerations are to move forward. When nutrition is not perceived as a priority, it does not receive the prominence necessary to get the job accomplished. This may be because nutritionists do not know how to "sell" their discipline. Excellent technical capacity and expertise are not enough.

The communication gap between nutritionists and policy makers must be closed. Policy makers require easily understood and implementable recommendations. Nutritionists must be able to prepare documents that also serve advocacy purposes. It is also important that nutritionists be able to convince decision makers that there are structural uncertainties that cannot be solved by simple technical recommendations and that require more extensive input.

Training programmes must, therefore, not only stress technical report-writing skills, but should explore the methods to accomplish the objectives of advocacy. Such skills would eventually help to create a policy environment conducive to incorporating nutrition in a country's planning strategies.

Conclusions

There is little appropriate training available in the management of emergency nutrition. This deficiency can be met by including additional courses in existing advanced programmes or by creating special courses in universities and institutes. In some areas, such as Africa, because of the frequency of their emergencies and the necessity for capacity-building in preparedness, emergency nutrition programmes should be developed that would strengthen local institutions and train local persons. There is a special need to build up the nutritional capacity of these non-governmental organizations, because such organizations are on the spot and deal with emergencies as they arise. Recipient country governments are the appropriate organizations to carry out the necessary assessments, monitoring, and evaluations, as they have the advantage of being on site and of knowing the local languages, customs, and conditions.

A quick and easy way to improve the level of expertise and communication skills in emergency nutrition would be to develop course modules designed for different sorts of professionals, e.g., policy makers, technical experts, and food monitors. These modules would be used in workshops and/or training courses in a variety of settings. These should then be followed by the establishment of more elaborate and expensive training opportunities, which would offer field and other on-site experience. It is most important to establish emergency nutrition as a specialized field and to provide opportunities for specific training in this area.

Food fortification: A tool for fighting hidden hunger

Alberto Nilson and Jaime Piza

Abstract

This paper reviews the fortification of staple food as a tool to prevent micronutrient deficiencies. The rationale for fortifying salt, wheat flour, milk, and margarine was developed in the 1920s and 1940s, mainly in industrialized countries. At that time, fortification of staple foods was considered by only a few developing countries. Recent research has shown that the prevalences of some deficiencies (clinical and marginal) in some developing countries are higher than expected. Even more important has been the realization that the impact of marginal deficiencies on health and socio-economic development is considerably more important than the impact of clinical deficiencies. Iron, vitamin A, and iodine have gained more attention, but deficiencies of other micronutrients are also relevant. This paper shows that fortification of staple foods to prevent micronutrient deficiencies is effective, easy, fast, safe, and relatively inexpensive.

Introduction

The scientific rationale, including technology, stability, interactions, and effectiveness, for fortifying staple foods was developed early this century. In the 1920s and 1940s fortification of salt with iodine, fortification of wheat flour with iron, vitamins B_1 and B_2, and niacin, fortification of milk with vitamins A and D, and fortification of margarine with vitamins A and D were fully evaluated and included as part of national intervention programmes in several countries. For whatever reason, these strategies were adopted only by some developed countries.

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In the following decades, developing countries gave their attention mainly to clinical deficiencies, using the medical approach of supplementing the population at highest risk as soon as symptoms appeared. The most challenging problems have been xerophthalmia, anaemia, and goitre. Consequently, attention to other micronutrients has been practically nil.

Later research has shown that marginal deficiency is even more important than clinical deficiency, as it covers larger percentages of the population. Evidence has been accumulating showing the enormous impact of marginal deficiencies of vitamin A on infant and maternal mortality and morbidity, of iron on IQ in children and working capacity in the whole population, and of folic acid on neural tube defects.

Furthermore, there is growing evidence that micronutrients interact positively with each other. For example, vitamin C improves the absorption of non-haem iron from foods or supplements, and vitamin A together with supplementary iron is more effective than iron alone in reducing the prevalence of iron deficiency.

Although not the objective of this paper, it is worth mentioning that an adequate intake of some micronutrients, mainly vitamins E and C, sometimes at levels higher than the established recommended dietary allowances (RDAs), may play an important role in reducing the prevalence of cancer, cardiovascular diseases, and other health problems.

The above facts and the cost of potential intervention programmes show that the cost-benefit ratio of such programmes is highly favourable, motivating the scientific community, international agencies, and governments to seek alternatives for preventing micronutrient deficiencies through supplementation, fortification, and dietary diversification.

Staple foods such as wheat flour, milk, and margarine traditionally have been considered for fortification. Recent research has looked at alternative vehicles for one or more micronutrients, such as rice, oils, tea, maize, weaning foods, beverages, and foods for complementary feeding programmes [1].

Some more recent successful examples of efforts to

prevent deficiencies include fortification of sugar with vitamin A in Central America, fortification of precooked corn flour with vitamins A, B_1 and B_2, and niacin and iron in Venezuela, and fortification of a milk substitute and biscuits with several micronutrients as part of the complementary feeding programmes in Peru.

It is also worth mentioning the fortification efforts of the food industry. Some examples are the fortification of milk with iron in Argentina and Brazil, fortification of noodles with iron and vitamin A in Thailand and the Philippines, and fortification of chocolate powder for milk with iron and several vitamins in Mexico.

Micronutrient deficiencies

Micronutrient malnutrition is a widespread problem throughout the world that has both health and economic consequences. The latest estimates show that 254 million children suffer from clinical and marginal vitamin A deficiency [2], 2.2 billion people, mainly children and pregnant women, suffer from iron deficiency [3], and 1 billion suffer from iodine deficiency [4].

Furthermore, there is some evidence that the prevalence of other micronutrient deficiencies could be much higher than expected. Table 1 shows a recent compilation, by Dr. José Mora, of the evidence available on micronutrient deficiencies in Latin America, confirming the high prevalence of vitamin A, iron, and iodine deficiencies. Despite the lack of information on other micronutrients, there is enough information to suggest that there could be a regional problem, at least for some groups or in some regions, for vitamin B_2, niacin, folic acid, calcium, zinc, and even vitamin C. If a micronutrient is not mentioned in table 1, it is not necessarily because there is no problem, but rather that there is a lack of information.

Global commitment

In 1990, at the World Summit for Children, WHO, UNICEF, and the US Agency for International Development set specific micronutrient goals for the year 2000. These goals were unanimously confirmed by 159 countries at the International Conference on Nutrition held in December 1992 in Rome [5], and a plan of action was adopted. These objectives are to:

» virtually eliminate vitamin A deficiency;
» virtually eliminate iodine deficiency;
» reduce iron-deficiency anaemia by one-third of the 1990 levels;
» pay attention to other micronutrient deficiencies, such as B-complex vitamins, vitamin C, zinc, and calcium.

Three approaches are currently being implemented to address micronutrient deficiencies: food fortification, food supplementation, and dietary diversification. An intervention programme must consider a mix of these approaches.

Fortification

The results of fortification are fast, broad, and sustain-

TABLE 1. Evidence of micronutrient deficiencies in Latin America

Country	National deficiency	Deficiency in certain areas	Deficiency in certain groups	Widespread low intake
Argentina	Fe	I	Fe	Vitamins A, C, E
Bolivia	Fe	I, vitamin C	Vitamin A	Ca, vitamins B_1, B_2, niacin
Brazil	Fe	I, vitamin A	Vitamin A	Vitamins B_2, E
Chile			Fe	Ca, vitamins B_1, B_2, B_6, C
Colombia	Fe	I		Vitamins A, B_1, B_2, niacin
Costa Rica		I		
Dominican Republic	Fe, vitamin A, folate	I		
Ecuador	Fe, vitamins A, B_2, niacin	Zn	Zn	
El Salvador	Fe, vitamin A, I			
Guatemala	Fe, vitamin A	I		
Honduras	Fe, vitamin A	I		
Mexico	Fe, vitamin B_2	I, Ca, niacin	Vitamin C, folate	Vitamins A, B_1, B_2, C, niacin, Zn
Nicaragua	Fe, vitamin A	I		Vitamin B_1, niacin
Panama	Fe	I	Vitamin A	
Peru	Fe, I	Vitamin A	Folate, vitamin B_{12}, Zn	Ca, vitamins B_1, B_2

able. The nutrient intakes of the targeted group improve immediately, and an impact on micronutrient status can be detected within one to three months. When a staple food that is consumed regularly by the majority of the population is used as a fortification vehicle, high population coverage can be easily achieved.

Fortification vehicles

To ensure that the most vulnerable members of the population benefit from food fortification, the food vehicle(s) must be staple food(s) consumed throughout the year by a large proportion of the population at risk. In order to reach different segments of the population who have different diets, it may be more effective to select more than one food vehicle.

When selecting a staple food as a suitable vehicle for compulsory fortification with micronutrients, the following generally accepted criteria must be met [6]:

» The food selected as a vehicle should be consumed by the population at risk.
» The intake of the food should be stable and uniform; the upper and lower levels of intake should be known.
» The essential nutrient(s) should be present in amounts that are neither excessive nor insignificant, taking into account intakes from other dietary sources.
» The amount of essential nutrient(s) should be sufficient to correct or prevent the deficiency when the food is consumed in normal amounts by the population at risk.
» The nutrient(s) added should not adversely affect the metabolism of any other nutrients.
» The nutrient(s) added should be sufficiently stable in the food under customary conditions of packing, storage, distribution, and use.
» The nutrient(s) added should be physiologically available from the food.
» The nutrient(s) added should not impart undesirable characteristics to the food (changes in colour, taste, smell, texture, or cooking properties) and should not unduly shorten the shelf life.
» The technology and processing facilities should be available to permit addition of the nutrient(s) in a satisfactory manner.
» The additional cost to the consumer resulting from the fortification should be reasonable.
» Methods of measuring, controlling, and enforcing the levels of the essential nutrient(s) added to food should be available.

Fortification of staple food: A successful history

In 1923 Switzerland was the first country to fortify salt with iodine to prevent goitre and cretinism, which were widespread throughout the Alpine region. The initiative was later followed by the United States in 1930 [6].

Rickets, caused by vitamin D deficiency, was once common in young children in the northern hemisphere because of the lack of sunshine in the winter months and the low consumption of this vitamin. In 1923 the United Kingdom and the United States started fortifying milk with vitamin D to prevent rickets [6].

Margarine was the first substitute or imitation food produced on a large industrial scale. Its introduction in Denmark in 1910 led to widespread clinical deficiency of vitamin A in children (xerophthalmia). It was soon recognized that to be nutritionally equivalent to butter, margarine had to be fortified with vitamin A, eliminating xerophthalmia in Denmark. Vitamin D was added later [7].

Before 1933 the population of Newfoundland suffered from multiple nutrient deficiencies. The government, aware of the micronutrient losses during wheat milling, banned the consumption of white wheat flour in order to preserve the nutritional value of wheat. However, the population did not like to consume wholewheat flour, and the programme failed to achieve the expected results. In 1944 the government started fortifying white wheat flour with vitamins B_1 and B_2, niacin, and iron and fortifying margarine with vitamin A. The results were remarkable. Various clinical symptoms and indications of vitamins A and B deficiencies, such as skin follicular changes, eye hyperaemia, and magenta tongue, were substantially reduced or eliminated. Beriberi was eliminated completely (fig. 1), and infant mortality in the first year of life fell from 102/1,000 live births in 1944 to 61 in 1947. The biochemical indicators of deficiency of vitamins A, B_1, and B_2 improved

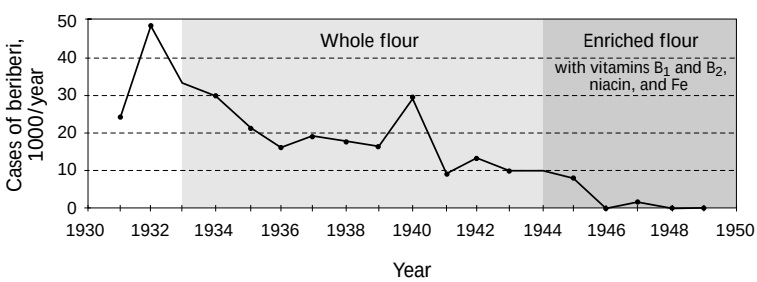

FIG. 1. Effect of enrichment of flour on beriberi in Newfoundland, 1931–49. Source: ref. 8

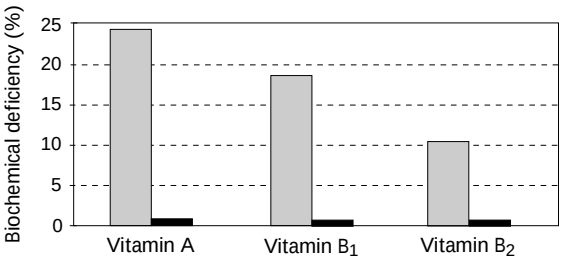

FIG. 2. Biochemical deficiencies of vitamins in Newfoundland before (1944: grey bars) and after (1948: black bars) enrichment of flour. Source: ref. 8

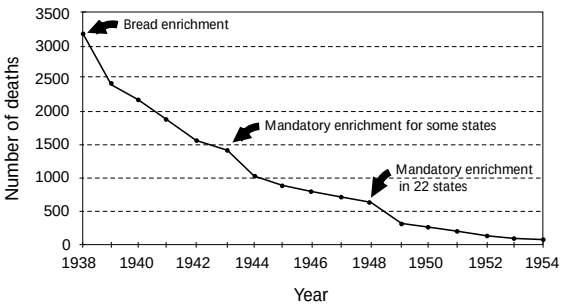

FIG. 3. Effect of enrichment of flour on deaths from pellagra in the United States, 1938–54. Source: ref. 9

dramatically as well (fig. 2).

In the United States during the late 1930s, pellagra caused more than 3,000 deaths annually, mainly in the southern states among a population relying on maize as the main staple food. In 1938, three years before the mandatory introduction of flour enrichment, bakers voluntarily began enriching flour with B vitamins and iron. This measure was associated with a rapid and dramatic decline in pellagra mortality to zero by 1954 (fig. 3).

The introduction of polished rice in the Philippines at the turn of the century led to large outbreaks of beriberi. In 1947, in the Province of Bataan, more than 12% of the population was affected by the disease. The distribution of thiamine-fortified rice began on October 1, 1948. This measure was followed by a spectacular reduction in deaths from beriberi from 254/100,000 to 80 (fig. 4).

Fortification of sugar with vitamin A was initiated in Guatemala in 1974. Sugar was selected because researchers from the Institute of Nutrition of Central America and Panama (INCAP) realized that there was no other staple food reaching all target groups in the country. The prevalence of deficient retinol plasma levels in children (less than 10 μg per 100 ml) was reduced from 3.3% to less than 0.2% within two years (fig. 5).

In 1993 Venezuela started fortifying pre-cooked yellow and white corn flour with vitamins A, B_1, and B_2, niacin, and iron. At the same time wheat flour was fortified with vitamins B_1 and B_2, niacin, and iron. These two cereals were selected as vehicles because they accounted for 45% of the total caloric intake of the population. A survey carried out in Caracas on 397 children showed that the prevalence of iron deficiency (as measured by serum ferritin concentration) and the prevalence of anaemia were reduced from 37% and 19%, respectively, in 1992 to 15% and 10% in 1994 [12].

In 1994 Guatemala revised the fortification of wheat flour, previously fortified with vitamins B_1 and B_2, niacin, and iron, to include folic acid, on the basis of available information on the high prevalence of deficiency of this vitamin and its function in preventing foetal neural tube defects and some anaemias. This measure was later followed by nearly all Central American countries.

In 1998 the United States will include folic acid in the fortification of wheat flour (1.54 mg/kg flour) in order to prevent the high prevalence of pregnancies affected by spina bifida and other neural tube defects. Most of the newborns affected by this problem die. The US Public Health Service has recommended that women of childbearing age consume at least 400 μg of folic acid daily to prevent neural tube defects [13].

Several technologies are available for fortifying rice. Using the technology of simulated kernels, Dr. H. Flores

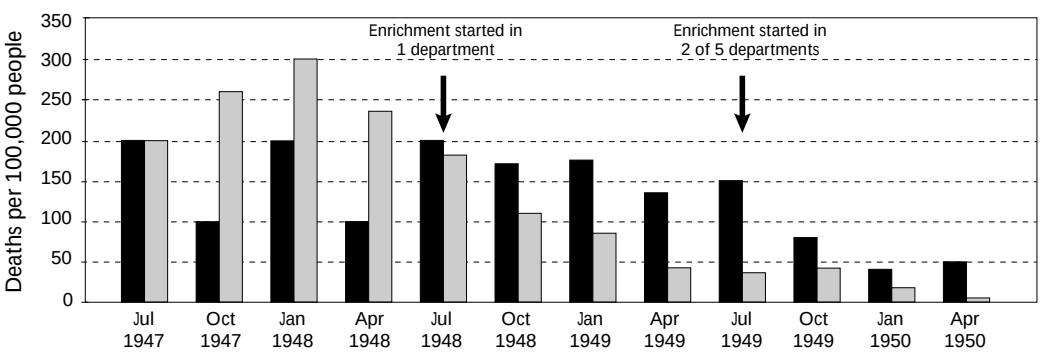

FIG. 4. Effect of enrichment of rice on deaths from beriberi in Bataan, Philippines, 1947–50. Grey bars: experimental area; black bars: control area. Source: ref. 10

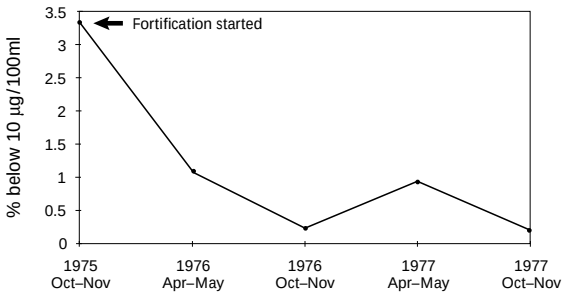

FIG. 5. Effect of enrichment of sugar with vitamin A on plasma levels of retinol in children in Guatemala, 1975–77. Source: ref. 11

demonstrated in Recife, Brazil, that consumption of fortified rice for one month had the same effect as a single dose of 200,000 IU of vitamin A in improving serum retinol levels in children (fig. 6) [14].

Foods supplied to the population as part of complementary feeding programmes can be excellent vehicles for micronutrients. In the Peruvian School Lunch Program, started in 1993, children receive 100 g of biscuits fortified with vitamins B_1 and B_2, niacin, and iron and a glass of a milk substitute fortified with vitamins A, B_1, B_2, B_{12} and C niacin, folic acid, iron, zinc, and iodine. In Huancayo, one of the regions covered by the programme, the prevalence of anaemia (haemoglobin less than 13 g/dl, considering altitude) was reduced from 68% to 18% in six months [15].

In 1996 Colombia, Bolivia, and Ecuador started fortification of wheat flour with vitamins B_1 and B_2, niacin, folic acid, and iron. Fortification of wheat flour with iron and B-complex vitamins and fortification of sugar with vitamin A are being considered by many other countries.

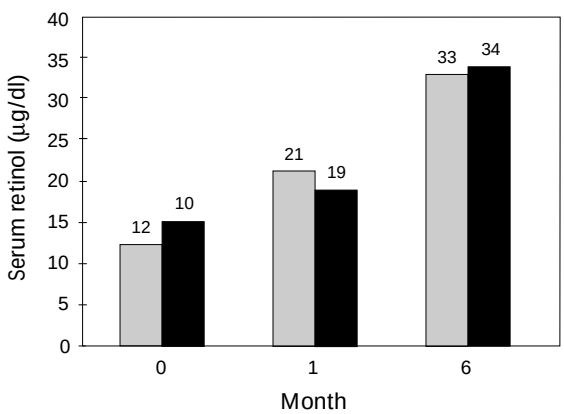

FIG. 6. Effect of fortification of rice with vitamin A (grey bars) in comparison with effect of supplementation with vitamin A (black bars) on serum retinol levels in Brazil. Source: ref. 14

Fortification with several micronutrients

Because diets are seldom deficient in one micronutrient alone, as shown in table 1, combinations of micronutrients increase the cost-effectiveness of fortification even further by addressing more than one deficiency through the same food.

Furthermore, there are several positive interactions among micronutrients. This is especially true for anaemia, where the role of folate, as well as iron, is well known [16], and there is also enough evidence of the high prevalence of folate deficiency in Latin America, mainly in pregnant women.

Fortification of sugar with vitamin A brought an unexpected finding in Guatemala. As well as reducing the prevalence of vitamin A deficiency, the fortification programme reduced the prevalence of anaemia [17].

A recent study in Indonesia showed that supplementation of pregnant women with iron and vitamin A was significantly more effective in controlling anaemia than supplementation with iron alone (fig. 7).

There is ample evidence that vitamin C plays an important role in improving absorption of non-haem iron. Dr. A. Stekel reported that feeding children for 15 months with milk fortified with 15 mg/L of iron as ferrous sulphate reduced the incidence of anaemia from 36% in the control group to 13% in the fortified group [19]. A more significant reduction was found in children given milk fortified with the same amount of iron and 100 mg of vitamin C per liter, which reduced the prevalence of anaemia from 28% in the control group to 2% in the fortified group (fig. 8).

Fortification technologies

As shown in table 2, technologies exist for fortifying staple foods [20]. For most foods, the technology is quite simple. The water-soluble vitamins can be dissolved in water and then added to liquid foods such as

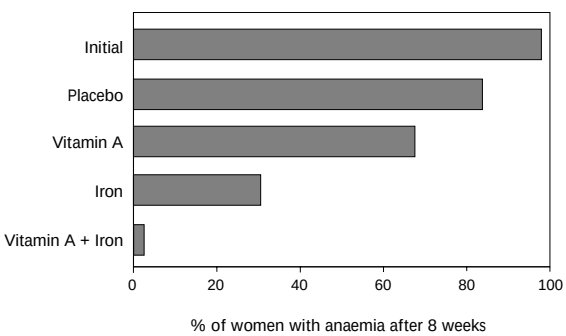

FIG. 7. Effect of supplementation with iron and vitamin A on anaemia in pregnant women in Indonesia. Source: ref. 18

dairy products, fruit juices, and beverages, or they can be mixed in powdered form directly with foods such as wheat flour, corn flour, corn starch, instant powdered beverages, and dry milk. The fat-soluble vitamins can be added directly to foods such as dressing oils, margarine, mayonnaise, and recombined milk. The industry has been able to microencapsulate the fat-soluble vitamins in order to get them into a water-soluble powdered form and to protect them from oxygen and other components of foods. These powdered forms can be mixed with the water-soluble vitamins and added to foods, as described before.

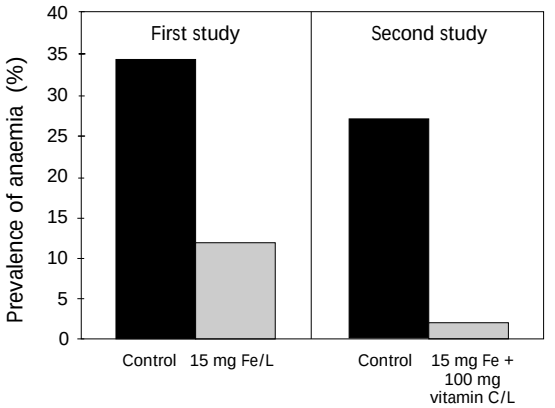

FIG. 8. Effect of enrichment of milk with iron and vitamin C on anaemia in children during the first 15 months of life. Source: ref. 19

Fortification of rice and sugar requires more complex technologies. Vitamin A in powdered form is adhered to the sugar crystals with vegetable oil. Vitamins are sprayed on the rice kernels, which are then coated with appropriate food-grade resins to avoid leaching the vitamins when the rice is washed before cooking. Alternatively, simulated kernels can be produced by technologies similar to the those used for noodles. In this case, the vitamins and minerals in powdered form are mixed with the flour used to produce the simulated kernel.

Stability

Vitamins can be affected by oxygen, humidity, heat, acids, redox agents, and light. Furthermore, other components of foods, such as heavy metals, can interfere with the stability of some vitamins. The technology exists

TABLE 2. Staple foods that can be fortified

	Vitamins											Minerals	
Food	β-Carotene	A	D	E	B_1	B_2	B_6	C	Niacin	Folic acid	B_{12}	Fe	Ca
Milk													
Liquid	+	+	+	+	+	+	+	+	+	+	+	o	+
Powder	+	+	+	+	+	+	+	+	+	+	+	+	+
With cereal	+	+	+	+	+	+	+	+	+	+	+	+	+
Flour													
Wheat	o	+	+	+	+	+	+	x	+	+	+	+	+
Corn	o	+	+	+	+	+	+	o	+	+	+	+	+
Cassava	o	o	o	o	o	o	o	o	o	o	o	o	o
Rice	o	+	+	+	+	+	+	+	+	+	+	+	+
Rice	o	+	+	+	+	+	+	+	+	+	+	+	+
Snacks	o	+	+	+	+	+	+	+	+	+	+	+	+
Corn flakes	o	+	+	+	+	+	+	+	+	+	+	+	+
Oil	+	+	+	+									
Margarine	+	+	+	+	o	o	o	o	o	o	o	x	o
Mayonnaise	+	+	+	+	o	o	o	o	o	o	o	x	o
Juices	+	o	o	+	+	+	+	+	+	+	+	+	+
Sugar		+											
Powdered beverages	o	+	+	+	+	+	+	+	+	+	+	+	+

Source: ref. 20.
+, Possible; o, trials needed; x, not possible.

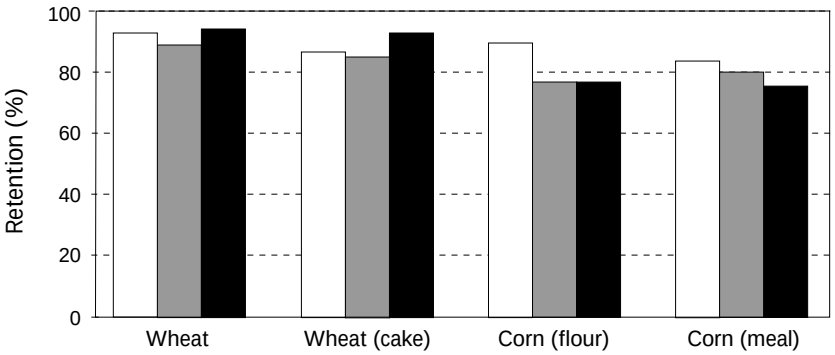

FIG. 9. Stability of 11,000 IU/kg vitamin A added to flours at 27°C after one month (white bars), three months (grey bars), and six months (black bars). Source: ref. 21

to prevent losses, but losses cannot be totally avoided. To ensure that the food contains the declared vitamin levels when it is ingested, the food industry adds extra nutrients to compensate for losses during processing and over the shelf life of the finished product.

Figure 9 shows that vitamin A is very stable when microencapsulated in powdered form and added to different flours, even when the flours are fortified with iron at the same time. When wheat flour is fortified, the typical losses during the production of bread and biscuits are 30% to 40% for vitamin A, 20% to 30% for vitamin B_1, 15% to 20% for vitamin B_2, 5% to 10% for niacin, and 15% to 20% for folic acid.

Figure 10 shows the stability of vitamins in pre-cooked corn flour during the production of *arepas* (corn bread), according to results from our laboratories in Switzerland. It is worth mentioning that the flour was also fortified with iron.

Bioavailabilty

It is generally recognized that the bioavailability of vitamins added to foods is about the same as for those originally present in foods. Carotenoids and iron, however, require more attention. β-Carotene present in foods is less bioavailable than β-carotene added as a colour or fortificant. The bioavailability of iron depends on several factors. For reduced iron, the most important factor is the mesh size of the form used, the smallest size being the best. Figure 11 shows the relative bioavailability of some typical forms of iron used to fortify foods. As mentioned before, vitamin C significantly improves the bioavailability of non-haem forms of iron.

When selecting the form of iron to be used in the fortification of a food, in addition to its relative bioavailability, the food industry has to consider its cost and potential interactions with the food. Table 3 shows the relative cost of typical forms of iron.

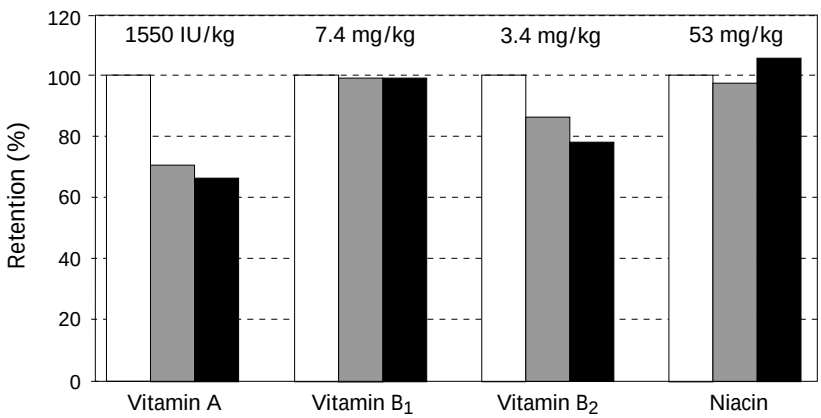

FIG. 10. Stability of vitamins in pre-cooked corn flour (grey bars) and corn bread (*arepas*)(black bars) in Venezuela. White bars, percentage at addition. Source: unpublished data of the authors

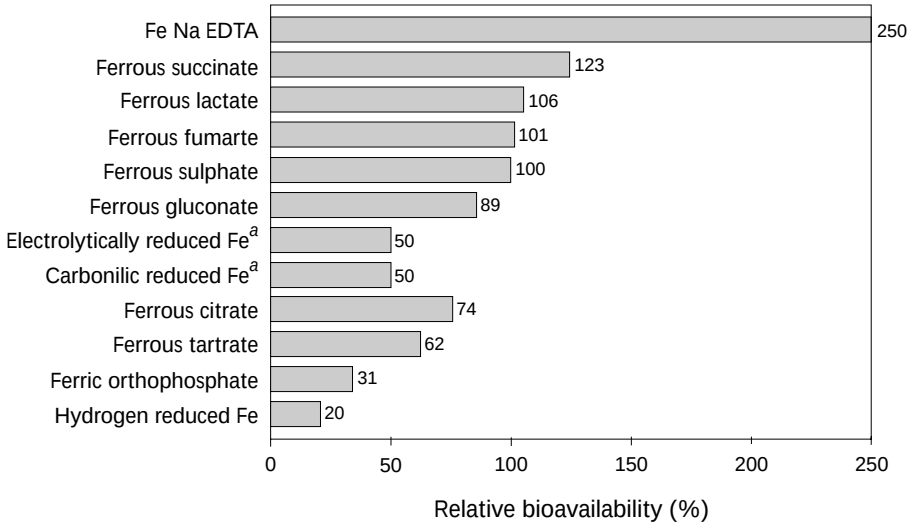

FIG. 11. Relative bioavailability of iron salts. Source: refs. 22–24.
a. Typical values published in several papers.

β-Carotene as colour and vitamin A

β-Carotene is extensively used as a food colour, at the same time contributing its nutritional value. As mentioned before, the bioavailability of β-carotene used as a colour is good. Figure 12 shows the nutritional contribution of β-carotene in the doses typically used as a colour for some selected foods.

Safety

J. N. Hathcok recently published a recompilation of the safety range for vitamins and minerals, defining the NOAEL (Non-Observed Adverse Effect Level) and LOAEL (Lowest Observed Adverse Effect Level) for every micronutrient [25]. Table 4 shows these levels expressed as multiples of the RDA [26].

Food fortification is the safest way to deliver necessary amounts of micronutrients to the majority of a population in an effective manner. Fortification levels of the nutritional intervention programmes should be determined by governments on the basis of an evaluation of consumption patterns of the food vehicle and the amount of nutrient needed to prevent deficiency, without possible harm from excessive intake.

TABLE 3. Iron content and relative cost of typical forms of iron used to fortify foods

Form of iron	Iron content (%)	Relative cost per unit of iron[a]
Iron reduced with H_2	98.0	1
Reduced iron, electrolytic	98.0	3
Ferrous sulphate, anhydrous	31.6	2.6
Ferrous fumarate	30.6	3.4
Ferric orthophosphate	26.0	5.9
Ferric lactate	20.5	22.8
Ferrous gluconate	12.5	26.2
FeNa EDTA + $3H_2O$	12.5	50.4

a. Iron reduced with H_2 is the reference substance. Relative cost considers cost and iron content.

Fortification cost

The direct cost of delivering nutrients as supplements or in food is remarkably low, compared with the social costs of deficiencies. The cost of fortification includes the costs of the fortificant, capital, and labour (for the blending operation), as well as the costs of transport and quality control. Depending on the type of food to be fortified and the fortification level and technology, fortification cost can vary over a wide range. In most cases, according to World Bank figures, it costs less than US$1 per year to protect an individual against deficiencies of vitamin A, iron, and iodine with food fortification [3]. The cost of fortification to protect an individual for one year against vitamin A deficiency is less than US$0.30 and against iron deficiency less than US$0.10. Table 5 shows typical costs of the quantity of micronutrients needed to cover the total requirement during a full year.

Eliminating micronutrient deficiencies can have major yet subtle social and economic benefits. When nutritional deficiencies are eliminated, adverse consequences, such as reduced IQ, impaired growth, reduced work capacity, and death associated with pregnancy and child-

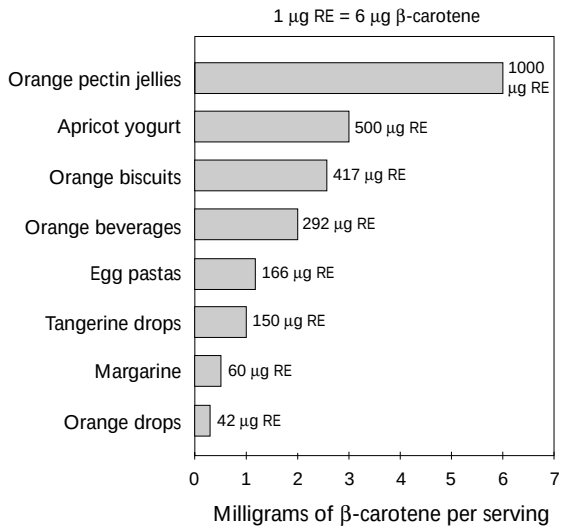

FIG. 12. Nutritional contribution of β-carotene used as food colour

birth are reduced. Food fortification provides maximum benefit for minimum investment.

Food fortification is generally recognized as being the most efficient as well as the most cost-effective means of eliminating micronutrient deficiencies when compared with supplementation and home gardening. In 1994 the USAID published an evaluation of the cost-effectiveness of three vitamin A interventions in Guatemala (fortification, supplementation, and home gardening) and compared the results with similar evaluations performed in Indonesia and the Philippines [27]. When the cost per high-risk person reached was considered, the conclusion was that fortification of staple foods was the cheapest intervention strategy (table 6). Furthermore, fortification was the most sustainable intervention and had the best coverage at the national level.

Voluntary versus mandatory fortification

The food industry has responded in some cases by voluntarily fortifying products. However, the development of voluntarily fortified foods has been impaired in some countries because of consumer and, in many cases, government lack of awareness of the prevalence of micronutrient deficiencies and their impact on health. Without consumer demand for fortified products, industry is often not motivated to fortify products voluntarily.

A number of staple foods around the world have been successfully fortified with micronutrients. Tables 7 and 8 show the countries with compulsory fortification of wheat flour and margarine, respectively [28]. As mentioned before, in 1998 the United States will start adding folic acid to wheat flour. In 1997 Ecuador, Bolivia, and Colombia started programmes to fortify wheat flour with vitamins B_1 and B_2, niacin, folate, and iron. The United States, Argentina, Venezuela, Mexico, the Philippines, and Malaysia fortify milk with vitamins A and D. Sugar is fortified with vitamin A in Guatemala, Honduras, and El Salvador. In addition to wheat flour, Venezuela has fortified pre-cooked corn flour with vitamins A, B_1 and B_2, niacin, and iron since 1993.

TABLE 4. Safety levels of micronutrients

Micronutrient	RDA	No. of times the RDA	
		NOAEL	LOAEL
Vitamin A	3,333 IU	3	6.5
Vitamin D	200 IU	4	10
Vitamin E	15 IU	80	NE
Vitamin K	80 µg	375	NE
Vitamin C	60 mg	> 17	NE
Vitamin B_1	1.5 mg	33	NE
Vitamin B_2	1.7 mg	118	NE
Niacin	19 mg	79	158
Vitamin B_6	2 mg	100	250
Folate	200 µg	5	NE
Vitamin B_{12}	2 µg	1,500	NE
Biotin	100 µg	25	NE
Pantothenates	7 mg	143	NE
Ca	800 mg	1.9	> 3.1
P	900 mg	1.9	> 3.1
Mg	350 mg	2	NE
Cu	3 mg	3	NE
I	150 µg	6.7	NE
Fe	10 mg	6.5	10
Se	70 µg	2.9	13
Zn	15 mg	2	4

Source: refs. 25, 26.
RDA, Recommended dietary allowance; NOAEL, non-observed adverse effect level; LOAEL, lowest observed adverse effect level; NE, not established.

TABLE 5. Recommended dietary allowance (RDA) and annual cost of micronutrients per person

Micronutrient	RDA	Annual cost per person (US$)
Vitamin A	1,000 µg RE	0.253
Vitamin D	400 IU	0.051
Vitamin E	10 mg TE	0.285
Vitamin B_1	1.5 mg	0.032
Vitamin B_2	1.7 mg	0.053
Vitamin B_6	2 mg	0.064
Vitamin C	60 mg	0.558
Niacin	19 mg	0.067
Folate	200 µg	0.016
Vitamin B_{12}	3 µg	0.053
Iron	15 mg	0.04
Total		1.47

Source: ref. 26.

TABLE 6. Comparison of annual cost-effectiveness estimates between countries

Type of intervention	Annual cost per person (US$ in 1991)		
	Guatemala 1979 Indonesia 1978 Philippines 1975	Philippines 1980	Guatemala 1991
Fortification			
Per person	0.16	0.14	0.29
Per high-risk person	0.37	0.32	0.65
Capsule distribution			
Per high-risk person	0.48	0.32	1.52
Gardening			
Per person		2.32	1.60
Per high-risk person			3.63

Source: ref. 27.

TABLE 7. Compulsory fortification of wheat flour in different countries (mg/kg)

Country	Vitamin B_1	Vitamin B_2	Niacin	Folic acid	Iron
Canada	4.4–7.7	2.7–4.8	35–64	0.4–0.5	29–43
Chile	6.3	1.3	13		30
Costa Rica	4.4–5.5	2.6–3.3	35.2–44		28.7–36.4
Dominican Republic	4.45	2.65	35.62		29.29
El Salvador	4.41	2.65	35.3		28.7
Guatemala	4–6	2.5–3.5	35–40	0.35–0.45	55–65
Honduras	4.4	2.6	35.2		28.7
Nigeria	4.5–5.5	2.7–3.3	35.5–44.4		28.9–36.7
Panama	4.4	2.6	35.2		28.7
Saudi Arabia	> 6.38	> 3.96	> 52.91		> 36.3
United Kingdom	> 2.4		> 16		> 16.5
United States	6.4	4	52.9		44.1
Venezuela	1.5	2	20		20

Source: ref. 28.

Labelling

Educated consumers can choose foods that enable them to maintain a balanced diet rich in vitamins and minerals. However, governments may need to intervene and require the food industry to provide consumers with the tools they need to make these educated choices.

In the United States, starting in 1975, the Food and Drug Administration (FDA) required most foods to be labeled with their nutritional content. Food labelling is a powerful tool to educate the consumer and to facilitate an informed choice of food. In 1993 the FDA revised the requirements of food labelling to include almost all the foods that consumers purchase. According to the FDA, "The purpose of food label reform is simple: to help consumers choose more healthful diets, and to offer an incentive to food companies to improve the nutritional qualities of their products" [29].

Along with information on saturated fat, cholesterol, and dietary fibre, the new labelling law mandated that nutrient levels of vitamins A and C, calcium, and iron must be reported on the label. These micronutrients were selected because of public health concerns and are listed on the label in order of priority (vitamin A, vitamin C, iron, and calcium) [29].

The mix of compulsory and voluntary fortification has produced an important increase in the availability of micronutrients in the United States, as shown in table 9.

Conclusions

More than 2 billion people, one-third of the world's population, suffer from micronutrient deficiencies. Inexpensive and cost-efficient solutions to eradicate these deficiencies are readily available; of these, food fortification is recognized as the most efficient and sustain-

TABLE 8. Compulsory fortification of margarine in different countries (IU/kg)

Country	Vitamin A	Vitamin D
Belgium	22,500–27,000	2,500–3,000
Brazil	15,000–50,000	500–2,000
Canada	> 33,000	> 5,300
Chile	30,000	3,000
Colombia	3,180–7,950	480–1,200
Denmark	25,200	
Ecuador	20,000–30,000	2,000–4,000
El Salvador	15,000	
Guatemala	15,000–50,000	
Honduras	35,000	1,500
India	> 30,000	
Indonesia	25,000–35,000	2,500–3,500
Malaysia	25,000–35,000	2,500–3,500
Mexico	20,000	2,000
Netherlands	> 20,000	> 3,000
Panama	20,000	1,500
Peru	30,000	3,000
Portugal	18,000	
Singapore	> 28,300	> 2,200
Sweden	> 30,000	> 3,000
Taiwan	> 45,000	
Turkey	20,000	1,000
United Kingdom	24,000–30,000	2,800–3,520
United States	33,000	2,080

Source: ref. 28.

TABLE 9. Contribution of food enrichment to availability of micronutrients in the United States

Micronutrient	Contribution (%)	
	1970	1985
Vitamin A	10	13
Vitamin C	10	8
Vitamin B_1	40	24
Vitamin B_2	15	20
Niacin	20	18
Vitamin B_6	4	6
Folic acid	0	6
Vitamin B_{12}	2	4
Iron	25	24

Source: ref. 30.

able solution. Successful fortification of a staple food reaches everyone, including the poor, pregnant women, young children, and populations that social services can never cover completely. In addition, fortification reaches secondary target risk groups, such as the elderly, the ill, and those who have an unbalanced diet, for whatever reason.

Fortification is socially acceptable, requires no change in food habits, does not change the characteristics of the food, can be introduced quickly, has readily visible benefits, can be legally enforced, is relatively easy to monitor, is safe, and is the cheapest intervention for a government. Commitment from government and the food industry, and an educated consumer who demands micronutrient-rich foods, will determine the success of fortification as an intervention strategy.

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A lesser-known grain, *Chenopodium quinoa*: Review of the chemical composition of its edible parts

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Abstract

In this era of ever-increasing world population, newer food and feed crops that have been hitherto neglected are gaining recognition. The rejection of such lesser-known food crops has been due not to any inferiority but to the lack of research resources in the place of origin and often to their being scorned as "poor people's plants." The genus Chenopodium *supplies tasty and nutritious leaves as well as pink- to cream-coloured edible seeds. Tolerance to cold, drought, and salinity and the high lysine content of the seed protein are the attractive features of quinoa* (Chenopodium quinoa), *the most frequently consumed species in the Andean regions of South America, Africa, some parts of Asia, and Europe. This review compares and evaluates the nutritional and antinutritional constituents of the leaves and seeds of* C. quinoa *vis-à-vis their conventional counterparts and argues for the acceptance of this plant in human diets.*

Introduction

Most of the world's food today comes from a mere 20 or so plant species. Throughout history mankind has used some 3,000 plant species for food, but over the centuries the tendency has been to concentrate on fewer and fewer. The rejection of lesser-known food crops has not been due to any inherent inferiority. Many have been overlooked merely because they are native to the tropics, a region generally neglected because the world's research resources are concentrated in the temperate zones. Others are neglected because they are scorned as "poor people's plants."

Quinoa (*Chenopodium quinoa)* is one of the lesser-known food crops, a poor people's crop that is native to the Andean regions of South America [1]. In contrast to maize, potatoes, and *Phaseolus* beans, all of which are staple crops originating from the Andes, quinoa has not attained global importance, possibly because the bitter, antinutritional saponins [2] need to be removed from the seed before cooking or processing [3].

Quinoa has an exceptionally attractive amino acid balance for human nutrition because of its high level of lysine. The tasty and nutritious leaves and seeds are consumed frequently in the Andean regions of South America, Africa, some parts of Asia, and Europe. The plant is native to Peru, and the seeds are used whole in soups or ground into flour to make bread and cakes [4]. The seeds are also used as poultry feed, in medicine, and for making beer.

Agronomic aspects of *Chenopodium*

C. quinoa is a dicotyledonous plant and is botanically classified as follows [5]:

Subclass:	Dicotyledoneae
Group:	Thalamiflorae
Order:	Caryophyllales
Family:	Chenopodiaceae
Genus:	*Chenopodium*
Species:	*quinoa*

The family Chenopodiaceae is composed of herbs and shrubs, or rarely small trees, that usually grow in alkaline soil. The plants are usually scruffy because of their external cells that dry into white flakes. The leaves are simple, sometimes more or less succulent or reduced to small scales, and usually alternate but rarely opposite. There are no stipules and the flowers are bisexual or rarely unisexual [6].

The family is found worldwide but it is centred in alkaline areas. Some species are restricted to wet, salty, or alkaline soil, such as that of coastal marshes or alkaline plains and desert areas. On the whole, the family is made up of weedy plants. Some of the more important genera are *Chenopodium* (goosefoot, pigweed, or lamb's quarters), *Kochia* (red sage), and *Salsola* [5].

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The genus *Chenopodium* has a worldwide distribution and contains about 250 species [3]. About eight species are found in India [7]. Some species of *Chenopodium* and the countries in which they are found are listed in table 1 [8]. *Chenopodium* species have been considered weeds [9], and many efforts have been directed towards their eradication [10].

Interest in quinoa as a valuable food source has been renewed in Asia in recent years because of its versatility and its ability to grow under conditions normally inhospitable to other grains. These include low rainfall, high altitude, thin cold air, hot sun, and sub-freezing temperatures.

The average yield of the fruit, as reported by Simmonds [11], is 840 to 3,000 kg/ha, whereas Weber [12] reported yields for quinoa as low as 450 kg/ha to a record of 5,000 kg/ha, with an average yield of 800 to 1,000 kg/ha. Quinoa is extensively grown in Peru and Bolivia. Because of its resistance to frost and drought, it is very suitable for cultivation in highlands and temperate regions. Production of quinoa in Ecuador has gone from backyard cultivation to extensive cultivation. In 1987 around 431 ha were harvested, producing 720 tonnes.

Quinoa as a vegetable

Quinoa leaves are widely used as food for humans and livestock [12] and constitute an inexpensive source of vitamins and minerals. Generally, the younger leaves are used for human food. The correlation between the nutrient content of a leaf and its age (as shown by its position on the plant) is an important factor in choosing leaves for harvesting. *Chenopodium* leaves have more protein and minerals than commonly consumed spinach and cabbage but less than amaranth leaves. The leaves of *Chenopodium* species contain from 3% to 5% dry weight nitrate [8]. The nitrate content in amaranth leaves ranges from 0.8% to 2% [13]. However, most of the nitrate is concentrated in the stem portion, which is generally discarded [8]. The oxalate content of *Chenopodium* leaves ranges from 0.9 to 3.9 g/100 g fresh weight, concentrated mainly in the stems [8]. Flavonoids have been identified in five species of *Chenopodium*. Quercitin (a flavonol) was found in all five species, kaempferol in four, and isorhamnelins in one [14]. The biological function of these flavonoids could be to provide resistance against viruses [15].

TABLE 1. Distribution of some *Chenopodium* species[a]

Species	Countries
C. *quinoa*, C. *pallidicaule*	Argentina, Bolivia, Chile, Guatemala, Peru
C. *berlandieri*	Mexico
C. *album*	India (valleys of Himalayas)
C. *ambrosoides*	India
C. *amaranticolor*	India
C. *murale*	India
C. *striatum*	Czechoslovakia
C. *opulifolium*	Czechoslovakia
C. *foliosum-polyspermum*	Finland

Source: ref. 8.
a. Hybrids available: *C. album-quinoa, C. foliosum-polyspermum.*

The amino acid composition of quinoa leaves as compared with that of other leafy vegetables is given in table 2. The higher content of lysine and lower content of methionine are its most distinguishing features.

Quinoa leaves can also be eaten in salads and are important in regions where vegetables are scarce. The leaves and stems are also fed to ruminants, and the chaff and the gleanings are generally fed to pigs.

Quinoa seed

C. quinoa is a starchy, dicotyledonous seed, not a cereal [17]. The small, round, flat seeds measure about 1.5 mm in diameter, and 350 seeds weigh about 1 g [18, 19]. Quinoa has been an important grain crop in the Andes for many centuries and now is gaining popularity elsewhere in the world. In comparison with the common cereals, quinoa generally has a higher content of lysine-rich protein (12%–19%; average, 15%), fat (5%–10%), and crude fibre (2%–3%). This makes it nutritionally superior to most cereal grains. Table 3 gives the proximate composition of quinoa in comparison with some other food grains. After mechanical abrasion, the α-amylase and protease activities of quinoa seeds increase [25]. High α-amylase activity is probably the cause of the low amylograph values of quinoa. The iron, calcium, and phosphorus levels are higher than those of maize and barley [13, 26].

The main food uses for quinoa are for soups, sweets, and a coarse bread called *kispina*. Various hot or fermented drinks can be prepared from it. High-protein cakes, cookies, and biscuits can be made by mixing up to 60% quinoa flour with wheat flour [12, 21]. The fermented beverage made from quinoa seeds is called *chicha*. Noodles can be made using 40% quinoa flour without affecting the appearance or other characteristics of the product. A number of recipes for cookies, chowders, croquettes, and casseroles using quinoa are available [27]. Quinoa can be germinated at 22°C in fresh water; the germination rate is 74% to 86%. However, germination at 0°C caused a decrease in the germination rate of 12% to 30% [28].

The protein, fat, and fatty acid composition of *Chenopodium* seeds is similar to that of amaranth [29].

TABLE 2. Amino acid composition of quinoa leaves compared with that of other leafy vegetables

Vegetable	Total N (g/100 g)	Amino acid (%)											
		Arg	His	Lys	Trp	Phe	Tyr	Met	Cys	Thr	Leu	Ile	Val
Quinoa	0.6	0.92	0.32	0.75	0.02	0.11	0.37	0.05	–[a]	0.17	0.41	0.41	0.29
Amaranth	0.6	0.24	0.13	0.25	0.07	0.18	0.19	0.07	0.04	0.14	0.37	0.29	0.28
Cabbage	0.3	0.45	0.13	0.24	0.07	0.20	0.12	0.06	0.07	0.22	0.34	0.23	0.26
Drumstick leaves	1.1	0.38	0.14	0.32	0.10	0.29	–[a]	0.11	0.13	0.25	0.46	0.28	0.35
Spinach	0.3	0.35	0.14	0.40	0.10	0.33	0.31	0.11	0.08	0.29	0.53	0.3	0.35

Source: ref. 16.
a. – trace or absent.

TABLE 3. Proximate composition (%) of quinoa seeds compared with that of other seeds

Seed	Moisture	Ash	Protein	Fat	Carbohydrate	Crude fibre
Quinoa	10–13	3	12–19	5–10	61–74	2–3
Amaranthus paniculatas	6–9	3–4	13–18	6–8	63	4–14
Wheat	13	2	14	2	69	1
Oats	8	2	14	8	68	1
Rice	15	1	8	1	78	2
Maize	15	2	13	4	66	3
Sorghum	12	2	12	2	73	2
Soya bean	8	5	47	21	14	4
Barley	13	2–3	12	1	70	4

Source: refs. 13, 16, 17, 19–24.

Protein content

Quinoa seeds contain high-quality protein [30] and large amounts of carbohydrates, fat, vitamins, and minerals. The seeds have a higher nutritive value than most cereal grains. The protein content of about 15% in quinoa is much higher than that found in cereals such as wheat, barley, oats, rice, and sorghum. The soluble protein contents in quinoa are similar to those in barley and higher than those in wheat and maize [26].

Table 4 gives the contents of essential amino acids in quinoa as compared with other grains. Quinoa protein contains large amounts of lysine, which is limiting in many plant proteins. The Sajma variety (developed in Bolivia) contains approximately twice as much lysine as whole wheat on a dry weight basis. The high levels of lysine in quinoa protein make it nutritionally superior to wheat. Dini et al. [31] reported lysine, with a chemical score of 83, as the limiting amino acid, although the level is higher than that for wheat and rice, with chemical scores of 31 and 40, respectively.

It is an interesting observation that methionine and cysteine (chemical score 127) and phenylalanine and tyrosine (chemical score 125) are limiting in other grains.

TABLE 4. Essential amino acid composition of quinoa seeds compared with that of other seeds

Seed	Amino acid (g/100 g protein)								
	Trp	Met	Thr	Ile	Val	Lys	Phe/Tyr	Leu	Cys
Quinoa	0.8–1.1	0.3–2.6	3.6–4.4	3.8–4.2	4.7–4.8	5.4–6.3	6.2–8.9	–[a]	0.6–1.4
Amaranthus cruentus (raw)	–[a]	4.1	3.4	3.6	4.2	5.1	6.0	5.1	2.1
A. cruentus (popped)	–[a]	3.7	3.5	3.6	4.3	4.3	6.0	5.2	1.8
A. edulis	1.1	4.0	3.8	3.9	4.5	5.7	7.8	5.9	2.3
Wheat	0.9	4.3	3.1	3.5	4.7	3.1	8.0	7.0	2.2
Oats	1.3	4.7	3.5	4.0	5.5	4.0	8.9	7.8	1.4
Soya bean	0.7	3.0	4.5	4.0	4.4	6.4	8.4	7.8	1.6
Corn	0.6	3.2	4.0	4.6	5.1	1.9	10.6	13.0	1.6
Rice	1.0	3.0	3.7	4.5	6.7	3.8	9.1	8.2	1.6
FAO/WHO standard	1.0	3.5	4.0	4.0	5.0	5.5	6.0	7.0	3.5

Source: refs. 13, 16, 17, 19, 20.
a. – trace or absent.

The ratio of tyrosine and phenylalanine to methionine and lysine is higher than FAO/WHO standards. Ruales and Nair [19] reported the aromatic amino acids tyrosine and phenylalanine, with a chemical score of 86, as the first limiting amino acids. However, the absence of gluten-like properties makes quinoa unsuitable for direct use in making bread. Telleria et al. [32] reported no differences in the amino acid composition of raw quinoa and quinoa seeds treated with water at different temperatures to remove saponins. Biological studies showed a decrease in protein efficiency ratio (PER) values after extraction at 85°C but not at 70°C.

White et al. [33] reported that the quality of quinoa protein was equal to that of dried milk protein when fed to rats. Pigs fed cooked quinoa were reported to grow as well as those fed dried skim milk [34]. Removal of saponins from the outer layers of the seeds increased the *in vitro* digestibility of the protein by 7% [35].

The protein content of seeds from Mexican *Amaranthus* spp. as well as South American *Chenopodium* spp. is 13% to 15%. Digestibility (53%–65%) improved when the seeds were toasted or popped (68%–78%). Their biological value was 73% and their PER [36] was similar to that of casein [1, 20]. Processes such as extrusion are known to improve the PER of quinoa flour [37].

In animal experiments, the net protein utilization (NPU) values of 76% and the biological value of 92 for protein in quinoa were comparable with those of other high-quality food proteins [38].

Lipid content

Quinoa seeds have approximately 9% fat on a dry weight basis. Quinoa fat has a high content of oleic acid (24%) and linoleic acid (52%) [38]. Quinoa oil is colourless to yellowish with a pungent, disagreeable, camphoraceous odour, characteristic of the seed. The flavour is bitter and burning.

Quinoa oil has been in use since the American Civil War. The original methods of production were quite primitive. The plants were boiled in iron pots equipped with soapstone lids. The oil condensed against the lids and was skimmed off. It was sold mainly in Baltimore, where the old name "Baltimore oil" is still used [39]. Maryland remains the chief producer of quinoa oil; the area of production is concentrated largely within a 25-mile radius in Carroll, Frederick, Howard, and Montgomery counties, with wood pine as the fuel for distillation. The total production in normal years varies between 60,000 and 80,000 lb. The yield depends on the weather conditions, the stage of maturity of the plant, and other factors. One acre of quinoa produces, on average, about 50 to 60 lb of oil per year.

On extraction with petroleum ether, quinoa yields yellow oil ranging from 6% to 8% of the weight of the whole seed, depending on the variety. The hulls, bran, and flour account for 10%, 40%, and 50%, respectively, of seed weight. The total fat contents in whole seed, hulls, bran, and flour extracted with diethyl ether were 7.6%, 5.7%, 11.6%, and 3.2%, respectively. The crude lipid content of quinoa was similar to that found in *Amaranthus caudatus*, a closely related plant [40, 41].

The constants of quinoa oil are compared with those of some selected edible oils in table 5. Quinoa seed oil is more unsaturated and also has a higher content of unsaponifiable matter than cereal oils.

Table 6 compares the fatty acid composition of quinoa seed oil and some other edible oils. Linoleic acid ($C_{18:2}$) accounted for over 50% of the fatty acids in quinoa oil, followed by oleic acid ($C_{18:1}$) and palmitic acid (C_{16}). The relatively high content of linolenic acid ($C_{18:3}$) in quinoa oil indicates an excellent nutritional quality of the grain. According to Morrison [44], the fatty acid composition of quinoa lipids is similar to that of wheat.

The ratio of polyunsaturated to saturated fatty acids (PS ratio) of quinoa oil is 4.9. This is higher than the PS ratios of most edible oils, such as soya bean oil (3.92), corn oil (4.65), and olive oil (0.65). The percentage of energy delivered by linoleic acid in quinoa seed oil is 10%, which is higher than the recommendation of the American Academy of Pediatrics that infant foods should contain at least 2.7% of their energy in the form of linoleic acid [38].

The percentage of free fatty acids is higher in quinoa

TABLE 5. Oil constants of quinoa seed oil compared with those of other seed oils

Variable	Oil				
	Quinoa	*A. paniculatas*	Wheat	Corn	Rice
% oil in whole seed	6–8	8	2	3–7	
% oil in bran	11–12	18–20	5–6		8–16
Specific gravity at 25°C	0.8910	0.9155	0.9248	0.9270	0.9192
Refractive index at 25°C	1.4637	1.47		1.3–2.0	
Saponification value	190	217	180–189	188–193	188
Iodine value	129	99.97	115–126	116–130	99.5
% unsaponifiable matter	5	5–8	4–9	1–2	4

Source: refs. 22, 23, 42.

TABLE 6. Fatty acid composition (%) of quinoa seed oil compared with that of other seed oils

Oil	Fatty acid										
	C_6	C_8	C_{10}	C_{12}	C_{14}	C_{16}	C_{18}	C_{20}	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$
Quinoa	–[a]	–	–	–	0.1	9.9	0.6	0.4	24.5	52.3	3.8
Amaranthus cruentus	–	–	–	–	–	13.4	2.7	0.7	20.4	62.1	1.1
Wheat	–	–	–	–	–	12.2	0.84	–	26.6	39.1	9.6
Corn	–	–	–	–	–	7.3	3.3	0.4	43.4	39.1	0.8
Rice	–	–	–	–	0.6	16.5	1.7	0.6	43.7	26.5	–
Coconut	0.5	9.0	6.8	46.4	18	9.0	1.0	–	7.6	1.6	–
Peanut	–	–	–	–	–	8.3	3.1	2.4	56	26	–
Soya bean	–	0.2	–	–	0.1	9.8	2.4	0.9	28.9	50.7	6.5

Source: refs. 13, 38, 43.
a. –Trace or absent.

seeds (18.9%) than in wheat (11%) and germinated barley (8.4%) [45]. Neutral lipids are predominant in cereals and have been reported to constitute around 90% of the lipids in members of the Amaranthaceae family [46] (table 7).

Quinoa oil contains squalene, an industrially useful unsaturated hydrocarbon, as the main constituent of unsaponifiable matter. Squalene is used as a bactericide and as an intermediate in many pharmaceuticals, organic colouring materials, rubber chemicals, and surface-active agents. Seven sterols have been identified in quinoa lipids, the major one being Δ^7-stigmasterol (43% of total sterols). The other sterols are cholesterol (3.6%), Δ^5-campesterol (2.3%), $\Delta^{5,22}$-stigmasterol (5.5%), Δ^7-campesterol (8%), $\Delta^{5,24\,(28)}$-avenasterol (21.7 %), and β-sitosterol (15%) [31].

Carbohydrate content

The chemical composition of some *C. quinoa* varieties harvested in the gardens of the tropical plant laboratory at Wageningen Agricultural University showed fairly small differences, except in starch content. Table 8 shows the carbohydrate profile of these varieties.

Quinoa starch has a granular diameter of 1 to 1.25 μ, a gelatinization temperature range of 57° to 64°C, an amylose content of 11% [47], and an average amylopectin chain length of 27 [48]. Processes such as extrusion and drum drying alter the starch digestibility, the values being 64% and 72% for the raw starch from

TABLE 7. Composition of lipids (% ± SD) in quinoa seeds

Component	Whole seed	Hulls	Bran	Flour
Lipids				
Neutral lipids	56 ± 0.6	40 ± 0.6	76 ± 0.7	70 ± 0.5
Polar lipids	25 ± 0.3	44 ± 0.5	13 ± 0.1	21 ± 0.2
Free fatty acids	19 ± 0.2	15 ± 0.1	11 ± 0.1	9 ± 0.1
Composition of neutral lipids				
Triglycerides	74 ± 0.6	72 ± 0.5	82 ± 0.1	8 ± 0.5
1,2-Diglycerides	13 ± 0.2	11 ± 0.2	8 ± 0.1	6 ± 0.1
Monoglycerides	3 ± 0.1	5 ± 0.1	2 ± 0.1	2 ± 0.1
Waxes	3 ± 0.1	2 ± 0.1	3 ± 0.1	1 ± 0.1
Composition of polar lipids				
Phosphatic acid	1 ± 0.1	1 ± 0.3	1 ± 0.02	0.4 ± 0.2
Phosphatyl serine	4.0 ± 0.1	3 ± 0.4	4 ± 0.04	3 ± 0.04
Phosphatidyl ethanolamine	19 ± 0.2	10 ± 0.1	13 ± 0.1	8 ± 0.04
Phosphatidyl inositol	11 ± 0.1	10 ± 0.1	6 ± 0.04	13 ± 0.1
Lysophosphatidyl ethanolamine	43 ± 0.2	43 ± 0.2	22 ± 0.2	7 ± 0.1
Phosphatidyl choline	12 ± 0.1	16 ± 0.1	48 ± 0.1	49 ± 0.1
Lysophosphatidyl choline	4 ± 0.1	3 ± 0.1	4 ± 0.1	3 ± 0.1
Monogalactosyl diglyceride	2 ± 0.0	1 ± 0.01	0.4 ± 0.01	3 ± 0.04
Digalactosyl diglyceride	3 ± 0.0	2 ± 0.02	1 ± 0.02	4 ± 0.05
Others	3 ± 0.1	3 ± 0.1	0.4 ± 0.02	0.2 ± 0.01

Source: ref. 22.

TABLE 8. Carbohydrate profile (%) of quinoa seeds

Carbohydrate	*C. quinoa* red	*C. quinoa* yellow	*C. quinoa* white
Starch (polarimetrically)	59	58	64
Starch (pancreatic method)	58	58	65
Reducing sugars	2	2–3	2
Crude fibre	2	3	2
Pentosans	3	3	4
Dietary fibre	ND[a]	9[b]	ND

Source: refs. 20, 23.
a. Not determined.
b. 8% insoluble dietary fibre and 2% soluble dietary fibre.

quinoa seeds [35]. The extremely small size of the starch granule can be beneficially exploited by using it as a biodegradable filler in polymer packaging [49]. Quinoa starch pastes do not gel on standing [50]. Its excellent freeze-thaw stability makes it an ideal thickener in frozen foods and other applications where resistance to retrogradation is desired [51].

Mineral and vitamin content

The mineral composition of some quinoa grains as compared with other grains is given in table 9. Quinoa seeds have a high concentration of potassium and phosphorus. The ratio of calcium to magnesium is 1:3 and that of calcium to phosphorus is 1:6, which is far greater than the recommended Ca:P ratio of 1:1.5 [52]. Although quinoa is not a cereal, it is often consumed instead of cereals. It contains more riboflavin and folic acid than common cereals such as wheat, barley, rice, and maize [53]. No trace of ascorbic acid has been found. This is probably due to oxidation of the vitamin C in the seeds during storage.

Quinoa satisfies the requirements for most vitamins recommended by the Committee on Dietary Allowances [52]. The process of removing saponins seems to alter the vitamin composition of quinoa to a minor degree [38]. Table 10 shows the vitamin composition of quinoa as compared with some other grains.

Antinutritional contents

The important antinutritional factors in quinoa seeds are saponins, protease inhibitors, and phytic acid. Reichert et al. [54] identified the bitterness of saponin as the limiting factor in the use of quinoa, but Chauhan et al. [17] showed that 34% of the total saponins are located in the hulls of quinoa seeds and can be removed by dehulling. The total amount of saponin remaining in quinoa seeds was much lower than that found in soya beans and some pulses [55].

Saponins

Saponins are widely distributed throughout the plant kingdom and have been identified in at least 400 species belonging to 60 different families. Common plants that contain saponins include spinach, beets, asparagus, alfalfa, and soya beans [56]. Saponins have been found in bulbs, roots, stems, fruits, leaves, and in some cases throughout the whole plant. The percentage of saponins varies in different plants, usually from 0.1% to 5% [57]. Saponins are uncommon in animals [58].

Several plant extracts used as flavouring agents in food contain active saponins. The majority of saponins are powerful haemolytics *in vitro*, but large doses are required to produce haemolysis on intravenous injection [42].

Saponins have a direct influence on the central nervous system, presumably affecting the permeability of the nerve cells. Initial symptoms of acute poisoning are violent convulsions and paralysis, followed by death. Small doses cause intestinal disorders and death after several days [56].

Most saponins are nitrogen-free glycosides, each consisting of a sapogenin and a sugar. The sapogenin may

TABLE 9. Mineral profile (mg/100 g) of quinoa seeds compared with that of other seeds

Mineral	Seed					
	Quinoa[a]	Wheat	Barley	Maize	Rice	Amaranth
Potassium	845–1,201	370	560	286	70–150	290–580
Calcium	70–874	29–48	10–80	30–90	0–40	25–389
Phosphorus	355–5,350	355	215–420	270–348	160–230	655
Magnesium	161–2,620	128	120	120–144	48–60	232–363
Sodium	2.7–22	3	3	1–16	8–9	7–100
Iron	6.3–81	11.5	3–10	2	3	18
Manganese	1.9–33	5	1.6	0.5	2	2–3
Zinc	1.2–36	2	1.5	2	2	4
Copper	0.7–10	0.5	0.8	0.19–0.21	0.3–0.7	1

Source: refs. 1, 13, 16, 17, 20, 23, 24, 28.
a. Values are given as ranges for different varieties and as reported by different investigators.

TABLE 10. Vitamin contents of raw quinoa seeds compared with those of other seeds

Vitamin	Seed					
	Quinoa[a]	Wheat	Barley	Maize	Rice	Amaranth
Vitamin A (mg/100 g)	0.02	–[a]	–	–	–	0
Vitamin C (mg/100 g)	16.4	0	0	0	0	3.36–7.24
Thiamine (mg/100 g)	0.2–0.4	0.45–0.49	0.47	0.42	0.06	0.17
Riboflavin (mg/100 g)	0.2–0.3	0.17	0.2	0.1	0.06	0.2
Folic acid (μg/100 g)	78.1	78	67	26	20	–
Niacin (mg/100 g)	0.5–0.7	5.5	5.4	1.8	1.9	3.6
β-Carotene (μg/100 g)	5,300	64	10	90	0	0

Source: refs. 13, 14, 20, 23, 24, 38.
a. – Trace or absent.

be a steroid or a triterpene, and the sugar moiety is generally glucose, galactose, pentose, or methyl pentose [59].

Seeds of *C. quinoa* variety Latinreco-40057, from the experimental farm of Latinreco, were found to contain two major saponins [38], whose structures are shown in figure 1. According to Mizui et al. [60], the chemical structures of saponins from quinoa brans are 28-O-β-glucopyranosyl-(1—>3)-α-arabino pyranoside, 3-O-β-glucopyranosyl-(1—>3)-β-galacto pyranoside, and 28-O-β-glucopyranosyl-(1—>3) esters of phytoaccagenic acid 3-O-α-arabino pyranoside.

Besides glycosides of oleonolic acid, 3-O-[(β-D_{20}-xylopyranosyl)(1—>3)-β-D-glucorono pyranosyl-6-OMe ester]-oleanoic acid has also been identified [61]. The other aglycons in the quinoa saponin mix have been identified as phyto laccagenic acid (> 40% total) and hederagenin (~26%) [62]. The saponin content has been correlated with that of oleanolic acid by an equation, saponin = 8.5204 oleanolic acid [63]. It can be determined by gas chromatography [64] and could serve as an index of saponin content. The results of a larva bioassay with *Tribolium castaneum* were correlated with the sapogenin content of seed flour [65].

Quinoa contains about 1.0% to 1.2% saponins [62], which are bitter [66] and have antinutritional effects. To be edible, quinoa grains must have the saponins removed, since they affect the colour and palatability of the products [67]. Saponins are located on the outer layers of the seeds and can be removed by polishing and washing with water. Reichert et al. [54] used abrasion milling to dehull quinoa and reduce the saponin levels. The amount of saponins present in quinoa differs according to the variety [63, 68]. Removal of saponins is associated with reduction in bitterness and astringency. As a result of sustained efforts in plant breeding, new low-saponin varieties of quinoa are available that afford better possibilities for use of the grain.

Quinoa saponins produce stable foams in aqueous solutions and haemolysed red blood cells. Because saponins form persistent foams in aqueous solutions, even

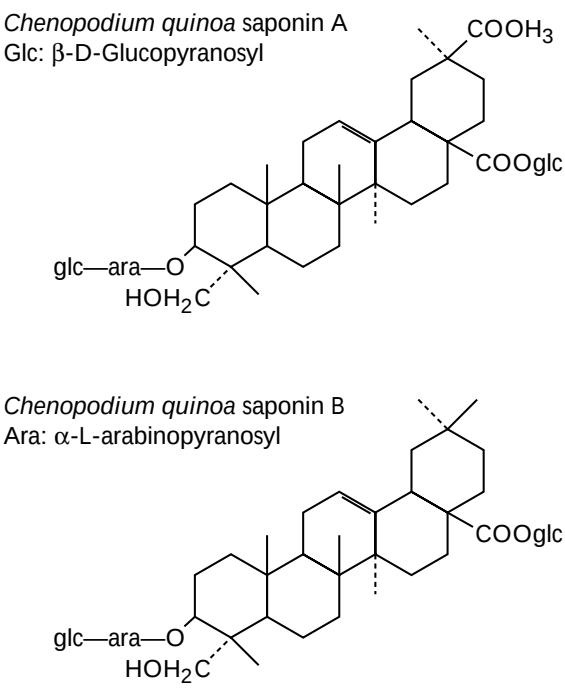

FIG. 1. Structures of quinoa (*Chenopodium quinoa*) saponins

at concentrations as low as 0.1%, they have found wide application in soft drinks, lager, shampoo, soaps, and fire extinguishers. They are prohibited as foaming agents in beverages and foods in Italy, Yugoslavia, and several countries of the Americas. Since they form permanent suspensions with oil powders, they are also used in the manufacture of confections and pharmaceuticals [56]. Saponins are known to have some beneficial effects on the skin and hence have been incorporated into toilet soaps, shaving soaps, and shampoos. The addition of saponins is found to lower the level of cholesterol in

plasma by increasing faecal bile excretion [69]. Saponins do not have any negative effect on the digestibility of proteins at the levels at which they are present in the samples [19]. Lopez de Romana et al. [70] reported better values for the digestibility of quinoa flour than of quinoa seeds. They concluded that quinoa proteins are adequate as human food. However, there is evidence that saponins from Chenopodiaceae inhibit growth in mice [71].

Since the commercial processing of quinoa yields a saponin-rich by-product, identifying possible uses for this material will be useful.

Phytic acid

Phytic acid is not only present in the outer layers of quinoa seeds, as in the case of rye and wheat [72], but is also evenly distributed in the endosperm. Ranges of 10.5 to 13.5 mg/g of phytic acid for five different varieties of quinoa were reported by Koziol [73], similar to the range of 7.6 to 14.7 mg/g for other cereals [74]. The phytates form complexes with minerals such as iron, zinc, calcium, and magnesium and can make the mineral content of a food inadequate, especially for children.

Tannins

The polyphenolic compounds, tannins, form complexes with dietary proteins and also with digestive enzymes [75]. The content of tannins measured as flavonols in whole raw quinoa seeds was 0.5%. Tannins were not detected in raw quinoa seeds that had been polished and washed [17](table 11).

Protease inhibitors

The concentrations of protease inhibitors in quinoa seeds are less than 50 ppm [76]. It can be seen from table 11 that the trypsin inhibitor units of quinoa are much lower than those in commonly consumed grains and hence do not pose any serious concern.

Conclusions

Since the early 1970s, Peru, Bolivia, and Chile have shown an interest in quinoa grain. In 1980 Bolivia passed a law requiring the use of at least 5% quinoa flour in commercially produced bread, pasta, and other products. Chileans have been using quinoa to improve the nutrition of poor children, whereas in Peru an increase in quinoa production is seen as a means of reducing costly wheat imports. Quinoa-based infant food has been manufactured on a commercial scale. Commercial exploitation of quinoa in many regions of the world is still far from reality. However, its constituents, particularly starch, which forms the bulk of the seed and which can be obtained in a saponin-free form, could find applications in the food and the non-food industries. Low-fat, fried noodle-like snacks have been prepared from blends of quinoa starch and soya bean protein isolate. In these trials the efficacy of quinoa starch as compared with corn starch with respect to the oil content of the fried snacks was demonstrated [81]. These trials should pave the way for the use of quinoa grain in regions where the grain is cultivated but has yet to see any commercial exploitation.

TABLE 11. Antinutrient (saponins, phytic acid, and tannins) contents of quinoa seeds compared with those of other seeds

Seed	Antinutrient			
	Saponin (mg/g)	Phytic acid (mg/g)	Tannins (%)	Trypsin units inhibited (mg)
Quinoa				
Whole raw	9.0–21	10	0.5	1.4–5.0
Polished and washed raw	3.0			
Amaranthus paniculatas	Traces	5–6	0.04–0.13	0.5
Soya bean (*Glycine max*)	4–6	8	0.05	24.5–41.5
Kidney bean (*Phaseolus max*)	4	8–12	1.02	12.9–42.8
Lentils (*Lens esculenta*)	NA[a]	8	NA	17.8

Source: refs. 13, 17, 68, 77–80.
a. Not available.

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IFPRI Report

Intrahousehold resource allocation in developing countries: Models, methods, and policies

Lawrence Haddad, John Hoddinott, and Harold Alderman, editors

Most development policies focus on improving the well-being of individuals. But the welfare of an individual is, in large part, based on complex interactions within that individual's family or household. The processes by which time, money, and other resources are allocated among individuals—commonly referred to as "intrahousehold resource allocation"—are the focus of a new volume published jointly by the International Food Policy Research Institute (IFPRI) and the Johns Hopkins University Press. *Intrahousehold Resource Allocation in Developing Countries: Models, Methods, and Policy*, edited by Lawrence Haddad, John Hoddinott, and Harold Alderman, examines the many complex factors that influence decisions made by households about how they spend time, money, and other resources. It shows that a more complete understanding of intrahousehold behaviour can increase the likelihood that policies will reach the people they are intended to affect, leading to better policies in areas such as food production and consumption, nutrition, and natural resource management.

Surveying a broad body of theory and evidence, the 19 contributors to the book, who include economists, demographers, sociologists, and anthropologists, examine the many economic, social, and cultural factors that influence decisions at the household level.

How allocation issues affect policy

Policy makers typically assume that by reducing poverty for an individual, they can alleviate poverty for the household, or that individual poverty can be reduced without taking the actions of other household members into account. These assumptions are erroneous. Neglecting or misunderstanding household decision-making processes can cause well-intentioned policies to backfire.

Several theories of household decision-making have been posited over the decades. One theory holds that households act as single or "unitary" decision-making bodies. This theory assumes either that all household members have the same preferences or that the head of the household acts completely dictatorially, neither of which is likely. Another theory looks at the household as a "collective" entity where the sometimes conflicting preferences of individuals within the household are combined in various ways to reach a collective choice. This theory holds that the identity of the person targeted by policy will affect how benefits for the household are used, and that decisions often reflect the bargaining power of different household members. For example, when women have control over resources, they tend to use them differently than men, often spending more on the children, with differing results for the welfare of the household.

The two theories suggest different outcomes for welfare and development policies. The unitary approach predicts that the success rate will be the same regardless of whom in the household a policy targets. The collective approach to the household suggests that the identity of the recipient (man, woman, or child, for example) will affect how this transfer is used and who benefits. The book presents evidence showing that household decisions in fact depend greatly on the identity of the individual being targeted.

This consideration plays an important role in, for example, the design of public works programmes. When the nature of the work and the level of the wage offered are such that the participants are predominantly male, policy makers often assume that the benefits of this intervention will trickle down to wives, mothers, children, and other household members. One way to ensure that this occurs may be to pay with food stamps rather than cash, for in many areas women are the main food purchasers.

A deeper understanding of household decision-making helps policies target individuals in the most effective way. The book cites a Zambian example where households were encouraged to grow maize, a crop typically grown by men, in the same fields as beans, a woman's crop. The researchers hoped that the households would take advantage of the complementary nutritional benefits of the two crops. In addition, they

hoped that the overall weeding time would be reduced because both crops could be weeded simultaneously. Women, however, opposed this innovation because if beans were planted on land normally allocated to maize, they would lose ownership of the beans and the men would benefit from the cash generated by their sale. In contrast, a project in Togo to encourage soya bean production succeeded precisely because it took into account the collective nature of household behaviour. At the outset, the project was targeted to women. Workshops were organized in women's homes, and women returned to their villages after these workshops to train other women. Soya beans were not introduced as a cash crop but were promoted as legumes that could be used to make sauces. As a result, men did not become interested in cultivating soya beans and even allowed women to use small plots of land for soya bean cultivation.

Policies can also be weakened or enhanced by individuals who are not targeted by policy, depending on the interactions among household members. For example, if a school meal programme is targeted to undernourished children, a household may respond by reducing the amount of food the child receives at home and increasing the amount of food consumed by other household members.

Policies may also influence allocation decisions indirectly in important ways. The editors argue that changes in the legal environment, such as divorce and child-support laws, affect family allocation decisions not only through their direct impact when the laws are applied, but also through changes in the relative bargaining positions of household members. Of course, legal and social inequalities often reflect the perceptions of both men and women. Women often do not see themselves as entitled to a larger share of household resources. This, in turn, leads to unequal investments in, for example, education for males and females, and a persistent cycle emerges that reinforces inequalities.

Caveats

Although a number of policy measures fail to reach their potential because of neglect of intrahousehold decision-making processes, policies that attempt to take these processes into account also pose risks. Individuals and households will change their behaviour in response to new approaches taken by governments and non-governmental organizations. Given the difficulty of anticipating all of these responses, there is a risk that policies will fail, even when efforts have been made to address intrahousehold allocation.

To illustrate, the editors cite a Gambian project. In the early 1980s, irrigation was introduced to an area of swamp rice production in order to raise yields, commercialize the product, and raise women's share of household income. However, an initiative intended to raise female income ended up reducing it. Initially, women were the rice growers. But as the yields grew, rice was transformed from a private crop under the control of women into a communal crop under the control of men. Although project designers had studied past household decisions, which had left rice production under the control of women, they did not fully understand the process of decision-making and did not sufficiently protect the women's rights. A fuller appreciation of the dynamics of household resource allocation might not have prevented this outcome, but a perspective that viewed the women as interdependent members of the community (rather than as independent agents) might have led project managers to expect the men's response.

Although more experience and research on intrahousehold allocation will lessen the probability of similar unwanted results, this area of research is still at an early stage. (Indeed, one of the contributions of the volume is to outline the "state of the art" and to suggest where future work would be especially valuable.) Does this suggest that intrahousehold considerations should not yet be incorporated in policy design and implementation? Although the risk of incorrectly analysing complex policy measures, as well as the extra costs of applying intrahousehold analysis, must always be carefully assessed, the editors argue that analysts and policy makers must also consider the often serious consequences of not taking into account intrahousehold decision-making.

Conclusion

It is incorrect to assume that policies designed to reduce household poverty are sufficient to lower individual poverty, and that individual poverty can be alleviated without due regard to actions and attitudes of other household members. Moreover, errors in understanding household allocation processes may result in beneficial policies not being adopted and in policies having unintended consequences.

When research on intrahousehold allocation began in the mid-1980s, researchers wondered whether going inside the "black box" of the household would yield any useful insights. This book argues that from a policy perspective, the answer is an emphatic "yes." A more complete understanding of intrahousehold behaviour can increase the likelihood that policies will reach the people they are intended to affect.

Intrahousehold Resource Allocation in Developing Countries: Models, Methods, and Policy, edited by Lawrence Haddad, John Hoddinott, and Harold Alderman, is available from the Johns Hopkins University Press, 2715 North Charles St., Baltimore, MD 21218-4319, USA. US$55.00.

Books received

Agricultural uses of by-products and wastes. Edited by Jack E. Rechcigl and Herbert C. MacKinnon. ACS Symposium Series 668. American Chemical Society, Washington, D.C., 1997. (ISBN 0-8412-3514-7) 284 pages, hardcover. US$99.95.

In the 1970s there was a great deal of interest in the recycling of the world's enormous quantities of organic waste for the production of food and feed. As population continues to increase, so do agricultural and industrial by-products. This volume, developed from a 1996 symposium, *Uses of By-Products and Wastes in Agriculture*, lives up to its title by focusing on agricultural uses for these wastes as fertilizer. Therefore, it is of primary interest to agricultural specialists.

The potential of organic wastes from agriculture, industry, and municipalities to be used as substrates for the production of biomass through fermentation receives only brief mention in one chapter. For readers interested in the production of food and feed from organic wastes, the United Nations University monograph *Bioconversion of Organic Residues for Rural Communities* is still recommended, even though it was published in 1978.

Field guide on rapid nutritional assessment in emergencies. World Health Organization Regional Office for the Eastern Mediterranean, P.O. Box 1517, Alexandria 21511, Egypt, 1995. (ISBN 92-9021-198-9) 63 pages, spiral-bound paperback. US$6.00.

This concise and clearly written field guide is based on a consultation with experts and is intended for all who are faced with the need to make rapid but reliable estimates of nutritional status in emergencies, as a basis for subsequent action. Clear instructions are provided for diagnosing the extent of the problem, identifying groups at highest risk, and monitoring the effectiveness of interventions. Chapter topics include planning the survey, selection of subjects, sampling procedures, survey methodology, data recording, training and supervision, interpretation of results, and reporting findings. Annexes include the CDC/WHO normalized reference table of weight-for-height, instructions for using the Epi-Info computer programme, a list of requisite equipment, and other useful information.

Handbook of antioxidants. Edited by Enrique Cadenas and Lester Packer. Marcel Dekker, New York, 1996. (ISBN 0-8247-9298-X) 602 pages, hardcover. US$150.00.

This book reviews the growing evidence now available that antioxidants play a critical role in wellness, health maintenance, and the prevention of chronic degenerative disease. Four chapters deal with the antioxidant functions of vitamin E, three with carotenoids, and two with ascorbic acid. The current knowledge of antioxidant characteristics of coenzyme Q, uric acid, vitamin A, flavonoids and polyphenols, the herbal antioxidants, tea, gingko extract, α-lipoic acid, and melatonin and aminoindoles receives one chapter for each. Although the volume discusses general current aspects of antioxidant therapy for each of these antioxidant substances, it tends to focus mainly on the positive evidence. However, the specific chapters dealing with the clinical significance of the principal dietary antioxidants, vitamin E, carotenoids, and vitamin C, are more comprehensive. This is a useful current reference book but should not be used as the sole source of information on the health aspects of this important subject.

Introduction to nutrition and metabolism. Second edition. David A. Bender. Taylor and Francis, Bristol, Pa., USA, 1997. (ISBN 0-7484-0781-2) 335 pages, paperback. US$17.95.

This is a well-presented introduction to the principles of nutritional biochemistry and metabolism, with emphasis on the integration and control of metabolic functions. It is written at a level appropriate for undergraduate students with little previous knowledge except for organic chemistry. It serves this purpose well.

Mineral elements. Edited by Boyd L. O'Dell and Roger A. Sunde. Marcel Dekker, New York, 1997. (ISBN 0-8247-9312-9) 691 pages, hardcover. US$195.00.

Although this handbook is designed primarily for students and professionals in all aspects of nutrition, it is also a valuable source of information for professionals in all areas of biology. Authoritatively written individual chapters on each of 22 minerals cover the full range of these minerals' biological functions in animals and, where appropriate, in plants and microorganisms. Practising physicians may need to supplement this handbook with more comprehensive clinical examinations, but they will find this book invaluable for the basic information it provides on what is known about the metabolism of all the minerals of established or potential biological significance. This book should be available, at the very least, in every academic and medical library.

Sight and life manual on vitamin A deficiency disorders (VADD). Donald S. McLaren and Martin Frigg. Task Force SIGHT AND LIFE, P.O. Box 2116, 4002, Basel, Switzerland, 1997. (ISBN 3-906412-00-8) 138 pages, paperback. Limited distribution without charge.

This is a clearly written and well-illustrated comprehensive summary of current knowledge of vitamin A functions, food sources, and deficiency and of the methods of assessing vitamin A deficiency. There is also excellent coverage of the ocular complications as well as the effects on morbidity, mortality, growth, and immune response, and other functional consequences of vitamin A deficiency. The book also briefly but effectively discusses the epidemiology and control of vitamin A deficiency. This volume is highly recommended for its readability, authority, and choice of content.

Vitamin C in health and disease. Edited by Lester Packer and Jürgen Fuchs. Marcel Dekker, New York, 1997. (ISBN 0-8247-9313-7) 538 pages, hardcover. US$150.00.

This book provides excellent and balanced coverage of its subject and includes an initial chapter on the history of scurvy and vitamin C, 7 chapters on the chemistry and biochemistry of vitamin C, 11 on physiological and biomedical aspects, and 10 on nutrition and health. This is an adequate and balanced single source of information on this topic and should be available to all professionals concerned with any aspect of nutrition and related health issues.

News and notes

IUNS Award

The IUNS Award, sponsored by the International Nutrition Foundation for Developing Countries, is given every four years at the International Congress of Nutrition. The 1997 IUNS Award was presented at the 16th International Congress of Nutrition in Montreal in July 1997 to Dr. Noel W. Solomons. Dr. Solomons was presented with a plaque that read "in recognition of longstanding dedication to improvement in the health of populations around the world through nutrition research and training" and a check for US$5,000. The next award will be presented at the 17th International Congress of Nutrition in Vienna in 2001. Past awards were given to Dr. T. N. Maletnlema, Tanzania (1985), Prof. C. Gopalan, India (1989), and Dr. Fernando Mönckeberg, Venezuela (1993).

Course announcement

The Graduate School for Advanced Studies in Nutrition, Food Technology, Agrobiotechnology, and Health Sciences, the Netherlands, in cooperation with the United Nations University, the Food and Agriculture Organization of the United Nations, the COST Programme of the European Union, and the International Union of Nutritional Sciences, announce the Fourth International Graduate Course on Production and Use of Food Composition Data in Nutrition (FoodComp'98).

The course, directed by Professor D. A. T. Southgate and Professor C. E. West, will be held in Wageningen, Netherlands, 5–23 October 1998. It is intended for those involved in nutritional database programmes as analysts, compilers, or users and will be of value to those teaching nutrition and nutritional aspects of food chemistry. The aim of the course is to show how those involved in the production of analytical data for nutrients in foods and the compilation of these data into food composition tables and nutritional databases contribute to the quality and usefulness of these compilations in nutrition. The course will be based on the philosophy that the preparation of nutritional databases requires close understanding of the needs of the users by both compilers and producers of analytical data. The course will show how this understanding can be achieved and the benefits that flow from the collaboration of users, analysts, and compilers. Stages in the production of a nutrient database will be examined.

The course will consist of lectures, seminars, and group work. The course fee is Dfl 6,800, including a non-refundable deposit of Dfl 680. The fee covers accommodation and meals at the Wageningen International Congress Centre, course materials, tuition fees, and excursions. The closing date for application is 1 July 1998, but candidates are recommended to apply as soon as possible.

Further information can be obtained from Mrs. L. Duym, Secretariat FoodComp'98, Division of Human Nutrition and Epidemiology, Wageningen Agricultural University, P.O. Box 8129, 6700 EV Wageningen, Netherlands; telephone +31 317 483054; telefax +31 317 483342; E-mail Lous.Duym@Staff.NUTEPI.WAU.NL. More information about the course can also be found on the World Wide Web: http://www.wau.nl/vlag/foodcomp.html.

The State of the World's Children 1998

Malnutrition is largely a silent and invisible emergency, exacting a terrible toll on children and their families. The result of multiple causes, including a lack of food, common and preventable infections, inadequate care, and unsafe water, it plays a role in more than half of the nearly 12 million deaths each year of children under five in developing countries, a proportion unmatched since the Black Death ravaged Europe in the fourteenth century. Malnutrition blunts intellects and saps the productivity and potential of entire societies. Poverty, one of the causes of malnutrition, is also a consequence, a tragic bequest by malnourished parents to the next generation.

UNICEF'S *State of the World's Children 1998* report details the scale of the problems caused by malnutrition and the steps being taken to solve them. It contains chapters on the causes of malnutrition, trends in child malnutrition by region, and recognizing the right to nutrition. Three-quarters of the children who die worldwide of causes related to malnutrition are what nutritionists describe as "mildly to moderately malnourished" and show no outward signs of the problems. No less than half of all children under the age of five in South Asia and one-third of those in sub-Saharan Africa, as well as millions of children in industrialized countries, are malnourished, says the report.

The UNICEF report, however, details progress in combating malnutrition: nearly 60% of the world's salt is now iodized, and millions of children every year are spared mental retardation as a result. Vitamin A supplementation is helping bolster disease resistance in children and may soon become an important measure for helping to reduce maternal deaths around the world. The report cites examples of UNICEF projects around the world that are successfully taking on the problems caused by malnutrition.

The State of the World's Children 1998 also contains the traditional statistical tables that help chart progress towards the goals set by country governments at the 1990 World Summit for Children. The eight tables in this report have been expanded to give the broadest possible coverage of important basic indicators for nutrition, health, education, demographics, economy, and the situation of women, plus rates of progress and regional summaries.

The Report is available from:

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UNICEF House
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Fax: (212) 326-7768
E-mail: meisner@unicef.org

UNICEF Geneva Regional Office
5–7 avenue de la Paix
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Books available

A limited number of copies of the following books are available for the cost of postage and handling from the International Nutrition Foundation, Charles St. Sta., P. O. Box 500, Boston, MA 02114-0500, USA; fax (617) 227-9405; E-mail unucpo@zork.tiac.net.

Single-cell protein—Safety for animal and human feeding. Edited by Silvio Garattini, Silvio Paglialunga, and Nevin S. Scrimshaw. Pergamon Press, New York, 1979. Paperback, 213 pages. Postage and handling: US$4.00.

Nutrition and agricultural development. Significance and potential for the tropics. Edited by Nevin S. Scrimshaw and M. Béhar. Plenum Press, New York, 1976. Hardcover, 500 pages. Postage and handling: US$8.50.

Nutrition policy implementation. Issues and experience. Edited by Nevin S. Scrimshaw and Mitchel B. Wallerstein. Plenum Press, New York, 1982. Hardcover, 558 pages. Postage and handling: US$8.50.

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International scientific unions
International Union of Food Science and Technology (IUFoST)
International Union of Nutrition Sciences (IUNS)

The United Nations system
The UNU Programme of Food and Nutrition for Human and Social Development cooperates with the appropriate units or divisions of the following organizations, among others:
Food and Agriculture Organization (FAO)
International Atomic Energy Agency (IAEA)
United Nations Children's Fund (UNICEF)
World Bank (IBRD)
World Food Programme (WFP)
World Health Organization (WHO)

The University is represented on the Sub-Committee on Nutrition (SCN) of the United Nations Administrative Committee on Coordination.

Research networks

Chronic energy deficiency

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Rapid assessment procedures for nutrition and primary health care—Anthropological approaches to improving programme effectiveness

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Note for contributors

The editors of the *Food and Nutrition Bulletin* welcome contributions of relevance to its concerns (see the statement of editorial policy on the inside of the front cover). Submission of an article does not guarantee publication—which depends on the judgement of the editors and reviewers as to its relevance and quality. All potentially acceptable manuscripts are peer-reviewed. Contributors should examine recent issues of the *Bulletin* for content and style.

Language. Contributions may be in English, French, or Spanish. If French or Spanish is used, the author should submit an abstract in English if possible.

Format. Manuscripts should be typed or printed on a word processor, double-spaced, and with ample margins. Only an original typed copy or a photocopy of equivalent quality should be submitted; photocopies on thin or shiny paper are not acceptable.

When the manuscript has been prepared on a word processor, a diskette, either 3½- or 5¼-inch, should be included with the manuscript, with an indication of the disk format and the word-processing program used.

Length. Ordinarily contributions should not exceed 4,000 words.

Abstract. An abstract of not more that 150 words should be included with the manuscript, stating the purposes of the study or investigation, basic procedures (study subjects or experimental animals and observational and analytical methods), main findings (give specific data and their statistical significance if possible), and the principal conclusions. Emphasize new and important aspects of the study or observations. Do *not* include any information that is not given in the body of the article. Do not cite references or use abbreviations or acronyms in the abstract.

Tables and Figures. Tables and figures should be on separate pages. Tables should be typed or printed out double-spaced. Submit only original figures, original line drawings in India ink, or glossy photographs. Labels on the figures should be typed or professionally lettered or printed, not handwritten.

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2. Committee on Enzymes of the Scandinavian Society for Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gammaglutamyltransferase in blood. Scand J Clin Lab Invest 1976;36:119–25.

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