

**Food consumption in selected rural  
communities in western Kenya with special  
reference to sorghum**

**BY**

**Nokuthula Vilakati**

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## DECLARATION

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I declare that the dissertation herewith submitted for the degree MSc Nutrition at the University of Pretoria, has not previously been submitted by me for a degree at any other university or institution of higher education.

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## ABSTRACT

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### **Food consumption in selected rural communities in western Kenya with special reference to sorghum**

**By**

**Nokuthula Vilakati**

**Study leaders: Prof. A.Oelofse and Prof. J.R.N. Taylor**

**Degree: MSc Nutrition**

#### ABSTRACT

Sorghum is considered a staple food for most rural communities in Kenya. Sorghum is mainly favoured for its ability to thrive in adverse climatic conditions. This study was carried out to determine sorghum consumption in selected rural communities in western Kenya. This was done by determining how much sorghum the children aged 2-5 years consume daily, what the consumption patterns of sorghum are and also to determine if biofortification of sorghum with protein, Vitamin E, Vitamin A, iron and zinc will make any significant contribution to the children's nutrient intake.

A cross-sectional food consumption survey was conducted using an interviewer administered Quantitative Food Frequency Questionnaire (QFFQ) to 102 mothers and caregivers. The QFFQ was run concurrently with focus group interviews as data collection tools. The results indicated that the diet consumed by the children in the selected communities offered a variety of foods resulting in sufficient nutrient intake for the majority of the children. The daily contribution made by sorghum, however, was low with 36.4 g soft porridge (uji) and 26.2 g

stiff porridge (ugali) being the average amounts given daily to the children. The nutrient contribution made by sorghum was; energy 140 kJ (2%), protein 0.9 g (1.7%), iron 0.3 mg (4.3%), zinc 0.1 mg (2.1%), Vitamin A (0%), Vitamin E (0%). The proportion of the population who consumed a diet deficient in one or more of these nutrients was 36.3% energy, 4.9% protein, 48% iron, 21.6% zinc, 46.1% Vitamin A and 17.6% Vitamin E.

The small contribution made by sorghum to the diet made it a minor component in the children's diet. For the deficient children, the insufficient nutrient intake from the diet is an indication that the diet quantity rather than the quality needs to be improved. A multiple dietary approach that is practical and sustainable for rural people through dietary diversification would be more beneficial. The multiple dietary approach would ensure that people consume a variety of locally available foods that contain a rich source of micronutrients and energy in order to address shortfalls in the diet quality and quantity. Biofortification of sorghum would not make any significant contribution to the children's nutrient intake because of the fact that the children are consuming a very small amount of sorghum daily. For biofortification of sorghum to make a significant difference in the children's nutrient intake in these communities, the people in these communities need to be encouraged to consume more sorghum than they are currently consuming. Educating the rural communities about the importance of growing locally adapted crops such as sorghum and incorporating them in their diets would assist in improving the micronutrient status of rural people.

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## 1. Background and motivation for the study

Cereal foods make up the most important part of the diet of most developing countries (Tucker, 2003). These cereal foods contribute significantly to the dietary intake of rural people in developing countries (Genc, Humphries, Lyons & Graham, 2005). Cereals are, however, not always reliable in providing a nutritionally adequate diet. The bioavailability of essential nutrients such as iron and zinc which are vital for proper nutrition and health is often affected by anti-nutrient factors such as phytates which are contained in the grain.

Even though cereals offer limited nutritional variety, they serve as the main source of food (Henry & Kettlewell, 1996). One such cereal, which serves as a staple cereal for people living in poor and food insecure areas is sorghum (FAO and ICRISAT, 1996). Sorghum is considered to be an important crop in countries where the climatic conditions do not favour production of other cereals (FAO, 1995). Sorghum does not only grow favourably in areas that experience dry climatic conditions but it also thrives in areas that experience erratic but high rainfalls especially in the eastern part of Africa (Taylor, 2003).

The main sorghum producing countries in Africa are Nigeria in the west and Sudan in the northern part of Africa (FAO and ICRISAT, 1996). In West Africa, sorghum accounts for 50% of the total crops produced (Dicko, Gruppen, Traoré, Voragen & van Berkel, 2006). Sorghum also remains the staple cereal in other areas prone to drought, where other cereals fail to grow (Taylor, 2003).

Sorghum is used in the production of the following African traditional foods: porridges, rice products, breads, alcoholic and non-alcoholic products (Taylor, 2003; Murty & Kumar, 1995). Sorghum also has health benefits, as it is a gluten-free cereal, which makes it suitable for celiac patients (Taylor, Schober & Bean, 2006). In addition to the nutritional contributions made by sorghum, the phytochemicals contained in sorghum offer health benefits.

Sorghum like other cereals is low in the essential amino acid lysine (Anglani, 1998). Sorghum also has poor protein digestibility which has an effect on the nutritional value of amino acids (Duodu, Taylor, Belton, & Hamaker, 2003). Similar to other cereals, sorghum has a low bioavailability of zinc and iron and is also a poor source of Vitamin A and Vitamin C, which are useful in the absorption of the zinc and iron (Michaelsen & Friis, 1998). Due to the nutrient contribution made by sorghum, there is a great need for strategies geared towards improving its nutritional contribution especially in food insecure areas.

### 1.1 Problem statement

Most African diets are often bulky, monotonous and are mainly cereal based. The nutrient contribution from such diets is often poor. One of the main reasons for the poor nutrient contribution from cereals is caused by phytic acid found in cereal grains, which inhibits iron bioavailability in cereal products (Davidsson, Galan, Hercberg, & Hurrell, 1997). The poor nutrient contribution made by cereals is experienced mainly by children, especially from the weaning stage up to the point where they are ready to be given an adult diet (Onofiok & Nnanyelugo, 1998). This is because cereals are the most important food component in developing countries given to the children as soon as they are able to take solid foods. In Malawi for example, the most important food group contributing to the energy and nutrient intakes was found to be cereals, which provided 75% energy (Hotz & Gibson, 2001).

In Kenya, sorghum is the fourth most important cereal (FAO, 1995). Sorghum is mainly favoured for its unique ability to survive under various environmental conditions (Awika & Rooney, 2004). In addition to this agronomic quality, sorghum contributes macro- and micronutrients and it also has a big nutritional potential as it is a good source of phytochemicals which show high antioxidant activity.

In spite of all the benefits that sorghum has nutritionally, it also has poor protein digestibility making it a poor source of protein in the diet (Belton & Taylor, 2004). The poor digestibility in sorghum is in part caused by the presence of digestive enzyme inhibitors such as phytic acid, phenolics and tannins (Slavin, 2004). The presence of phytate in sorghum is responsible for low mineral availability as it complexes with the minerals (Hulse, Laing, & Pearson, 1980). This situation often results in malnutrition and hence requires nutrition interventions. In order to deal with nutritional deficiencies, various malnutrition alleviation strategies have been employed. Strategies that have previously been used are supplementation, fortification, nutrition education and dietary diversification (Ruel & Levine, 2000). A new strategy that has recently been introduced and aims to improve the nutritional status of people in rural areas is biofortification.

The principle behind biofortification is that it increases the bioavailability of nutrients in plant foods through the genetic selection of specific traits which are then incorporated in the crop (Welch & Graham, 2005). Biofortification aims at ensuring sustainability of the crop while at the same time delivering the necessary micronutrients for nutrition. The Africa Biofortified Sorghum (ABS) project led by Africa Harvest Biotech Foundation International (AHBFI) seeks to use the technology of biofortification in order to make a difference in the nutritional and health status of people living in rural areas in sub-Saharan Africa (The ABS Consortium, 2007). The ABS project intends to develop a nutritionally enhanced sorghum variety, which will be used to improve the nutritional status of the rural poor where sorghum is consumed as a staple food (Wambugu, 2007). The biofortified sorghum variety will have increased levels of essential amino acids especially lysine, Vitamin A, Vitamin E, iron, zinc and will also have improved digestibility..

## 1.2 Hypotheses for the research

- Children's diets in rural western Kenya are mainly sorghum based. This is because sorghum is an important cereal in Kenya and is commonly produced



in the semi-arid rural areas where other crops fail to survive (Export Processing Zones Authority, 2005).

- The diet of rural western Kenyan children is deficient in some essential micro- and macro-nutrients which are essential for good nutrition. This is because sorghum has poor protein digestibility making it a poor source of protein in the diet (Belton & Taylor, 2004). The poor protein digestibility is caused by the presence of digestive enzyme inhibitors such as phytic acid, phenolics and tannins which are present in sorghum (Slavin, 2004). Sorghum also has low iron and zinc bioavailability and is a poor source of Vitamin A and Vitamin C (Michaelsen & Frii, 1998).

### 1.3 Objectives for the research

In order to accomplish the ABS project's goal of making a difference in the nutritional and health status of people living in rural areas in sub-Saharan Africa, it is essential to find out more about sorghum as a staple cereal consumed in a rural areas in Africa, hence western Kenya was selected. The primary aim of this study was to determine if sorghum is consumed in these areas and what the consumption patterns of sorghum are in the selected rural areas. The specific aims of the study were:

- To find out how much sorghum contributes to the energy, protein, Vitamin E, Vitamin A, iron and zinc intake and determine the deficiencies of these nutrients in the diet of rural Kenya children aged 2-5 years.
- To determine if the biofortification of sorghum with protein, Vitamin E, Vitamin A, iron and zinc will make any significant contribution to the children's nutrient intake

#### 1.4 Definition of terms used in the study

- **Recommended Dietary Allowance (RDA)** - is the daily dietary intake level of a nutrient, which is considered to be sufficient to meet the nutrient requirements of nearly all (97–98%) healthy individuals in each life-stage and sex group (Nutrition Information Centre and University of Stellenbosch (NICUS), 2003). It can be used to evaluate nutrient inadequacies in an individual
- **Estimated Average Requirement (EAR)** – refers to a nutrient-based reference value that meets the estimated needs of a nutrient of 50% of a population. (NICUS, 2003). It can also be described as the amount of a nutrient recommended for a population (Institute of Medicine, 2000). It can be used to assess the prevalence of inadequate intake in a given life-stage group.
- **Acceptable Macronutrient Distribution Ranges (AMDR)** - is defined as a range of intake for a particular energy source that has a lower and upper boundary, associated with reduced risk of chronic disease while providing adequate intakes of essential nutrients (NICUS, 2003). If an individual consumes below or above this range, there is potential for increasing the risk of chronic diseases shown to affect long-term health as well as increasing the risk of inadequate intake of essential nutrients.
- **Total dietary intake** – This is also referred to as total nutrient intake and is defined as all nutrients derived from consuming foods and beverages, measured in kilojoules (kJ), grams (g), milligrams (mg) and micrograms (µg) (Lombardi-Boccia, Aguzzi, Cappelloni, Di Lullo & Lucarini, 2003).
- **Average dietary intake** - The consumption and absorption of sufficient food, Vitamins, and essential minerals necessary to meet the body's nutritional needs and maintain health (Lombardi-Boccia *et al*, 2003).

- **Inadequate dietary intake** - The insufficient consumption and absorption of food, Vitamins, and essential minerals necessary to meet the body's nutritional needs and maintain health (IoM, 2000).
- **Nutrient deficiency** - Refers to the nutrient intake levels that are below those recommended for the specific age group (IoM, 2000).
- **Food group** - These are part of a method of classification for the various foods that humans must consume everyday in order to achieve optimal nutrition (Lombardi-Boccia *et al*, 2003). Food groups are often responsible for major and minor contributions to the intakes of nutrients. The most common food group classification include whole grains/cereals, vegetables, fruits, meat, milk, meat and fats/oils/spreads
- **Uji** – This is a thin cereal porridge usually made from pure or mixed flour from maize, sorghum, finger millet or pearl millet. It can be made of pure or mixed flour of the cereals and can either be fermented or unfermented.
- **Ugali** – It is the nationally consumed staple food in Kenya which is a stiff porridge made of pure or mixed flour from either maize, sorghum, pearl millet, finger millet, cassava or a combination of these depending on availability (Obilana, 2001).
- **Quantitative Food Frequency Questionnaire (QFFQ)** – is an instrument used for gathering food information taken over long term (past few days, weeks or months) (FAO, 2004b). The foods included in the QFFQ are foods frequently consumed by the whole population being studied.

- **Focus groups (FG)** - are a form of qualitative research in which an in depth discussion on a specific topic of interest to the researcher is undertaken by a group of people representative of a population (Dawson, Manderson & Tallo, 1993).
- **The Global Environment Monitoring System/Food Contamination Monitoring and Assessment Programme (GEMS/Food)** - GEMS/Food is an important health-related component of national and international efforts to provide assurance regarding the safety with respect to chemicals in the food supply and provides the basis - where appropriate - for remedial actions, for standards development, for industry and public education and for resource management (World Health Organization, 1999). The GEMS/Food was used to classify foods and beverages contained in the South African Food Composition Tables according to the GEMS/Food commodities of the World Health Organization (Steyn, Nel & Casey, 2003).

## 1.5 Outline of the study

### **1. Background and motivation for the study.**

This section serves as an introduction and gives the motivation why the study was conducted. It also briefly describes the intentions of the study the ABS project.

### **2. Literature review: Food consumption in rural Kenya with special emphasis on sorghum and young children's nutritional needs.**

The literature review gives background information on the food production and consumption patterns in sub-Saharan Africa in general and in Kenya in particular. This section also reviews why specific nutrients are essential and what the consequences of their deficiencies are mainly in the growth and development of young children.

### **3. The energy and nutrient contribution of sorghum to the diet of children aged 2-5 years old in selected rural communities in western Kenya**

This is the research chapter, which includes the research methodology, results, discussion and recommendations in the form of an article.

### **4. General discussion**

It is the interpretation of the research findings in respect of what should be done to combat malnutrition among young children in rural western Kenya.

### **5. Conclusions**

The major findings of the investigation that details the importance of what has been learnt about sorghum consumption in the surveyed areas are summarised. Recommendations based on the findings are given.

## **2. Literature review: Food consumption in rural Kenya with special emphasis on sorghum and young children's nutritional needs**

The term food consumption is used to define the amount of food prepared at the household level or the amount of food eaten by individuals (O'Brien-Place & Frankenberger, 1989). It can also be defined as available food, which is either acquired through agricultural production or purchased and eaten to impact on the nutritional status of a population. The consumption pattern of a population generally depends on the production pattern, which determines what is to be consumed and how much should be consumed.

Food consumption is to a great extent affected by a nation's agricultural policy because most of the food that is consumed is acquired through agriculture (Josserand, 1984). Agricultural production therefore plays a very important role in meeting the food consumption needs of any household (Von Braun, 1988). The nation's agricultural policy provides a link between agricultural production and nutritional status of a population ensuring that nutritionally adequate food is available (Josserand, 1984; Von Braun & Paulino, 1990).

Population growth has had a significant impact on food consumption (Johnson, 2000). It brought about the movement of people from rural to urban areas, resulting in a change in their food composition and dietary patterns (Kennedy & Readon, 1994). The growth in population world-wide has resulted in higher food demands that need to be met by agricultural production (Teklu, 1996). The sub-Saharan Africa region also experienced its fair share of population growth resulting in the shift from traditional foods to processed and convenience foods (Von Braun & Paulino, 1990).

The consumption of the traditional coarse cereal staples such as sorghum and millet has declined over the years in Africa as a result of consumers changing their diet to imported staples (Diagana, Akindes, Savadogo, Reardon & Staartz, 1999). However,

even with the shift in production and use of the traditional staple cereal foods, these foods still form an important part of most rural African diets (Teklu, 1996).

## 2.1 Food production and consumption in sub-Saharan Africa

Food production depends on the availability of natural, economic and human resources (Abulana & Hassan, 1998). The economic and human resources have the capacity to be improved in order to meet the food requirements of a population. The natural resources on the other hand, for example the soil, can be improved through the use of fertilizers, but the size of the surface area cannot be expanded (Gerbens-Leenes & Nonhebel, 2002).

Starchy crops such as roots, tubers and cereals make up an important part of the diet of the people in sub-Saharan Africa (Delgado & Miller, 1985). These starchy staples are mostly consumed in the rural areas and their consumption depends on the agricultural environment (Pearce, 1990). Based on the differences in the agricultural conditions in African countries, millet, sorghum, maize and rice are the main cereal crops consumed in varying proportions (Teklu, 1996).

To illustrate the importance of cereals in the African diet, Steyn *et al.* (2003), undertook a study to determine the food items consumed and the average amounts of these items commonly consumed by different age groups in South Africa. This study found that maize porridge was most commonly consumed by children aged 1-5 years, with 80% of the children consuming an average of 426 g per day. In fact, the cereal food group was consumed by 99% of the population (Table 1.1).

As mentioned above, cereals are an important part of the African diet. Millet, sorghum, maize and rice are the main cereals consumed as staple foods in Africa. Most of the sorghum produced in the southern African region is grown by subsistence farmers, in arid and semi-arid regions covering a total area of 1.6 million hectares (Obilana, 2001). In West Africa, sorghum production accounts for about 50% of the

cultivated cereals (Dicko *et al*, 2006). Maize as a staple cereal has been adopted by most subsistence farmers in the eastern and southern regions of Africa as the primary staple cereal, occupying about a third of the cultivated land (Blackie, 1990). The maize yield produced by subsistence farmers in the drier countries in these regions makes up about 500–900 kg/ha while other countries in the region produce about 1000-2000 kg/ha.



**Table 2.1: Comprehensive table of (GEMS/Food)<sup>1</sup> main food groups consumed by children in South Africa (Steyn *et al*, 2003)**

GEMS/Food main group	% of sample consuming the item	Average consumption (g/day)	Standard deviation of average consumption	Average per capita consumption (g/day)
<b>Cereals</b>	<b>99.22</b>	<b>493.00</b>	<b>301.11</b>	<b>489.15</b>
Sugar	82.64	79.23	141.77	65.48
Stimulants	63.82	230.21	123.48	146.93
Milk	56.27	220.21	223.65	123.9
Meat and Offal	47.93	94.08	69.64	45.09
Vegetables	43.64	118.07	96.86	51.52
Vegetable Oils	36.76	12.70	11.21	4.67
Fruits	26.38	110.64	81.82	29.18
Eggs	21.60	222.58	167.61	48.07
Pulses	13.21	71.92	32.04	9.50
Nuts/Oilseeds	10.73	154.07	109.35	16.53
Fish	7.70	89.66	17.39	1.13
Human Milk	7.56	366.96	90.41	6.78
Soups	6.92	147.12	324.86	25.41
Infant Foods	2.58	105.29	240.51	10.87
Condiments	1.41	11.62	115.44	1.95
Animal Fats	0.73	15.67	20.66	0.16
Spice	0.20	1.25	9.52	0.11
Supplements	0.20	75.25	0.5	0.00

<sup>1</sup> GEMS/Food (The Global Environment Monitoring System/Food Contamination Monitoring and Assessment Programme)-GEMS/Food is an important health-related component of national and international efforts to provide assurance regarding the safety with respect to chemicals in the food supply and provides the basis for remedial actions, for standards development, for industry and public education and for resource management (World Health Organization, 1999).

In Africa, the cereal production pattern has gone through changes, from producing exclusively millet and sorghum to the introduction of other cereals such as maize and rice (Pearce, 1990). Production in the drier regions has shifted more towards the production of millet and sorghum, while the wetter regions produce mainly rice and maize with a few producing sorghum. In 1994, food consumption in West Africa went through a shift due to the CFA franc devaluation (Diagada *et al*, 1999). This resulted in a decline in the total cereal intake from 192 kg to 162 kg per Adult Equivalent (AE) between 1993 and 1997. The rice intake however did not change with an intake of 87 kg per AE in 1993 to 88 kg per AE in 1997.

According to Kennedy & Readon, (1994), in the early 1980's the consumption of rice in the eastern and southern regions of Africa rose to a point where it replaced the consumption of millet and sorghum. In the central African region, the situation was worse than in the eastern and southern regions whereby the coarse grain consumption dropped from 87% to 68%, while wheat consumption was on the increase. In the western region, the coarse grain consumption dropped by 20%, while rice and wheat increased significantly.

A closer look at the production and consumption of sorghum in Africa gives a vivid picture of the importance of cereals in Africa. Sorghum is an important crop especially in the semi-arid areas where most other crops cannot thrive (Novellie, 1993). Sorghum in these areas is mainly responsible for providing nutrition especially to poor rural people. The production and consumption of sorghum in Africa varies with some countries producing more than others.

#### 2.1.1 Sorghum production and consumption in sub-Saharan African countries

Sorghum is an important crop in the drier African countries because of its drought resistance traits and its ability to succeed in wet conditions, therefore making it more favourable than maize in some regions (Novellie, 1993). Most of the sorghum grown in Africa is grown for home use (Obilana, 2001). In South Africa and Zimbabwe,

sorghum is grown mostly for commercial purposes for use in the malting and brewing of opaque beer. Sorghum consumption in Africa is considered high in semi-arid rural areas when compared to other parts of the world. Sorghum consumption has been negatively affected by the consumption of imported cereals such as wheat, maize, barley and rice (Dendy, 1995). Between 1979 and 1994, sorghum production globally fell by 0.7% per annum, in Africa the situation was different where sorghum production grew by 2.9% per annum (ICRISAT & FAO, 1996).

In Southern Africa, sorghum is produced in varying quantities in Botswana, Lesotho, Malawi, Mozambique, Tanzania, Zimbabwe, Angola, Namibia, South Africa, Zambia and Swaziland (Obilana, 2001). In the Southern African Development Community (SADC) Region, Botswana has the largest hectarage of sorghum. Botswana and Namibia have the highest per capita consumption of sorghum in the region contributing the highest caloric intake. Other sorghum producing countries in other parts of Africa include Sudan, Bukina Faso, Niger, Nigeria, Ethiopia, Somalia, Uganda and Kenya (ICRISAT & FAO, 1996).

In East Africa, sorghum production data were collected for five countries by focusing on areas identified as Sorghum Producing Areas (SPA) (Wortman, Mamo, Abebe, Mburu, Kayuki, Letoya, & Xerinda, 2006). These countries are Ethiopia, Kenya, Mozambique, Uganda and Tanzania. In these countries, sorghum production was found to be highest in the north central, north eastern and western parts of Ethiopia, the eastern mid-altitude area of Ethiopia, the area to the east of Lake Victoria in Kenya and Tanzania, central Tanzania, and northern and eastern Uganda. Production in these countries ranged between 5 000 ha for the Coast Province of Kenya to 515 000 ha for the North Central Highlands of Ethiopia

The most common form in which sorghum is consumed in Africa include a stiff porridge variously called *sadza* or *ugali* or *mabele* meal or *bogobe* made from sorghum flour (Obilana, 2001). Other products include *ting* (a fermented porridge), *mosokwane* (a firm non-fermented porridge), sorghum rice, a stiff porridge called *tô*

from West Africa, *couscous* and *injera* from Ethiopia, *nasha* and *kisra* from Sudan (Dicko *et al*, 2006). Traditional sorghum beverages include *kibuku*, *chibuku* and *umqombothi* which are fermented alcoholic beverages as well as a non-alcoholic beverage made from fermented sorghum called *maheu* in South Africa (Obilana, 2001).

Although sorghum is a suitable cereal crop for the semi-arid regions, many producers decreased its production opting instead to produce maize (Pearce, 1990). Maize is favoured because the potential yields are higher than those of sorghum. There is more demand for maize through export and there is more available technical support for maize production than there is for sorghum. In addition, maize is easier to process either commercially or domestically than sorghum (FAO, 1997).

## 2.2 Food production in Kenya

Food availability for most developing countries in Africa is derived from sources such as domestic production, imports and food aid (Boussard, Daviron, Gérard & Voituriez, 2005). Agriculture production is an important aspect that contributes to both subsistence crop production, as well as cash crop production in developing countries (Wiebe & Tegene, 2000). Agricultural production strongly influences the availability of crops as well as the price at which these crops are sold.

Onchere (1984) estimated that in Kenya, agriculture contributes about 40-70% of the total household income through sale of crops as well as for consumption purposes. With more than 80% of the population living in rural areas, subsistence farming plays a significant role in providing for the households (Jansen, Horelli & Quinn, 1987). Crops produced through subsistence farming in Kenya include cereals, pulses, roots and tubers (Niemijer & Klaver, 1990). Cereals make up the staples in rural areas and therefore are considered the most important crops. Crops that are produced for commercial purposes include coffee, tea, sugar cane and horticulture crops (The Economist Intelligence Unit, 2006).

In Kenya, the major cereal crops grown through subsistence farming are maize, wheat and rice (FAO, 2004a). In addition to these crops, traditional crops like sorghum, finger millet, cassava, indigenous green leafy vegetables and some fruits also form part of the important subsistence crops in rural areas. Because of its versatility, maize is grown in most parts of Kenya and it is considered as the main staple crop (Muyanga, 2000). Maize is produced for both subsistence and sale purposes by both small and large scale farmers (FAO, 2004a). Small scale farmers form the largest sector of maize producers producing about 75% of the total maize produced in the country while large scale farmers produce 25%.

Wheat, rice, sorghum and finger millet thrive well in the western part of the country, which includes the Central, Western, South Rift and Nyanza Provinces (Export processing zones authority, 2005). The eastern part of the country which covers the Coastal, North Eastern and Eastern Province (known as the Arid and Semi-Arid Lands (ASAL)) mostly favours the growth of sorghum and finger millet in comparison to the other cereals (The Economist Intelligence Unit, 2006).

Wortman *et al.* (2006) identified five major sorghum producing areas in Kenya which were the Coast, Rift valley, Eastern-Central, Western and Nyanza provinces (Figures 2.1 and 2.2). Sorghum production per year in these areas ranged between 3 000 ha in the Coastal province to 51 000 ha in the Nyanza province as shown in Table 2.2. The area with the highest sorghum production was the area to the east of Lake Victoria.

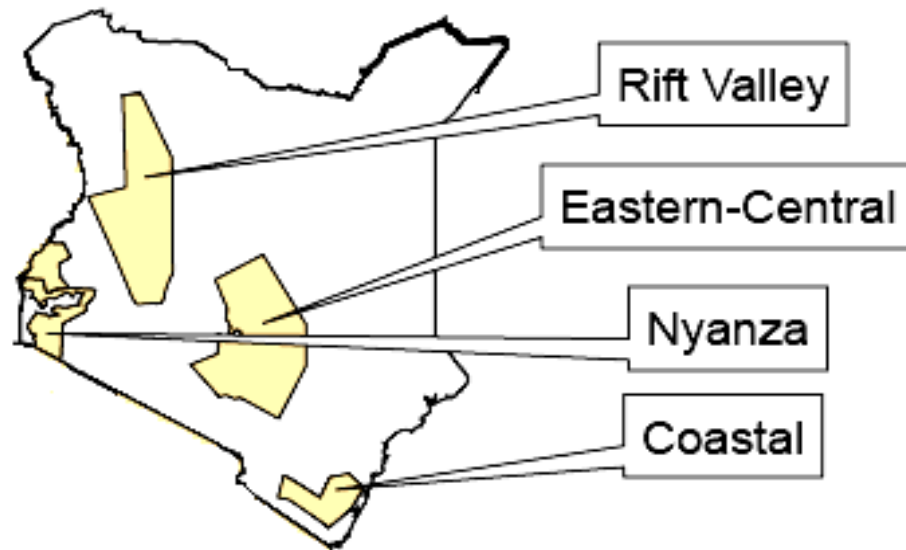
**Table 2.2: Annual sorghum production area and characteristic means of sorghum production areas (SPAs) in Kenya (Wortman *et al*, 2006).**

Province	Production area, '000 ha/yr	Median elevation, m asl <sup>1</sup>	Median latitude	Main sorghum production season	
				Mean temperature, °C	Rainfall, mm/month
Coast	3	185	-3.8	24	87
Rift Valley	14	1915	-0.1	16	75
Western	9	1370	0.4	21	174
Eastern-Central	46	1385	-1.1	21	76
Nyanza	51	1190	-0.2	22	130

<sup>1</sup> asl-above sea level



**Figure 2.1: Distribution Map of Sorghum Production in Kenya (dot (■) = 1000 ha/yr) (Wortman *et al*, 2006).**



**Figure 2.2: Sorghum producing areas in Kenya (Wortman *et al*, 2006).**

Because of the high level of cereal consumption in Kenya, a high proportion of the expenditure is spent on cereals as is the case with many other African countries (Kennedy & Readon, 1994). As can be seen in Table 2.3, the highest portion of the expenditure goes to maize, followed by millet/sorghum, bread alone, rice and wheat respectively.

**Table 2.3: Cereal expenditure patterns for agricultural and quasi-urban households in South Nyanza, Kenya from 1984–1987 (Kennedy & Readon, 1994)**

Percentage of expenditures on the different cereals in the household (%)						
Zone and stratum	Millet/ Sorghum	Maize	Rice	Wheat products	Bread alone	Total
1984-87						
South Nyanza, Kenya						
<b>Agric.</b> Household						
Lower tercile	7	81	2	1	4	100
Middle tercile	8	78	2	1	5	100
Upper tercile	7	74	4	2	6	100
South Nyanza, Kenya						
<b>Quasi-Urban</b>						
Household						
Lower tercile	3	78	3	1	9	100
Middle tercile	4	71	3	1	14	100
Upper tercile	1	69	5	3	13	100

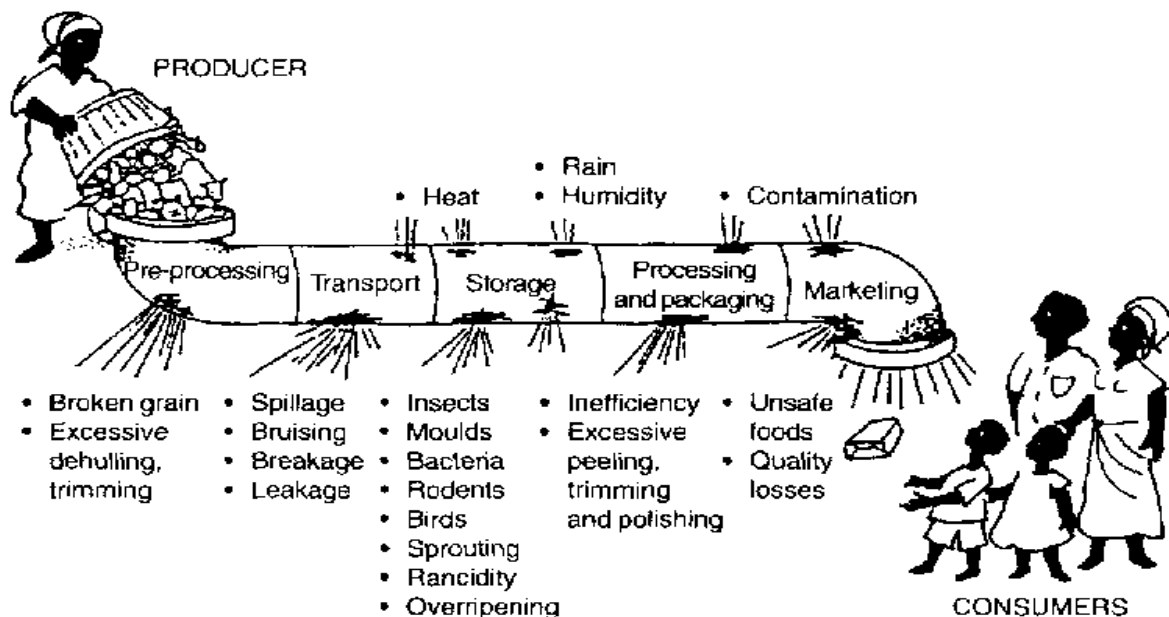
In Kenya, food production is still unable to meet the growing population (Muyanga, 2004). In most cases when production is not enough to meet the requirements, the result is insufficient food supply resulting in food shortages.



### 2.2.1 Food shortages

Food shortages often result from insufficient food supply at the national level and insufficient access to food at the family level (Smith, El Obeid & Jensen, 2000). Special attention is given to food acquired at the household level or family level, whereby food is acquired through production, food gathering, purchasing from the market and receipts of food from others. It is at this level that most people in developing countries experience food shortages.

Successful food productivity depends largely on good rains in dryland production systems, which determine if there will be good food supply or food shortage in the following season (Wangalachi, News & Humphries, 2005). Most food shortages therefore depend on the climatic conditions during the cropping season (Boussard *et al*, 2005). Losses are caused by insect infestation, rodents and poor storage practices which account for about one fourth of the total food produced (Figure 2.3) (Horenstein, 1989).



**Figure 2.3: The food pipeline: source and nature of some food losses (Horenstein, 1989).**

The arid and semi-arid areas in Kenya often experience repeated seasonal food shortages (Boussard *et al*, 2005). These areas are mostly populated by small scale subsistence farmers that grow crops and rear livestock (Muyanga, 2004). Farmers in these areas rely on maize, which they consider easy to grow and maintain than semi-arid crops like sorghum and millet.

In Kenya, most households experience food shortage during the months of December, January and February after the weeding season and just before harvesting (Onchere, 1984). During weeding or harvesting, most food stores run low and therefore households begin to sell the little that is left in exchange for other products in order to supplement the maize diet (Muyanga, 2004). Also during drought periods, food intake is reduced (FAO, 2004a). In order to compensate for the shortages, people tend to rely on food relief programmes offered by either the government or Non-Governmental Organisations in schools, hospitals and in communities (FAO, 2004a). On some occasions, food shortages are averted by people selling their animals such as chicken to get money, gathering of wild fruits, vegetables and insects (Ngala & Imungi, 2005).

Other coping strategies implemented during food shortages include finding off-farm labour, and seeking assistance from better-off relatives (Ngala & Imungi, 2005). The use of old traditional methods of food preservation during times of abundance is also used as a coping strategy (Lepoora & Epatt, 2005). The preservation methods used include, fermentation of milk and making *gee*, drying meat, drying wild fruits, honey harvesting and storage, timing of livestock birth, as well as consumption of hides and skins. The areas that previously had livestock in Kenya have since seen a decline in food production due to persistent drought conditions. (Rioba, Sheikh & Stevens, 2000). During shortages, people living in the arid and semi-arid areas rely on surpluses produced during the rainy season (Lepoora & Epat, 2005). In conclusion, it is evident that there are different causes of food shortages in rural areas and these are addressed using different coping strategies. In most cases, these coping strategies influence what the people eat at any given time.

### 2.3 Family food habits in Kenya

In Kenya, as elsewhere, food habits and dietary patterns are related to the environment in which people live (Oniang'o, Mutuku & Malaba, 2003). They are based on traditions of the people in the community and the changes are influenced by their participation in development (FAO, 1965). Food habits are also dictated by the type of environment that people settle in at any given time and it is for this reason that they are subject to change.

The Kenyan population consists of different ethnic, ecological and economic backgrounds, with different food habits unique to different population groups (Oniang'o & Komoti, 1999). Studying the food habits in Kenya is a difficult task due to the fact that the Kenyan lifestyle is slowly shifting from traditional to a modern lifestyle. The following section gives details of the foods most commonly consumed by different ethnic groups in Kenya.

#### 2.3.1 Meal patterns and commonly consumed foods in rural Kenya

Three meals are normally served in a day in typical rural Kenyan households (Klaver & Mwadime, 1998). These consist of breakfast in the morning, mid-day meal and supper in the evening. Breakfast usually consists of leftovers of *ugali* (stiff porridge), rice or sweet potatoes from the previous night, which is re-heated and taken together with some tea or fresh breakfast porridge (*uji*) (Oniang'o *et al*, 2003). For those families that can afford to have more variety, breakfast may include chapattis (traditional unleavened bread), *uji* (thin porridge) or bread.

Sometimes the mid-day meal is often not served because children are usually away from home at school or herding livestock (Klaver & Mwadime, 1998). The most important meal of the day then becomes supper when all the family members are present to share the food (Van Steenberg, Kusin & Onchere, 1984). Lunch and supper may consist of a number of foods. However, the main food component is *ugali*

which could be served together with any available local vegetables, milk and sometimes fish in areas near by Lake Victoria or the Coastal area (Oniang'o *et al*, 2003). In most cultures in rural Kenya, the members in the household have to share their meals by eating from a communal bowl (Oniang'o *et al*, 2003).

The national staple food in Kenya is *ugali* (boiled/steamed mash) generally prepared from maize flour (Oniang'o & Komoti, 1999). Some communities may prepare *ugali* from other indigenous cereals such as sorghum and millets (Klaver & Mwadime, 1998). *Ugali* and *uji* may also be made from a combination of different cereals, legumes, roots and sometimes fish (Figure 2.4) (Oniang'o *et al*, 2003). Other types of *ugali* are made from bananas, cassava, and roasted or boiled maize mixed together with beans as well as mashed Irish potatoes (Conelly & Chaiken, 2000).



INGREDIENTS:  
Maize, sorghum, green grams, soya beans, millet, groundnuts

INGREDIENTS:  
Millet, sorghum, soya beans, cassava, milk powder, groundnuts, fine maize flour

**Figure 2.4: Commercially available *uji* for children, which is made from sorghum together with other ingredients**

As stated, the food habits in Kenya may also differ by region and ethnic group. For example, the traditional dishes in the southern part of Kenya are maize and beans, often supplemented with vegetables, fat and milk (Van Steenberg *et al*, 1984). These are eaten at least twice a day, especially by the poor people. For people that can afford variety in their diet, fat and meat is more common and may be eaten together with a large portion of beans, peas or maize. An example of some food combinations that might be eaten in some parts of Kenya is given in Table 2.4 (FAO, 1997).



**Table 2.4: Examples of daily food intakes in some areas in Kenya (FAO, 1997)**

Kenya coast		Nairobi		Lake Victoria		Massailand	
Food	Amount (g/person/day)	Food	Amount (g/person/day)	Food	Amount (g/person/day)	Food	Amount (g/person/day)
Rice	500	White-wheat bread	400	Maize	600	Milk	2000
Fish	100	Rice	100	Fish	100	Blood	100
Beans	150	Eggs	30	Cowpeas	150	Maize	150
Amaranth	100	Meat	100	Papaya	150	Wild leaves	100
Mango	100	Carrots	100	Vegetable	200	Wild fruits	100
Coconut	50	Green leaves	50	Groundnuts	75	Bananas	200
Oil	15	Butter	25	Oil	20	Salt	15
Salt	15	Fresh bananas	100	Salt	10		
		Milk (in tea)	60				
		Sugar	30				
		Salt	10				

The Massai, who are pastoralists living in the southern part of Kenya and northern part of Tanzania, keep a lot of livestock, which is not consumed but instead used for by-products, especially milk and blood (Imbumi, Saitabau & Maund, 2005). The practice of consuming animal blood mixed with milk by the Massai has been considered a good practice, which serves as a rich source of protein and iron (FAO, 1965). Another good habit also practiced by the Massai is the consumption of sour milk rather than fresh milk (Imbumi, 2007). The souring process (fermentation) is considered to be good because it substantially reduces pathogens that are likely to be contained in the fresh milk if milking was not performed hygienically (FAO, 1965).

The Massai diet also relies largely on wild fruits, roots and tubers which is boiled to make soups and also to prepare other products (Imbumi, 2007). Some of the wild plant products consumed by the Massai include traditional beer made from roots of some aloe species, traditional tea made from roots and barks of certain trees, as well as fruits, roots, gall, gum and resin which are consumed as snacks.

A list of some commonly consumed dishes by some rural communities in Kenya was compiled by Imbumi (2007) showing the diverse food habits found in various parts of Kenya (Table 2.5).

**Table 2.5: Diet and dishes among different ethnical groups of Kenya (Imbumi, 2007)**

Location & Ethnic group	Main dish
Nyanza province (Luo)	<ul style="list-style-type: none"> <li>• <i>Ugali</i> (stiff porridge from sorghum flour (<i>mtama</i>) or finger millet (<i>ka</i>))</li> <li>• <i>Uji</i> (fermented or unfermented soft porridge made from cereal flour)</li> <li>• <i>Githeri</i> (mixture of beans (<i>oganda</i>) and maize (<i>oduma</i>))</li> <li>• <i>Samaki</i> (deep fried fish)</li> <li>• <i>Nyama choma</i>, <i>matumbo</i> (roated beef, stewed beef)</li> </ul>
Central province (Kikuyu)	<ul style="list-style-type: none"> <li>• <i>Irio</i> (mixture of maize various kinds of beans and mashed bananas)</li> <li>• <i>Ucuru</i> (gruel made from millet flour)</li> <li>• <i>Ugali</i> (stiff porridge from sorghum flour or finger millet)</li> <li>• <i>Uji</i> (fermented or unfermented soft porridge made from cereal flour)</li> </ul>
Costal region (Giriama)	<ul style="list-style-type: none"> <li>• <i>Sima</i> (porridge made from maize)</li> <li>• Porridge made from brown rice, cassava and banana,</li> <li>• <i>Kitowea</i> (a mixture of red beans (<i>kunde</i>) small round green beans (<i>podzo</i>), stewed beef or goat, boiled fish or shark, prawns or chicken)</li> <li>• Boiled, raw bananas or bananas fried in gee,</li> <li>• Sweet potatoes roasted in ashes or boiled</li> <li>• <i>Samaki</i> (deep fried fish)</li> </ul>
Northern Kenya (Sambura)	<ul style="list-style-type: none"> <li>• Fermented milk</li> <li>• Wild fruits and vegetable soups</li> <li>• Blood</li> <li>• <i>Oljukoti</i> (mixture of fresh milk and blood)</li> <li>• <i>Imotori</i> (meat soups)</li> </ul>
Kenya coast strip (Digo)	<ul style="list-style-type: none"> <li>• <i>Mandazi</i>, deep fried wheat bun</li> <li>• <i>Chapati</i> (a pan fried unleavened wheat bread)</li> <li>• <i>Mahindi choma</i> (maize on cob grilled on charcoal)</li> <li>• <i>Mchele</i> (boiled rice)</li> </ul>



### 2.3.2 Sorghum consumption in Kenya

Sorghum is grown and consumed in most parts of Kenya but mainly in the arid and semi-arid areas in the eastern parts of the country (FEWS.NET, 2006). The sorghum grain is pounded or milled into flour in order to make *ugali* or *uji* (Figure 2.5). Sorghum flour can be mixed with other cereals, legumes or roots such as maize, finger millet, beans, groundnuts and cassava to make *ugali* and *uji* (Oniango *et al*, 2003).



**Figure 2.5: Some common sorghum preparations in western Kenya (*ugali*, *uji* and tea)**

According to Van Steenberg *et al.* (1984), in Kenya sorghum is a popular cereal consumed from childhood as a weaning food up to adulthood. The soft porridge is usually prepared in the morning for breakfast for the whole household, as well as for feeding infants throughout the day. The soft porridge is usually enjoyed with milk, sugar and/or tea, even though at times it may be eaten alone when these are not available. *Ugali*, on the other hand, is often consumed twice a day, at lunch time and at supper time together with vegetables, fish, meat stew or milk (Oniango *et al*, 2003).

The overall sorghum consumption in Kenya has declined over the years, from an average of 9.5 kg/person/year in 1972-74 to 3.3 kg/person/year in 1992-1994 (FAO, 1995). One of the factors that are responsible for the reduced consumption of sorghum is the introduction of maize as a staple food (Ogoye-Ndegwa &

Aasaarrd-Hansen, 2006). Sorghum production and use in Kenya, just like in many other African countries, has been overshadowed by maize production (Obilana, 2001). Households in the arid and semi-arid areas have shifted from producing sorghum at a large scale to maize production because the traditional sorghum dishes are regarded as a sign of poverty and their preparation being time consuming (Muyanga, 2004). This, together with the unfavourable pricing policies, inappropriate use of new processing technologies, limited access and inadequate quantities of appropriate grain quality types, lack of adequate grain transportation and industrial storage, as well as the perceived image of sorghum are still hindering its improved marketing and utilization (Obilana, 2001).

#### 2.4 The future for sorghum

The drop in per capita cereal and food production in the world has led to a serious problem of diminished food supply especially in the developing countries (Abulana & Hassan, 1998). Several organizations have focused their attention in fighting the food shortage situation especially in semi arid areas where food deficiency is most rife. These organisations have reintroduced the production and use of traditional crops such as sorghum and finger millet. Attention is currently directed towards improving the production, use and marketing of sorghum as a staple crop in countries such as in the west and central Africa (Akintayo & Sedgo, 2001).

One such technology is the use of biotechnology to produce a sorghum variety that is nutritious and can be used for feeding people in rural areas where food shortages are common (The ABS consortium, 2007). Biotechnology is considered as a good approach towards the fight against hunger because it is a cost effective technology that requires only a one time investment and can be distributed to other places where it is needed. The benefits and success of biofortification have been explored in the production of a high Vitamin A rice variety known as the Golden Rice (Potrykus, 2001). This rice variety was developed so that it is able to synthesize pro-Vitamin A in the endosperm. The rice was developed for use in Vitamin A deficient countries where rice is the staple food (Toenniessin, O'Toole & De Vries, 2003).

The Africa Biofortified Sorghum (ABS) project which is led by Africa Harvest Biotech Foundation International (AHBFI) seeks to use the technology of biofortification to make a difference in the nutritional and health status of people in rural areas in sub-Saharan Africa (The ABS consortium, 2007). The ABS project is aimed at developing a nutritionally enhanced sorghum, which will be used to improve the nutritional status of the rural poor where sorghum is consumed as a staple food (Wambugu, 2007). It is intended that the biofortified sorghum will have an increased levels of essential amino acids especially lysine, improved digestibility, Vitamin A, Vitamin E, iron and zinc.

The success of the biofortified sorghum depends on its acceptance by the sorghum consumers. It also depends on the consumers' confidence and realisation that sorghum is more nutritious and affordable than other cereals such as maize and rice. The challenge at the moment is to re-introduce and increase the use of sorghum in African countries and find ways to deal with the negativity that sorghum is often associated with.

In order to determine the amounts and types of food products consumed by individuals, food consumption surveys are often used to collect information about the food items actually consumed. This information that is collected is then converted into nutritive values by using the appropriate food composition data. To collect dietary data, a suitable dietary assessment method must be used. It is, however, important to understand that there is no specific assessment method that is perfect for measuring dietary intake (Anderson, 1995). Factors such as the objectives of the assessment, the amount and reliability of available information about the population to be studied and resources available (finances, time, qualified personnel) must always be considered before deciding on the most suitable dietary assessment method to use (Beghin, Cap & Dujardin, 1988). The next section briefly outlines the importance of the Food Frequency Questionnaire (FFQ) and the Focus Groups (FG) interviews as dietary assessment methods.

## 2.5 Dietary assessment in food consumption studies

Food consumption surveys are an important tool for assessing how people eat as well as what people eat (FAO, 2004b). Food consumption surveys provide data on the amounts of different foods consumed by individuals and households; the nutritional content and quality of diets; and the socio-economic and demographic characteristics of the population from which the sample is taken. To get this kind of data dietary assessment methods are used as assessment tools.

Various dietary assessment methods are often used in order to assess the adequacy of dietary intakes of different population groups and to plan/evaluate intervention programmes, among other things (Poleman, 1997). These dietary assessment methods are classified as the quantitative assessment method and qualitative assessment method (FAO, 2004b). Quantitative assessment methods provides data on the amounts of various foods consumed by individuals and or populations and the qualitative assessment methods on the other hand provides information on the kind of foods consumed, food preparation procedures, food preferences, cultural influences and attitudes towards foods.

The quantitative approach to dietary assessment assesses both current and past intake. Quantitative assessment methods that record intake as they take place (current), are called prospective dietary assessment methods (Anderson, 1995), and those that recall intake after it has happened (past), are known as retrospective dietary assessment methods (Rutishauser, 2005). Qualitative assessment methods can be used together with quantitative assessment methods in order to validate and clarify information gathered by the quantitative results (FAO, 2004b). For the purposes of this study, this review only focuses on the Food Frequency Questionnaire (FFQ) and the Focus Groups interviews (FG).

### 2.5.1 Food Frequency Questionnaire (FFQ)

The principle involved in the Food Frequency Questionnaire (FFQ) is based on gathering food information on long term dietary intake (past few days, weeks or months) which is more important than short term intake (FAO, 2004b). The foods included in a Food Frequency Questionnaire are foods frequently consumed by

the whole population being studied. Sometimes a modified version of the questionnaire which contains a specific list of food items may be used when the study is concerned about the consumption of specific foods (Shahar, Shai, Vardi, Brener-Arzdad & Fraser, 2003).

The Food frequency questionnaire can either be self administered or interview administered, asking respondents to indicate the portion size and the frequency of consumption over a day, week month or seldom (Anderson, 1995). The Food Frequency Questionnaire is mostly used in epidemiological research for large population when resources such as finances and time are limited (FAO, 2006). The Food Frequency Questionnaire is the most favoured method for large epidemiological studies because it is low cost, contain a limited number of foods specific to the study population and it can also be developed from a pre-existing questionnaire (Cade, Thompson, Burley & Warm, 2002).

#### 2.5.2 Focus groups (FG)

Focus groups are a form of qualitative research in which an in depth discussion on a specific topic of interest to the researcher is undertaken by a group of people representative of a population (Cameron, 2005). The people used in the Focus group are selected using purposive sampling, which focuses on the informants knowledge and experience on the issue to be discussed. The focus group interview focuses on the group's meanings, views and experiences in relation to the concept being investigated (FAO, 2004b). The discussion can gather the required information in one group discussion taking place between six to twelve participants (Folch-Lyon & Trost, 1981).

It is vital that the group's discussion focuses on the topic of interest which requires a facilitator/moderator to control the group's discussion (Bender & Ewbank, 1994). The importance of the focus group in this regard is that it can be combined with a quantitative method such as the 24 Hour recall or the Food Frequency Questionnaire in order to boost information gathered from the focus group discussion (Cameron, 2005).

Information gathered from qualitative dietary intake surveys is needed to provide detailed information on the types and amounts of foods consumed by the majority of a population (Harrison, 2004). The information gathered from these surveys is meaningless without information about the nutritional composition of the food (Greenfield & Southgate, 1992).

### 2.5.3 Food Composition Data

In order to find out the nutrient intake of the study population, the food composition data is the best tool to use. Food composition tables are useful in converting food intake to individual nutrient information which can then be checked against nutrient parameters that tells us if the population meets the nutritional requirements or not (Dehghan, Al hamad, Yusufali, Nusrath, Yusuf & Merchant, 2005).

Even though most countries still have food composition data available on table, a lot of improvement has been made in developing computerised databases with improved speed, accuracy and extended use (Greenfield & Southgate, 1992). A complete food composition database often provide data on all food and food components of interest to the specific population, with some values borrowed and adapted from elsewhere because development of a food composition data from scratch is expensive (Harrison, 2004). Food composition databases from different countries have become more important for local and international use (Van Heerden & Schönfeldt, 2004). Most developing countries that have food composition databases have them through combining of local and regional food composition data from other countries (Harrison, 2004).

Why is there all the fuss about ensuring there is adequate food production and consumption? This is because the major underlying causes of malnutrition include poor food production or supply; poor food distribution, both between families and within families and poor education (Shori, 2000). The next section focuses on the causes and consequences of malnutrition, and how inadequate food intake can affect growth and development in children.



## 2. 6 Causes and consequences of malnutrition

Worldwide, trends in childhood malnutrition have shown a steady decline in the past few years (Caballero, 2002). This, however, has not been the case in the sub-Saharan Africa region especially in the east African countries where nutritional deficiencies are still widespread (Chopra & Darnton-Hill, 2006). The east African sub-region was reported to have experienced the highest increase in undernourished children from 1990 to 2005 of 36% (Young, Borrel, Holland & Salama, 2004).

Malnutrition, which can mean either over nutrition or under nutrition is a term often used to refer to a combination of the incidences of obesity, low energy intake, low protein intake and low micronutrient intake (Neumann, Harris & Rogers, 2002). Under nutrition affects the most vulnerable groups of a community, which are women, the elderly and children (Bentley, Aunger, Harrigan, Jenike, Bailey & Ellison, 1999).

Malnutrition in children is an important health indicator used to monitor the nutritional status of the whole population (De Onis & Blössner, 2003). Malnutrition in children is characterised by low body weight, low weight for height, low height for weight and chronic under weight (Vankatesh Iyenger & Nair, 2000). These conditions are often evident during the period of rapid growth and development during infancy and early childhood (Nuemann *et al*, 2002). But what causes malnutrition?

According to The United Nations Children's Fund (UNICEF) conceptual framework, the causes of malnutrition are interrelated sectors at the societal level, household level and individual level (UNICEF, 1998). At the societal level the causes are basic caused by insufficient national food supplies. At the household level the causes are underlying causes, which are influenced by insufficient food production, income availability and the intra-household food distribution. At the last level, which is the individual level, the causes are immediate and they are

influenced by access to a nutritionally adequate diet coupled with good health free from diseases.

The nutritional deficiencies that are of major concern and will be looked at into detail are Protein Energy Malnutrition (PEM), Vitamin A deficiency, iron deficiency anaemia, iodine deficiency and zinc deficiency. Because the effects of micronutrient malnutrition often go unnoticed, when it occurs it is often termed as the “hidden hunger” (Faber & Wenhold, 2007). First, we will look at the nutritional requirements for children.

### 2. 6.1 Children’s nutritional requirements

During the first six months of life, children born from healthy mothers hardly experience any nutrition related illnesses until when they reach the weaning stage where they have to take complementary foods (Michaelsen & Friis, 1998). It is believed that the nutritional status of the children gets affected when they start taking complementary foods which are often bulky cereal based diets that are low in essential nutrients and high in anti-nutrient factors (UNICEF, 1998).

A proper diet is therefore essential in providing the proper quantity of food for energy and quality of the food to provide the essential micro- and macro- nutrients for proper human growth and development especially from early childhood (Neumann *et al*, 2002). The nutrients that are essential for proper growth and development and are often of major concern in developing countries are carbohydrates, proteins, iron, zinc, iodine, calcium, Vitamin B12 and Vitamin A, which are acquired from a number of foods that make up the diet (Onyango, 2003). These nutrients are also of low bioavailability and poor quality especially in cereal based diets.

The nutritional requirements for protein, zinc, iron and Vitamin A in children’s diets will be discussed and these will be looked at in relation to the children’s Recommended Dietary Allowance’s (RDA) in order to meet their growth and



developmental needs. Table 2.6 gives a summary of the RDAs for the age groups 2-3 years and 4-6 years.

**Table 2.6: Recommended Dietary Allowances (RDAs) values of selected nutrients for children aged 1-3 and 4-6 years<sup>1</sup>**

	Unit	1-3 years	4-6 years
Energy	kJ	4393	7100
Protein	g	13	30
Vitamin A Activity Retinol Equivalent	µg RE <sup>2</sup>	300	500
Vitamin D	µg <sup>3</sup>	5.0	10
Vitamin E Activity	mg α-TE <sup>4</sup>	6	7
Ascorbic Acid (Vitamin C)	mg	15	45
Biotin	µg	8.0	8.5
Folic Acid	µg	150	200
Panthenic Acid	mg	2.0	4
Nicotinic Acid	mg	6.0	11
Riboflavin (Vitamin B2)	mg	0.5	1.0
Thiamin (Vitamin B1)	mg	0.5	0.9
Pyridoxine (Vitamin B6)	mg	0.5	1.3
Cyanocobalamin (Vitamin B12)	µg	0.7	2.5
Vitamin K	µg	30	30
Calcium	mg	500	800
Phosphorus	mg	460	800
Iodine	µg	90	90
Iron	mg	7.0	10
Magnesium	mg	80	200
Copper	mg	2.0	2.0
Zinc	mg	3.0	10
Fluoride	mg	0.7	2.5
Chromium	mg	11	0.12
Selenium	mg	2.0	0.12

<sup>1</sup> Nutrient Information Centre of the University of Stellenbosch (NICUS), (2003).

<sup>2</sup> Retinol Equivalent. 1 Retinol equivalent (RE) = 1 µg retinol or 3.33 IU Vitamin A activity or 6 µg β-carotene.

<sup>3</sup> As cholecalciferol. 1 µg cholecalciferol = 40 IU of Vitamin D.

<sup>4</sup> α-tocopherol equivalent. 1 mg α-tocopherol = 1 α-TE (tocopherol Equivalents) = 1.49 IU (1 IU = 1 mg dl-α-tocopheryl acetate).

- Protein – Protein is required by all cells and body tissues and it forms the basic part within all cells (Mann & Truswell, 2002). Proteins are responsible for providing; amino acids, nitrogen which is required for non-essential amino acids and nitrogen balance in the body (Kruger, Van de Spuy & Viljoen, 2004). Protein is also responsible for cell multiplication as well as increasing the size of the cells (Jackson, 2002). The amino acids are essential for; supporting linear growth and maintenance, building body compounds (enzymes, hormones), defending the body against diseases by providing antibodies, controlling electrolytes and fluid balance, regulating acid balance, transporting nutrients and providing energy (Whitney & Rolfes, 2002).

In order to support all these functions in young children, the recommended protein intake should make up 5-20% of the total energy intake (Pellet, 1990). From three months of life after birth, up until twelve months, the RDA for protein ranges between 1.2 and 1.4 g/kg body weight per day (Institute of Medicine, 2000). From one to five years of life, the requirements change slightly from 0.8 to 1.0 g/kg body weight per day

- Vitamin A – Vitamin A compounds in the diet are found in the forms of retinoids (retinol, retinaldehyde and retinoic) derived from animal products and carotenoids which are derived from plant products (Van Lieshout & West, 2004). Each one of these Vitamin A compounds cannot perform all Vitamin A metabolic function on its own, which is why these compounds must be taken from the diet collectively (Institute of Medicine, 2000).

Vitamin A is involved in a number of biochemical functions. It maintains vision at low light intensity, is involved in protein synthesis, is involved in cell differentiation and is also involved in reproduction (West, 2002). The compound retinol is only responsible for providing vision at low light intensity, synthesis of active sulphates and reproduction. Retinoic acid, on the other hand, is involved in cell differentiation, morphogenesis, synthesis of glycoproteins, gene expressions, immunity, growth, prevention of cancer and heart diseases.

In order to support all the required functions, the recommended intake for Vitamin A from birth to one year is 375 µg of retinol daily (Institute of Medicine, 2000). From 1 to 3 years, 4 to 6 years and 7 to 10 years, the recommended allowance is 400 µg, 500 µg and 700 µg, respectively.

- Iron –There are generally two forms of iron that are available from the diet, haeme iron which is derived from animal products and the non-haeme iron derived from plant foods such as cereals, pulses or fruits (Olivares, Walter, Hertrampf & Pizarro, 1999). Iron in the body is generally controlled by available iron stores which determine if there is a need for more iron or not.

Infants born from healthy mothers with adequate iron stores usually have adequate iron supply for the first few months of life up until they are weaned (Osiki, 1993). High iron requirements in children often arise when the child starts taking normal food where he no longer relies on the mother's breast milk for food and nutrient supply. Iron requirements are even higher in unhealthy children who are suffering from conditions such as intestinal parasitic infections (Kruger *et al*, 2004).

The recommended intake for 1 to 2 year old children is 120 µg/kg body weight/day or 11 mg per day (21 mg at low bioavailability, 11 mg at intermediate bioavailability and 7 mg at high bioavailability) (MacPhail, West & Verhoef, 2004). From 2 to 6 years the required intake is lower than that of younger children at 56 µg/kg/day or 10 mg per day (12 mg at low bioavailability, 6 mg at intermediate bioavailability and 4 mg at high bioavailability).

- Zinc –Zinc is obtained from animal products, cereals and legumes. However fibre and phytate in cereals often limit the absorption of zinc from a cereal based diet (Van Lieshout & West, 2004). Zinc acts as a cofactor in many enzyme involved in metabolic functions (Kruger *et al*, 2004). Requirements for dietary zinc in infants are recognized at about six months, as soon as the child begins taking complementary foods. The recommended intake of zinc from birth to

one year is 3 mg/day after, which is increased to 5 mg/day for children from one to three years and 10 mg per day from four years upwards (Institute of Medicine, 2000).

## 2. 6.2 Nutritional deficiencies in children and their consequences

The most common nutritional deficiencies, as it has already been mentioned, are PEM, iron deficiency anaemia, iodine deficiency disorders, zinc and Vitamin A deficiency. At the early stages of development of these deficiencies, it may not be easy to identify the clinical signs as they are often mistaken for other conditions (Bhan, Sommerfelt & Strand, 2001). In most cases these deficiencies are recognized at a very complicated stage when the patient has developed severe conditions such as blindness, mental retardation or death.

- PEM - Protein energy malnutrition (PEM) is a term used to describe the existence of the combination of kwashiorkor and marasmus (Waterlow, 1997). Kwashiorkor is a condition that develops as a sign of protein deficiency and on the other hand marasmus is a condition that signifies energy deficiency in children. A child's condition is declared as marasmatic when the subcutaneous fat and muscle are depleted from excessive use of energy and nutrients by the body without them being replenished (Muller & Krawinkel, 2005). Signs of marasmus in the child include severe weight loss, low amounts of skin fat and muscle tissue (Shetty, 2006).

With kwashiorkor on the other hand, noticeable changes are seen with the hair, and skin colour, anaemia, hepatomegaly, lethargy, severe immune deficiency and early death. To declare a child suffering from weight loss as having kwashiorkor, in addition, there has to be signs of oedema (Muller & Krawinkel, 2005). Sometimes the child may display both oedema and severe muscle wasting and the resulting condition is then called marasmic kwashiorkor.

- Iron deficiency anaemia – Anaemia can develop from a deficiency in either folate, Vitamin A or Vitamin B12 (Zimmermann, 2007). However, in most

developing countries the major cause of anaemia deficiency is due to iron deficiency (Bhan *et al*, 2001). Iron deficiency anaemia arises when the iron stores in the body are depleted, leading to insufficient iron supply to the tissues (Gleason & Scrimshaw, 2007). Depletion of iron may be due to insufficient iron intake or excessive iron loss from injuries without replenishing (Schultink & Gross, 1996).

The consequences of iron deficiency in children are cognitive impairment, reduced work performance and reduced resistance to infections (Gleason & Scrimshaw, 2007). In children under the age of two, iron deficiency results in problems with coordination, balance and withdrawal (UNICEF, 1998). In severe cases of iron deficiency anaemia when the body fails to produce enough haemoglobin to transport oxygen and carbon dioxide between the lungs and the tissues in the body, death may occur (Gibson, 1990).

- Iodine deficiency disorders (IDD) – Iodine deficiency is usually prevalent in highlands where the topsoil that contains iodine is lost resulting in crops that lack iodine (Federal Ministry of Health, Family Health Department, Ethiopia, 2004). Without iodine there is a reduced production of the thyroid hormone resulting in the increased stimulation of the thyroid stimulating hormone (Muller & Krawinkel, 2005). Iodine deficiency results in the development of goitre, hypothyroidism, impaired mental function, retarded mental and physical development, and reduced school performance (Bhan *et al*, 2001).
- Zinc deficiency –Zinc is present in all tissues, organs, fluids and secretions in the body because it is responsible for many metabolic and cellular functions (Hotz & Brown, 2004). Zinc deficiency is often an indication of inadequate dietary intake of zinc often repressed by the presence of dietary factors such as the high phytate content which inhibits the absorption of zinc from the diet. Marginal zinc deficiency in children may lead to immune deficiency and increased prevalence of infections, such as diarrhea and pneumonia and later on may lead to death (Dijkhuizen, Wieringa, West & Van Wouwe, 2001). In severe cases, zinc deficiency may result in impaired growth and development in children.

- Vitamin A deficiency - Vitamin A is required for the maintenance of a healthy immune system, eye health, eye sight, growth and survival (Gibson, 1990). Vitamin A deficiency has been found to have some kind of connection to the risk of developing iron deficient erythropoiesis and anaemia (West, Gernand & Sommer, 2007). This is due to the fact that Vitamin A is involved in the mechanisms that control iron storage and release the tissue into circulation.

Vitamin A deficiency occurs when Vitamin A intake fails to meet daily requirements (Van Lieshout & West, 2004). Vitamin A deficiency risks are higher in children between the ages of 2 and 4 years and boys tend to be at a much higher risk than girls. The consequences of Vitamin A deficiency are xerophthalmia (night blindness), triangular grey spots on eye (Bitot spots), softening of the cornea (keratomalacia), impaired immunity (development of infectious diseases such as measles and diarrhoea), plugging of hair follicles with keratin and forming white lumps (Whitney & Rolfes, 2005).

Even though micronutrients are an essential part of the diet, they seem to be the most limited resource in the diets of most developing countries. Decline in crop production has in some way been implicated in the increasing problem of malnutrition in developing countries especially since crops such as cereals and legumes are an important part of the rural diet (Ruto & Wamocho, 2005). It is for this reason that developing countries should concentrate their attention on the food production system that contributes to nutrition and achievement of the Millennium Development Goals (MDG) number one “*Eliminate extreme poverty and hunger*” (Sigot, 2005). Of major interest with most development agencies involved in the fight against malnutrition, is to improve food security at the household level, economic growth, poverty alleviation, social development and education (Muehlhoff, Simmersbach, Baron & Egal, 1995). To deal with the nutrition problem, intervention strategies to improve nutrition in rural communities have been enforced

## 2. 7 Nutrition intervention strategies implemented in alleviating malnutrition

The need for increased food production to meet the demands created by increases in population has over the years has been treated as top priority by many countries (Muehlhoff *et al*, 1995). In an effort to deal with the nutrition concerns brought about by food insecurity, some intervention strategies that aim to solve the nutrition problems were introduced. The fight to reduce malnutrition has been focused on using strategies that pay particular attention to increasing the amount of food consumed, leading to an increase in the energy intake, and also to increasing the consumption of protein and micronutrient rich foods to improve the quality of nutrition (UNICEF, 1998). Strategies that aim at eliminating malnutrition focus on two approaches, increasing the efficacious supply of nutrients through the use of food or tablets; and reducing situations where high nutrient intake is required such as in illnesses (Van Lieshout & West, 2004). In most cases, when a strategy is implemented, the aim is to achieve long term impact, however, when immediate results are required, short-term interventions may be applied (Ramalingaswam, 1998)

The most popular strategies used are supplementation, fortification and dietary diversification (Ruel & Levine, 2000). The success of each strategy depends on the availability of the following; policy support, safety regulations, multiple sectoral involvement, economic and marketing incentives, constant monitoring of the nutrient levels, food regulatory systems, sustainability, education, communication and continued investments (Ramalingaswam, 1998). Even though these strategies have been in use for a long time, they have their advantages and disadvantages that must be considered before they are used. These nutrition intervention strategies are discussed and assessed in terms of their impact in improving the levels of nutrition.

- Fortification – Fortification is a term used to refer to the addition of one or more nutrients in small amounts to a food to improve the nutrient status of that particular nutrient in the population that it is intended for (Van Lieshout & West, 2004). Fortification has been used by a number of countries for many years to



improve nutritional deficiencies such as Vitamin A, iodine and iron declared as a national problem (Darnton-Hill & Nalubola, 2006). The most popular fortification practice employed by a number of countries is the Vitamin A fortification of white sugar (UNICEF, 1998). Other food fortification vehicles that have been successfully used also include salt, sugar and flour (Ramalingaswam, 1998).

The following measures need to be adhered to in order for fortification to be successful: the population at risk must be regular consumers of the potential fortification vehicle in large amounts, day to day variations in consumption must be minimal, the price of the product to be fortified should not be too high when compared to the unfortified version of the product, the physical characteristics such as the taste and colour must not be altered by the fortification process and the fortified food must be produced by a limited number of manufacturers so that it is easy to monitor the fortification process (Van Lieshout & West, 2004). The most limiting factor in using fortification mainly in developing countries is the implementation of regulations that are satisfactorily enforced (Ramalingaswam, 1998).

- **Supplementation** – Supplementation is a short term approach used to alleviate nutrient deficiencies over a specific period of time (Van Lieshout & West, 2004). Supplements are usually administered in capsule form to have a rapid impact and supplementation is often administered as a complementary strategy if fortification is not able to reach the population in time (UNICEF, 1998). Due to its immediate effectiveness, supplementation could be used for a specific deficiency where other strategies could be too slow and then the long term sustainable strategy implemented afterwards (Ramalingaswam, 1998). Since supplementation programmes are usually difficult to administer in large populations, it is usually easier to administer supplementation to women and/or children attending ante-natal or post-natal clinics (Prinzo & de Benoist, 2002).

Just like fortification supplementation is more likely to succeed if the cost for administering the capsules is affordable and also if the transportation and storage

system to deliver the capsules to the target population is reliable (Allen, 2003). In addition to these factors, supplementation needs to be closely monitored and supervised; hence it must go together with education (Prinzo & de Benoist, 2002). Supplementation is an expensive short term strategy mainly for developing countries (Gibson & Fergusson, 1998). This is because supplementation requires a reliable supply, distribution, and delivery of the supplement to the targeted group, which fails when there is poor commitment. One such failure due to lack of full compliance on the full iron supplementation provided for children was reported in Bangladesh (Hossain & Hussain, n.d.)

- Dietary diversification – Dietary diversification is a food-based strategy whose main aim is to increase the availability, access, production, bioavailability and consumption of foods that are a rich sources of the essential nutrients (Ruel & Levine, 2000). With both supplementation and fortification having to depend on good government, market and health infrastructure, which are not always available in rural areas, food based strategies such as this one have the potential to reach the targeted population (Harvest plus, 2006). Dietary diversification is often promoted by advocating for the growing of kitchen gardens, indigenous food utilization, and proper food preparation, preservation, processing and storage methods (Tumwet, Kirogo & Warjohi, 2005). Dietary diversification strategy is a long-term strategy sustainable strategy that involves changes in food production, selection and preparation practices of locally available indigenous foods (Gibson & Hotz, 2001).

An acceptable description for dietary diversification is defining it as having variety between and within food groups (Ruel, 2003). An effective dietary diversity intervention strategy can be implemented through the following practices; promote the use of improved cereal varieties, include foods that enhance the absorption of minerals, modified milling practices, promote soaking, fermentation and germination of cereals to reduce phytic acid activity (Gibson & Ferguson, 1998) In Kenya, the use of Animal Source Foods (ASF) which are foods mainly of animal

origin has been implemented to improve their micronutrient intake (Whaley, Sigman, Neumann, Bwibo, Guthrie, Weiss, Alber & Murphy, 2003).

Other food based strategies that contribute dietary diversification include plant breeding for improved micronutrient content and bioavailability of selected plant-based staples, use of fresh fish, dried fish and preparing fish flour in local communities, promote the use of germination, soaking and fermentation of cereals staples from unrefined flours in order to enhance nutrient bioavailability and also to enhance the energy and nutrient density of cereal-based porridges, use legumes, fruits and vegetables rich in ascorbic acid and pro-Vitamin A carotenoids to enrich the flour, use amylase-rich flours to cereal based porridges for infant feeding so as to reduce the viscosity of thick porridges (Gibson & Hotz, 2001).

A recent dietary based strategy that uses plant breeding techniques is biofortification. Biofortification uses selective plant breeding techniques to improve the nutritional content of crops (Nestel, Bouis, Meenakshi & Pfeiffer, 2006).

#### 2. 7.1 Biofortification

Biofortification is a term that refers to the process used to increase the bioavailability and the concentration of nutrients in crops through plant breeding (White & Broadley, 2005). Biofortification is a strategy that is applied in order to assist low income rural families with the aims of developing seeds that will fortify themselves with no recurrent costs of having to apply the technology repeatedly (Nestel *et al*, 2006).

As an intervention strategy, biofortification has the capacity to increase the yield of crops through increasing crop resistance to insects and drought, development of staple crops that can survive the harsh environmental conditions, increase farmers financial gain by increasing farmers productivity, decrease the use of agricultural inputs such as fertilizers which could cost the farmers, and most importantly to help improve the nutrient content of the target crops and hence improve the nutrient status of most people in rural areas (Timmer, 2003).

The benefits and success of biofortification have been explored in the production of a high Vitamin A rice variety known as the Golden Rice (Potrykus, 2001). This rice variety was developed so that it is able to synthesize pro-Vitamin A in the endosperm. The rice was developed for use by Vitamin A deficient countries where rice is the staple food (Toenniessin, O'Toole & De Vries, 2003). For rural Bangladeshi rice consumers, it was found that the Vitamin A obtained from the diet was well below the recommended intakes. If the Golden Rice were to be consumed instead of the normal rice, there would be an expected 25% increase in the pro-Vitamin A for adult women and preschool children (Bouis, Chassy & Ochanda, 2003).

When a case study in Cebu, a poor region of the Philippines was conducted to compare the potential impact, coverage of deficient sub-populations, and costs of Golden Rice to food fortification and supplementation (Dawe, Robertson & Unnevehr, 2002). It was found that the Golden Rice had the potential to be a low cost wide coverage intervention that can deliver Vitamin A. It was, however, also realized that this intervention would be more effective if used to complement other existing interventions.

## 2. 8 Conclusions

Cereals form the major component of the diet and thus are responsible for contributing to the nutrient intake of rural communities. The main cereals that most rural people rely on in Kenya include maize, rice, finger millet and sorghum. Sorghum and millet are consumed in the drier areas, while maize and rice are staples in the wetter areas. The choice of millet and sorghum as the staple cereals has, however, gone through some changes as maize and rice have become the major cereals consumed even in the semi-arid areas leading to the decreased use of sorghum and millet.

The foods consumed in rural Kenya also include blood, wild fruits, vegetables and milk which are consumed by the Massai community to fish, legumes and rice

consumed by people living along the coast. Cereals also form an important part of the Kenyan diet and are often consumed as the major food component. Sorghum forms just a small part of the rural Kenyan diet. Sorghum in the diet is often used as part of the ingredients to make either *uji* or *ugali* consumed daily. The sorghum is milled together with other cereals, roots, legumes or fish to make the flour.

Based on the literature, it is important to find out what the sorghum consumption patterns in western Kenya are as well as to determine if the children in these areas are potentially malnourished.

### **3. The energy and nutrient contribution of sorghum to the diet of children aged 2-5 years old in selected rural communities in western Kenya**

#### **ABSTRACT**

Sorghum is a staple cereal that provides nutrition in semi arid and food insecure areas. In some rural parts of Kenya, sorghum forms part of the diet mainly in the form of porridge. This study was carried out to determine the amount of sorghum consumed by children aged 2-5 years in some selected rural communities in western Kenya, establish sorghum's contribution to the children's energy, protein, iron, zinc, Vitamin A and Vitamin E intakes and also determine the deficiencies of these nutrients in the children's total dietary intake. A cross-sectional food consumption survey was conducted using an interviewer administered Quantitative Food Frequency Questionnaire (QFFQ) to 102 mothers and caregivers. The QFFQ was run alongside focus group interviews to collect data. The results indicated that the diet consumed by the children in the selected communities offered a variety of foods resulting in sufficient nutrient intake for the majority of the children. The daily contribution from sorghum to the whole diet was low, only 36.4 g for soft porridge (uji) and 26.2 g for stiff porridge (ugali). The nutrient contribution to the total diet from sorghum was consequently low; energy 140 kJ (2%), protein 0.9 g (1.7%), iron 0.3 mg (4.3%), zinc 0.1 mg (2.1%), Vitamin A (0%) and Vitamin E (0%). A substantial proportion of the population consumed a diet that was deficient in one or more of the nutrients. The proportion of the population that was deficient in the selected nutrients was; 36.3% energy, 4.9% protein, 48% iron, 21.6% zinc, 46.1% Vitamin A and 17.6% Vitamin E. Sorghum's small contribution made it a minor component in the children's diet. For the deficient children, the insufficient nutrient intake from the diet was an indication that dietary quantity rather than quality needs to be improved. Biofortification of the sorghum can make significant nutrient contributions to the nutrient deficient diet only if a significant amount of the sorghum is consumed, more than the amount that is presently being consumed in western Kenya, otherwise it will not be beneficial. Currently, biofortifying sorghum in the selected communities will not have any positive results in terms of improving the children's nutritional status.

### 3.1 Introduction

In Africa, sorghum is grown in many parts of the continent. The major sorghum growing areas are along the Atlantic coast, in Ethiopia, in Somalia bordering the Sahara in the north and the equatorial forest in the south, and in the drier parts of eastern and southern Africa (FAO, 1995). In sub-Saharan Africa sorghum is the second most important crop after maize (FAO, 1995).

Sorghum forms part of the diet of most food insecure people mainly in semi-arid and sub-tropical climatic conditions (Taylor, 2003). This is mainly because of sorghum's ability to survive undesirable climatic conditions by being both drought resistant and being able to survive waterlogging conditions experienced in food insecure areas. For this reason, sorghum consumption tends to be higher in areas where climatic conditions and the economic production of other cereals are not possible (FAO, 1995).

More than 55% of the sorghum produced in the world is used for human consumption (ICRISAT, 2008). Food products of importance made from sorghum in the African diet include weaning foods, porridges, gruels, couscous, baked products, beers, and non-alcoholic fermented beverages (Taylor, 2003; Anglani, 1998). Sorghum is an important source of energy, carbohydrate, protein and fibre in the diet of people in semi-arid areas (FAO, 1995). In addition to this, sorghum grains have been found to contain a wide range of compounds with known health effects, which include phenolic acids, condensed tannins and flavonoids (Dykes & Rooney, 2006).

This study was conducted in order to determine the contributions of sorghum to the energy, protein, Vitamin E, Vitamin A, iron and zinc intake in the diet of children aged between 2 and 5 years from some selected rural community in the western part of Kenya and also determine if the biofortification of sorghum with protein, Vitamin E, Vitamin A, iron and zinc will make any significant contribution to the children's nutrient intake. Kenya was chosen for this study because it is one of the developing countries where sorghum is considered as the staple cereal that forms part of the rural diet.

## 3.2 Materials and methods

### 3.2.1 Sample selection

The population consisted of mothers and caregivers of children aged between 2 and 5 years from seven rural districts in the Nyanza Province in western Kenya. The selection of these areas was based on the recommendation of Africa Harvest Biotech Foundation International in Kenya. These selected areas were Homa Bay, Kuria, Kisumu West, Kisumu East, Siaya, Busia and Kisii Central District. These areas were all situated close to the Lake Victoria.

Participants were recruited using purposive sampling. Due to time, accessibility and financial constraints, the sample size had to be limited to approximately 100 participants. Sampling was done with the help of District Agricultural Officers (DAOs) from the different districts included in the survey. These officers assisted in identifying, contacting and informing people in the areas. The first ten to fifteen volunteers who reported to the location where the interviews were conducted and met the inclusion criteria, were included in the sample. No incentives were given; however, a snack was given on completion of the interview.

### 3.2.2 Ethical Considerations

The Ethics Committee of the Faculty of Natural and Agricultural Sciences at the University of Pretoria approved the study. In Kenya, approval was obtained from the Ministry of Education. Participants were fully informed in their home language (Swahili, Luo or Kisii) about the study and given a consent form to sign before the interview commenced (Appendix B).

### 3.2.3 Data collection

Data were collected using focus groups interviews and Quantitative Food Frequency Questionnaire (QFFQ) during 13-25 August 2007 in the selected districts in the Nyanza province in western Kenya. Data collection involved the following:



### 3.2.4 Dietary assessment

➤ Quantitative Food Frequency Questionnaire (QFFQ)

Dietary intake data were collected using a QFFQ comprising of 63 different food items. The QFFQ was adapted from the questionnaire that was used to assess the nutrient intake of children aged 1-9 years in South Africa (Labadarios, Steyn, Maunder, Macintyre, Gericke, Swart, Huskisson, Danhause, Voster, Nesemvuni & Nel, 2000). The original questionnaire was used in the National Food Consumption Survey for Children (NFCS) conducted in 1999, in South Africa. A validated food portion photograph book (Venter, MacIntyre & Vorster, 2000) was also used to help participants to estimate portion sizes by showing photographs of commonly eaten foods, commonly used utensil and containers.

The questionnaire used to assess the dietary intakes of Adult Africans in the North West Province for the Transition, Health and Urbanisation in South Africa (THUSA) study (Macintyre, 1998), was also modified in order to develop the questionnaire that was used in the Kenya study. The THUSA instrument was developed for use in an adult population. In order for the instrument to be suitable for use in children, the questionnaire developed for the children in western Kenya was adapted from the NFCS's QFFQ in conjunction with the THUSA questionnaire.

Based on the NFCS and THUSA questionnaire, a QFFQ suitable for use in Kenya was created with a list of common Kenyan foods eaten by children. The questionnaire (Appendix A) was also developed in such a way that it can be used together with a food photograph manual to make the interview easier.

Since both the THUSA questionnaire and the NFCS questionnaires had been validated and tested for repeatability, the developed questionnaire to be used in Kenya was only tested on a similar population in South Africa. The questionnaire was administered to mothers and caregivers of children aged between 2 and 5 years from a sorghum consuming area in the Limpopo Province of South Africa, called Sekhukhuneland. This was done so as to make sure that the questionnaire

was able to gather the relevant information it had been designed for and also to determine if the respondents understand the questions.

After the Limpopo Province trial, the questionnaire had to be further modified so that it was suitable for use in the Kenya study. Foods in the questionnaire that were only used in South Africa were replaced with those foods found in Kenya. Only a few changes had to be made as most of the foods found in Kenya were similar to those found in South Africa. The foods included in the questionnaire were gathered through personal interviews with a person from Kenya and also through consulting literature.

The foods were grouped into different food groups (cereals, vegetables, fruits, eggs, dairy, legumes, meat, spread, sugar and tea). The foods were then listed under the food groups they belong to. The questionnaire comprised a total of 63 different food items. Some foods that were prepared in more than one way were listed more than once.

The questionnaire was structured in such a way that those foods which are commonly consumed appeared first and those which were less frequently consumed and made a small contribution to the diet were listed last on the questionnaire. The questionnaire was structured to have columns listing the following; foods name and description, amount of the food consumed, frequency of food intake (which included how many times a day/week/month) and computer food code. The questionnaire was also translated into Swahili.

- Dietary assessment

Two sociologists from Kenya were recruited as fieldworkers to assist in conducting the survey in the local language. Both assistants were experienced in conducting surveys in rural areas. Due to time limitations the two fieldworkers were given a briefing to familiarise them with the questionnaire and also how to conduct the interviews. The questionnaire was interview administered by the field workers to the respondents.

The fieldworkers responsible for the interviews communicated with the respondents in their local language (Swahili, Luo and Kisii). Participants were asked to estimate the child's intake of a specific food. The respondents had to respond by showing/estimating the portion size of the particular food that the child usually consumes. The respondents estimated the portion size by either using the food photographs or by using the displayed utensil that the child uses to eat a particular food and also estimating how much the utensil would have to be filled up. The respondents were then required to describe the number of times a day/week/month the food was consumed by the child. Each interview lasted about 30 to 45 minutes.



**Figure 3.1: Quantitative Food Frequency Interview session in progress. Interviewee gives a description of a particular food / dish / product using the food photograph in the presence of an interpreter while the interviewer fills in the questionnaire**

The questionnaires had to be checked at the end of each day's interviews to check that the questionnaire had been filled in correctly. Inaccurate entries were checked and discussed with the fieldworker responsible for the questionnaire. Where

incorrect entries were found, the researcher and the field worker discussed the entries and tried to rectify the problem. If the information given on the questionnaire did not make any sense, the questionnaire was nullified.

The period covered by the questionnaire was the previous six months, taking into account the seasonality of some of the foods. Foods consumed less than once a month were ignored as they were regarded as not making a significant contribution to the diet. Household measures such as cups, plates and spoons were used to reduce frustration when estimating the size, weight or volume of the food given to the child (Lee & Niemann, 2003). Food portion sizes such as small, medium or large serving size were also used to help respondents estimate the portion sizes. A food photograph book was also provided to assist respondent estimate portion sizes.

- Limitations

Due to restrictions in time and finances, the first draft QFFQ was pre-tested in South Africa, in a sorghum consuming area in the Limpopo Province. Mothers and caregivers of children aged between 2 and 5 years were used to administer and test the questionnaire. Because developing a questionnaire from scratch is a difficult task, modifying an existing questionnaire can be applied if the following are considered and met;

1. What was the original purpose of the questionnaire?
2. Who was the target population?
3. When was the questionnaire developed?
4. Has a previous validation been carried out, and was it acceptable (Cade *et al*, 2002)?

If these criteria are met, the approach can then be applied. It is, however, important to ensure that the sample that the original questionnaire was used for is representative of the population to which the modified questionnaire will be applied.

➤ Focus Groups (FG)

A structured interview guide in the form of Focus Groups (FG) was also administered. The interview guide comprised of an introduction, interview and closure. The interview section was arranged to probe and get responses from the respondents. The questions addressed in the focus group interview were centred around the general food and sorghum production, means and methods of sorghum storage and food consumption (mainly sorghum consumption). The core topics discussed under each of the focus areas are listed on Table 3.1.

**Table 3.1: Discussion questions guide for the focus groups interviews of mothers and caregivers of children aged between 2 and 5 years from selected rural communities in western Kenya**

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**General food and sorghum production**

- What crops do you plant on the fields?
- How much sorghum do you grow?
- On the mentioned portion of land, how much do you harvest?
- What sorghum varieties do you grow?

**Means and methods of storage**

- What process does the sorghum go through from harvesting to storage?
- How do you preserve your sorghum grain?
- How often is sorghum processed for consumption purposes?
- What processing method do you use for sorghum?

**Food consumption**

- Who is responsible for meal preparation in your family?
  - What are the preferred sorghum varieties?
  - What are the common sorghum preparation methods?
  - Do you know of any new/commercial sorghum products?
  - What common sorghum products do you normally serve children (2–5 years) and how are they served?
  - What status does sorghum hold in the area (culturally/traditionally)?
  - How is sorghum perceived in the area?
-

- Sample characteristics

The sample characteristics of the individuals involved in the focus group interviews are presented in Table 3.2. The participants were mothers or caregivers of children aged between 2 and 5 years in western Kenya. These participants are responsible for the daily food preparation and feeding of the whole family especially the children.

A total of three focus groups were conducted, in Ntimaru, Kadibo and Matayos divisions in the Nyanza Province in western Kenya. The participants were aged between 15 and 55 years. The groups were structured such that the younger women and the older women were interviewed separately. The focus group participants were selected using purposive sampling with the help of the local extension officer who knew the households in each of the areas.



**Table 3.2: Demographic characteristics of the sample of mothers and caregivers of children aged between 2 and 5 years from selected rural communities in western Kenya who took part in the focus group interviews**

Location	Group	Age range	Characteristics	Focus Group size	
				Target	Achieved
Ntimaru	1	30–55 years	Older women who were farmers and were involved in the running of the household.	12	12
Kadibo	2	15–32 years	Young mothers responsible for the day-to-day running of their households.	12	10
Matayos	3	28–47 years	Mostly middle aged women who were all members of a farmers association.	12	12

- The moderator guide

The moderators guide was developed to give the discussion a flow from general food production, food storage and processing and then finally sorghum consumption. The guide contained open-ended questions, which were intended to be simple and easy to understand. Both the field workers assisted in conducting the interviews since they knew the local language, one of them served as the moderator and the other served as the recorder and translator (translating from local language to English).

- Group composition and sample selection

The group's participants were mothers and caregivers of children aged between 2 and 5 years in Ntimaru, Kadibo and Matayos divisions in the Nyanza Province in western Kenya. They were selected based on their involvement in sorghum production in the households and mainly of their responsibility in feeding the children because they knew what foods the child ate. The ages of the mothers in the focus groups ranged between 15 and 55 years. The groups were structured in such a way that the younger women and the older women were interviewed separately. The focus group participants were purposively selected with the help of the local extension officer who knew the sorghum growing households in each of the areas.

- Geographic location of the group

The focus groups were conducted in three divisions, which are Matayos division, Kadibo division and Ntimaru division. Matayos division is found under the Busia district, which covers a total area of 1262 km<sup>2</sup>. The average landholding per household is 2.0 ha. The area experiences an equatorial type of climate with bimodal rains falling between 760 and 1800 mm annually. The district experiences temperature varying between 14 and 30°C and the altitude is between 1179 and 1488 m above sea level (Ministry of Planning and National Development, n.d(a)).

The second focus group was conducted in Kadibo division, which is under the Kisumu east district. The district experiences bimodal rains like most parts of the Nyanza province in the western part of Kenya. The rainfall experienced in this



division falls between 600 and 1630 mm annually. The division lies on an altitude ranging between 1100 and 1600 m above sea level. The district falls under two agro ecological zones the upper midland 1 (UM) and the lower midland 4 (LM) (Ministry of Planning and National Development, n.d(c)).

Ntimaru division is under the Kuria district with an altitude that ranges between 1400 and 1887 m above sea level. Kuria also experiences the tropical equatorial type of climate receiving bimodal rains averaging between 1500 and 2600 mm annually. Temperatures in the district fall between 27 and 31 °C. Kuria district falls under three agro ecological zones, upper midland 2 and 3 and lower midland 2 and 3 (Ministry of Planning and National Development, n.d(b)).

- Time of interviews and number of groups

The first focus group was held in the Ntimaru division on 14 August 2007, commencing at 11:50 hr and ending at 13:30 hr. This interview lasted for approximately 100 minutes. The second focus group interview was held at Kadibo division on 21 August 2007. It resumed at 11:40 hr and ended at 13:15hr and it lasted for 85 minutes. The last interview was held at Matayos division on 23 August 2007. The interview began at 12:00 hr and ended at 13:50 hr, lasting for 110 minutes respectively.

- Facility description and location

All the focus group sessions were held in the local areas, a central place which in most cases was one of the participants homestead. Due to the lack of proper interview facilities as these were done in rural areas, the interview facility was selected based on its proximity, ease of access and convenience for both the researcher and the participants. A comfortable sitting arrangement was set up outside in the yard in a secluded place where the interview would be carried out in private. Efforts were made to put off and block out any outside interferences that may jeopardize the success of the interview. Individuals not participating in the focus group discussions were requested to keep people away from interfering with the group while interviews were in progress.

For the Ntamaru division the focus group had been scheduled to take place inside one of the huts in the homestead, but due to the poor lighting and uncomfortable temperature inside the room, the focus group had to be conducted outside under a tree shade in the compound (Figure 3.2). The sitting arrangement was set up in a horseshoe arrangement, with the researcher and the moderator sitting with the participants. A coffee table was placed in the centre to place the tape recorder.



**Figure 3.2: Focus group interview in session in Ntamaru division**

For the Kadibo division focus group the facility selected was one of the participant's homesteads. The focus group was conducted in a secluded place on the compound (Figure 3.3). The sitting arrangement was a horseshoe arrangement, with the researcher and the moderator sitting with the participants. A stool was provided to use as a prop to place the tape recorder.



**Figure 3.3: Focus group interview in session in Kadibo division**

The focus group held in Matayos division was held at the local chief's homestead where most agricultural activities and demonstrations are conducted. The sitting arrangement was set up behind one of the houses, which provided good shade and seclusion from intruders. The participants were provided with plastic mats to use for sitting in respect for the chief. The moderator and the researcher however were given chairs to sit on. An extra chair was provided and used as a prop for the tape recorder.





**Figure 3.4: Focus group interview in Matayos division**

- Taping

The focus group sessions were each recorded using a video recorder and a tape recorder. Two 60 minutes audio recording tapes were used in order to have sufficient recording time to capture the interviews. A video recorder was also made available to complement the audio tape recording.

- Conducting the Focus group

As already mentioned, efforts were made for the interviews to be conducted in a quiet surrounding. Once all the participants were sitting down comfortably, they were given name tags to put on. The participants were asked to introduce themselves and also to give information about their families, size, number of children and the ages of the children. As the participants introduced themselves, they were recorded and then the recording was re-played to see if all the voices can be captured in the recorder and also to make sure that each voice can be identified throughout the recording. Participants were requested to speak loudly, slowly and to give each other a chance to make their contribution so as to give the

translator enough time to make notes and translate the information. The participants were sometimes requested to give their name before responding.

### 3.2.5 Data analysis

- QFFQ

After completion of each questionnaire, it was crosschecked in order to make sure that the information entered was valid. The average daily intake of each food item was calculated by using the portion size and the frequency of consumption given by the respondent. The South African Medical Research Council's Food Finder 3 computerized Dietary Analysis programme, containing South African composition tables (Medical Research Council, 2003), was used for the dietary analysis of all the entered food items except sorghum. The United States Agency for International Development (USAID, 2007) food composition table was used to analyse sorghum. Dietary data were analysed for the energy, protein, iron, zinc, Vitamin A and Vitamin E contents of the different food groups and sorghum. Descriptive statistics (means, standard deviations and medians) were calculated for all the nutrients, food groups and sorghum. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS Version 11.0) (SPSS for Windows, 2001). Data were summarized using ranges, means and standard deviations.

- Focus Groups

After each interview session, the researcher with the help of the moderator and translator had to sit down and listen on the recorded interviews to make sure that the recording was clear. If there was any missing information, the translator's notes were consulted and used to clarify the information. To transcribe the interviews, the sitting arrangement and names of all the interview participants was set out. Specific words related to sorghum production, storage and consumption were picked up under each topic in the moderators guide and were used as themes from which the discussion was based on. The transcripts were based on exactly what was heard in the recording; writing out each question and response from the interview. The transcribed information was then review and notes of the important information related to the study were made. This was done by picking

out common patterns in the information given and then finding out what was meant.

### 3.3 Results

#### 3.3.1 Food consumption

To determine the contribution made by sorghum to the total dietary intake, the children's total food intake had to first be established. From the total food intake, the cereal contribution was established from which the sorghums' share to the diet was derived. A total of 63 food items were found to be consumed by the children in the area in varying proportions. These food items were further listed and grouped into 10 food groups. The food groups found in the children's diet and their mean daily contribution to the total dietary intake are shown in Table 3.3. These food groups include cereals, vegetables, fruits, legumes, dairy, eggs, meat, spreads, sugars and tea.

As can be seen on Table 3.3, tea contributed the highest mean amount in terms of weight (408.6 g) and its proportion of the total dietary intake by weight was 24.1%. The cereals food group, where sorghum belongs was the second highest contributor with a mean amount of 357.7 g, and a proportion of 21.1% to the total diet. When the tea was excluded, the cereals food group's proportion was 27.9%.

Other food groups that made a high contribution to the total diet were fruits, which contributed 17.3% (292.8 g), vegetables 14.7% (248.2 g) and the dairy food group whose proportion to the total diet was 11.2% (188.2 g). Food groups that made a small contribution to the total dietary intake were meat contributing 3.9% (66 g), legumes 3.6% (60.7 g), sugar 2.8% (47.9 g), eggs 1.1% (18.2 g) and spreads 0.2% (3.8 g).

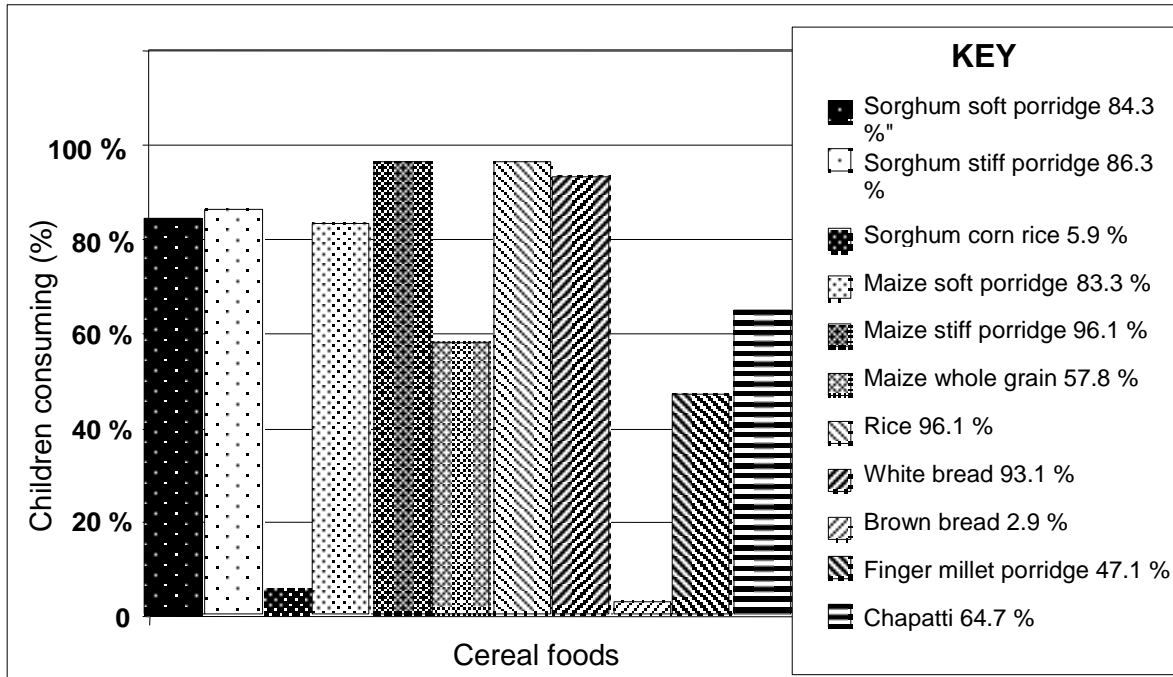
**Table 3.3: The mean amount in grams of the food groups consumed daily by the children aged 2-5 years old in some selected rural communities in western Kenya and their percentage contributions to the total dietary intake (g % /child/day)**

Food group name	Mean amount	Percentage	
	consumed from each food group daily (g) (standard deviation)	Percentage contribution to the total diet (g %)	contribution to the total diet when tea was excluded (g %)
<b>Cereals</b>	357.7 (48.7)	21.1	27.9
<b>Vegetables</b>	248.2 (44.6)	14.7	19.3
<b>Fruits</b>	292.8 (102.6)	17.3	22.8
<b>Legumes</b>	60.7 (39.0)	3.6	4.7
<b>Dairy</b>	188.2 (129.6)	11.1	14.7
<b>Eggs</b>	18.2 (13.7)	1.1	1.4
<b>Meat</b>	66 (7.0)	3.9	5.4
<b>Spread</b>	3.8 (4.3)	0.2	0.3
<b>Sugar</b>	47.9 (15.1)	2.8	3.7
<b>Tea</b>	408.6 (280.5)	24.1	Excluded
<b>TOTAL</b>	<b>1692.1</b>	<b>100</b>	<b>1283.5</b>

### 3.3.2 Cereal consumption

The children's diet contained a variety of cereals consumed in varying proportions. Figure 3.5 shows a summary of the different cereals consumed by the children and the percentage of the population consuming each cereal. According to Figure 3.5, stiff maize porridge and rice were consumed by a majority of the children (96.1%). Findings from the study show that of the three sorghum products found in the diet, two of them were consumed by more than 50% of the population. Sorghum soft porridge was consumed by 86.3% of the population and the sorghum stiff porridge was consumed by 84.3%. The sorghum corn rice on the

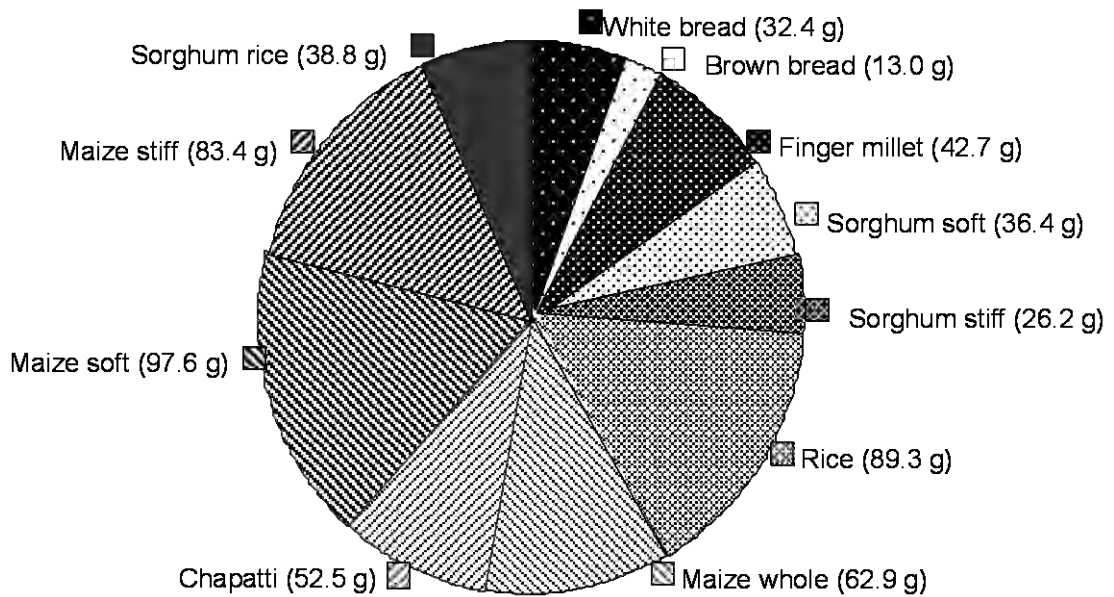
other hand was among the least consumed cereals and was taken by only 5.9% of the population.



**Figure 3.5: Percentage of children consuming the different cereal foods found in some selected rural communities in the western Kenyan diet.**

The amount of each of the sorghum products that was consumed was very small compared to maize, rice and wheat products (Figure 3.6). The mean amount of sorghum soft porridge consumed by the children daily was small only, 36.4 g and 26.2 g for the sorghum stiff porridge.





**Figure 3.6: The average contribution of each cereal food item to the cereal food group in the total diet of children aged 2–5 years in some selected rural communities in western Kenya**

### 3.3.3 Nutrient intake

The energy, protein, iron, zinc, Vitamin A and Vitamin E intake values from the children's diet are shown in Table 3.4 for children aged 2-3 years and in Table 3.5 for children aged 4-5 years. The children's individual intake values are also compared against the different age groups RDA values in order to determine if the daily intake of the nutrient meets the recommended intake for the specific age group.

To see if the population was not at risk of deficient nutrient intakes, the Estimated Average Requirement (EAR) values were used. The EAR is the nutrient intake value that is estimated to meet the nutrient requirement of 50% of the individuals in a given life-stage and gender group (NICUS, 2003). The EAR is used to assess the prevalence of inadequate nutrient intake of a population (Institute of Medicine,

2000). The method measures the percentage of the population with usual intake less than the EAR.

**Table 3.4: The total amount of nutrients consumed from the total diet of children aged 2-3 years old in selected rural communities in western Kenya and the mean contributions of the cereal food group, mainly sorghum to the nutrient intake (N=102)**

<b>Nutrient</b>	<b>Mean (standard deviation) intake from the total diet</b>	<b>Range of nutrient intake (minimum – maximum)</b>	<b>Mean nutrient intake from cereals (% contribution from cereals in the diet)</b>	<b>Mean nutrient intake from sorghum (% contribution from sorghum in the diet)</b>	<b>RDA value<sup>3</sup></b>	<b>Nutrient surplus <sup>1</sup></b>	<b>Percentage of sample whose nutrient intake was below RDA</b>
<b>Energy (kJ)</b>	6706 (2168.4)	2930-11065	3156 (45.1%)	140 (2%)	4393	2313	19%
<b>Protein (g)</b>	49.7 (19.5)	13.9-100.1	13.4 (26.4%)	0.9 (1.7%)	13	36.7	0
<b>Iron (mg)<sup>2</sup></b>	9 (3.7)	2.3-18.8	6 (59.7%)	0.3 (4.3%)	7	2	28.6%
<b>Zinc (mg)<sup>2</sup></b>	6.1 (2.4)	1.7-12	2.2 (35%)	0.1 (2.1%)	3	3.1	7%
<b>Vitamin A (mg)</b>	617.9 (1996.5)	69.8-526.6	0.2 (0.04%)	0	300	317.9	40.5%
<b>Vitamin E (mg)</b>	14.4 (9.1)	3-52	0.2 (0.8%)	0	6	8.4	19.1%

<sup>1</sup>Nutrient surplus = Actual Nutrient Intake - Recommended Dietary Allowance (RDA)

<sup>2</sup>Nutrient intake affected by bioavailability of the nutrient in the diet.

<sup>3</sup> Nutrient Information Centre of the University of Stellenbosch (NICUS), (2003).

**Table 3.5: The total amount of nutrients consumed from the total diet of children aged 4-5 years old in selected rural communities in western Kenya and the mean contributions of the cereal food group, mainly sorghum to the nutrient intake (N=102)**

<b>Nutrient</b>	<b>Mean (standard deviation) intake from the total diet</b>	<b>Range of nutrient intake (minimum – maximum)</b>	<b>Mean nutrient intake from cereals (percentage contribution from cereals in the diet)</b>	<b>Mean nutrient intake from sorghum (percentage contribution from sorghum in the diet)</b>	<b>RDA value<sup>3</sup></b>	<b>Nutrient surplus <sup>1</sup></b>	<b>Percentage of sample whose nutrient intake was below RDA</b>
<b>Energy (kJ)</b>	7200 (2224.1)	2446-11789	3156 (45.1%)	140 (2%)	7100	100	48.3%
<b>Protein (g)</b>	51.1 (17.9)	1.8–92.1	13.4 (26.4%)	0.9 (1.7%)	30	21.1	8.3%
<b>Iron (mg)<sup>2</sup></b>	10.7 (3.3)	2.9-77.6	6 (59.7%)	0.3 (4.3%)	10	0.7	6.7%
<b>Zinc (mg)<sup>2</sup></b>	6.2 (2.0)	2.7-11.3	2.2 (35%)	0.1 (2.1%)	5	1.1	30%
<b>Vitamin A (mg)</b>	522.9 (922.7)	147.6-1420.3	0.2 (0.04%)	0	500	22.9	50%
<b>Vitamin E (mg)</b>	18.2 (11.3)	3.3-59.6	0.2 (0.8%)	0	7	11.2	16.7%

<sup>1</sup>Nutrient surplus = Actual Nutrient Intake - Recommended Dietary Allowance (RDA)

<sup>2</sup>Nutrient intake affected by bioavailability of the nutrient in the diet

<sup>3</sup> Nutrient Information Centre of the University of Stellenbosch (NICUS), (2003).

- Energy - The mean daily energy intake for all the children in both age groups was 6997 kJ, ranging from a minimum of 2446 kJ to a maximum of 11789 kJ. For children aged 2-3 years the mean energy intake was 6706 kJ (Table 3.4) and for children aged 4-5 years the mean energy intake was 7200 kJ (Table 3.5). With a mean intake of 3156 kJ from the cereals food group, the cereals contributed 45.1% to the total energy intake. Sorghum, however, contributed an average of 140 kJ (2%) energy to the total dietary intake. Even though the range between the lowest to the highest energy intake was very wide, the mean energy intake for individuals in both age groups met the energy requirement. Nineteen percent of the population of children aged 2-3 years, however, had an energy intake below the RDA value of 4393 kJ. For the children aged 4-5 years, 48.3% had intakes below the RDA of 7100 kJ. A total of 36.3% of the children had an energy intake below their RDA.

- Protein - The mean protein intake for all the children was 50.6 g ranging from 1.8 g to 100.1 g. For children aged 2-3 years the mean protein intake was 49.7 g (Table 3.4) and for the 4-5 years age group, the mean protein intake was 51.1 g (Table 3.5). There was a wide distribution range from the highest to the lowest protein values for both age groups. The cereal food group contributed a proportion of 26.4% to the total diet with an average intake of 13.4 g. Of the cereals, maize contributed the highest amount of protein with an average contribution of 2.6 g (5.1%). Sorghum only contributed 0.9 g (1.7%) to the total protein intake.

The mean protein intake for all children in the 2-3 years age group was above their RDA of 13 g. All the children in the 2-3 years age group met their recommended protein intake. For children in the 4-5 years age group on the other hand 8.3% had intake below the RDA of 30 g. From a total sample of 102 children included in the study, only 4.9% did not meet their recommended protein intake. Only 1.7% of the children aged 4-5 years had a protein intake below the

EAR of 15 g and were thus at risk of being protein deficient. From the whole population, 1% of the children were at risk of protein deficiency.

- Iron - The mean iron intake from the children's diet was 10 mg. The range from the lowest to the highest iron intake values for the children was 2.3 mg and 77.6 mg respectively. The mean iron intake for the 2-3 years age group was 9 mg (Table 3.4), with the lowest intake of 2.3 mg and the highest intake of 18.8 mg. For the 4-5 years age group the mean iron intake was 10.7 mg (Table 3.5) with a minimum intake of 2.9 mg and a maximum intake of 77.6 mg. The percentage contribution of cereals to iron intake was 6 mg (59.7%). Sorghum contributed 0.3 mg (4.3%) to the total iron intake.

Surprisingly, the iron intake of 48% of the sample was below the RDA. For children aged 2-3 years, 28.6% were below the RDA. When the EAR was considered, 2.4% fell below their EAR of 3.0 mg. For children in the 3-4 years age group, 6.7% were below the RDA and when the ERA was used instead, only 3.3% of the population of 4-5 year olds fell below the EAR of 4.1 g.

- Zinc - The mean zinc intake from the children's diet was 6.1 mg with a minimum intake of 1.7 mg and a maximum of 12 mg. Children aged 2-3 years had a mean zinc intake of 6.1 mg (Table 3.4), a minimum intake of 1.7 mg and a maximum intake of 12 mg. For the 4-5 years age group, the mean zinc intake was 6.2 mg (Table 3.5), with a minimum intake of 2.7 mg and a maximum of 11.3 mg. The cereal food group's zinc contribution to the children's diet was 2.2 mg (35.0%). Sorghum contribution was only 0.1 mg (2.1%).

Some 7 % of the 2-3 years age group had a zinc intake below the RDA of 3.0 mg. For the 4-5 years age group 30% did not meet their zinc RDA intake of 5 mg. When calculated in terms of EAR, 18.3% of the children in the 4-5 years age group had a zinc intake below their EAR. The children were found to be at risk of

having an inadequate intake of zinc because of the high proportion of the population that could not meet the required intake.

- Vitamins A and E - The mean Vitamin A intake from the children's diet was 562 µg with the lowest intake of 69.8 µg and the highest 3526.6 µg. For children aged 2 to 3 years, the mean Vitamin A intake was 617.9 µg (Table 3.4), the lowest intake was 69.8 µg and the highest intake was 3526.6 µg. For children in the 4 to 5 years age group, the mean Vitamin A intake was 522.9 µg (Table 3.5) with the lowest intake of 147.6 µg and the highest intake of 1420.3 µg. Neither maize meal which was the major contributing cereal in the diet, nor sorghum contributed any Vitamin A to the whole diet. The cereal food group as a whole made a negligible contribution to the Vitamin A intake.

Although on average the children more than met their RDA for Vitamin A, 40.5% of the children in the 2-3 years age group did not meet the RDA, which is 300 µg. When the EAR was used, 14.3% were below the EAR intake of 210 µg. For the 4-5 years age group, 50% of the children did not meet their RDA of 400 µg, when the EAR was used, 25% did not meet their recommended EAR intake of 275 µg. A total of 21% of the children had Vitamin A intakes well below their EAR's and were thus at risk of being Vitamin A deficient.

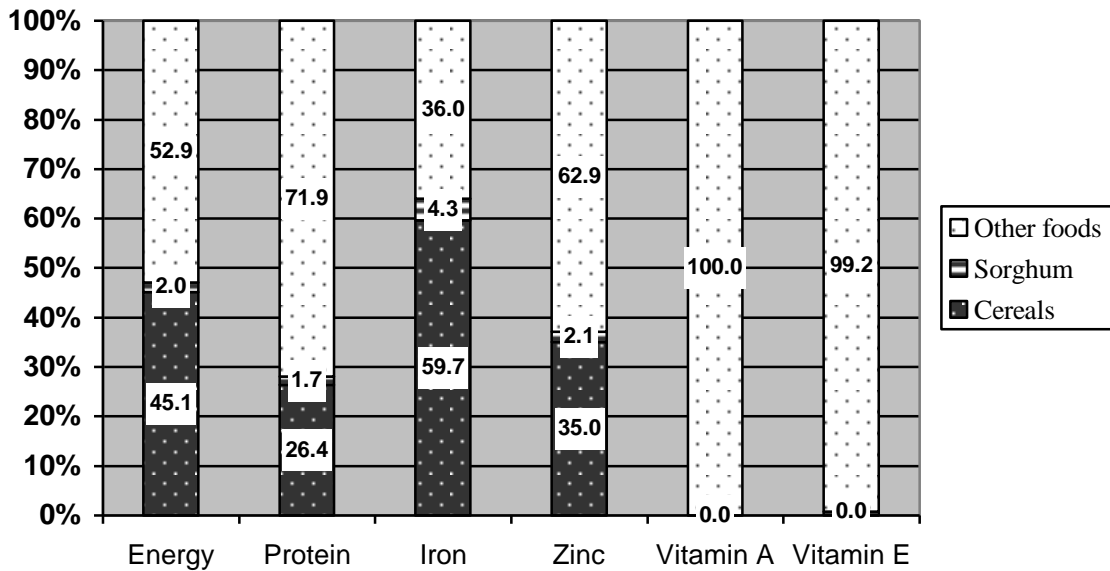
With regard to Vitamin E, the mean intake from the diet was 16.6 mg with the lowest intake at 3 mg and the highest intake at 59.6 mg. The mean Vitamin E intake for children aged 2-3 years was at 14.4 mg (Table 3.4), with the lowest intake at 3 mg and the highest intake at 52 mg. For the 4-5 years the mean intake was 18.2 mg (Table 3.5) and the minimum and maximum 3.3 mg and 59.6 mg respectively. The cereals food group only contributed 0.2 mg (1%) to the total diet. Maize as the major contributing cereal and sorghum, therefore, made essentially no contribution to Vitamin E intake.

As with Vitamin A, on average the children more than met their RDA for Vitamin E. However, a sizeable portion of the children had Vitamin E intake below their RDA. For children aged 2-3 years, 19.1% did not meet their RDA of 6 mg, and when the EAR was used, 9.5% did not meet the EAR of 5 mg. For children aged 4-5 years 16.7% had an intake below their RDA of 7 mg, and when the EAR was used, 15% did not meet the EAR of 6 mg. From the whole population, 12.7% of the sample had a Vitamin E intake well below their EAR's and were at risk of a Vitamin E deficiency.

The distribution ranges between the highest and the lowest value was wide for all the observed nutrients. As shown earlier, this was also observed for the sorghum intake. On average, sorghum did not make much of a contribution to the children's energy and nutrient intake as shown in Table 3.4, 3.5, 3.6 and 3.7. Figure 3.7 shows a summary of the contributions made by sorghum, cereals and other foods in the diet.

Figure 3.7 outlines the percentage contributions made by the cereal food group, sorghum and other food items to the daily nutrient intake in the diet of the children. As can be seen in Figure 3.7, the contributions made by sorghum to the energy, protein, iron and zinc intake are barely significant. For the Vitamin A and Vitamin E intake, sorghum did not contribute anything.





**Figure 3.7: The percentage contribution of the cereal food group, sorghum and other food items to the daily intake of energy, protein, iron, zinc, Vitamin A and Vitamin E of rural children from selected communities aged 2–5 years in western Kenya**

In addition to the energy, protein, iron, zinc, Vitamin A and Vitamin E intake that were assessed for the children in rural Kenya, the total fat, iodine, Vitamin C, Vitamin D, B Vitamins, folate and lysine intake were also assessed. The intakes for these nutrients are listed in Tables 3.6 and 3.7 below and are further discussed in the sections that follow.

**Table 3.6: The mean amount of nutrients consumed from the total diet of children aged 2-3 years old in selected rural communities in western Kenya**

<b>Nutrient</b>	<b>Mean (standard deviation) intake from the total diet</b>	<b>Range of nutrient intake (minimum – maximum)</b>	<b>RDA value</b>	<b>Nutrient surplus/deficit<sup>1</sup></b>
<b>Total fat (g)</b>	49.7 (23.1)	13.3–111.6 g	30.0–40.0 g (AMRD <sup>2</sup> )	19.7–9.7 g
<b>Iodine (µg)</b>	35.0 (14.7)	10.0–74.3 µg	90.0 µg	- 55 µg
<b>Vitamin C (mg)</b>	237.7 (333.0)	7.9–1687.9 mg	15.0 mg	222.7 mg
<b>Vitamin D (µg)</b>	1.6 (1.2)	0.3–5.0 µg	1.7 µg	- 0.1 µg
<b>Vitamin B6 (mg)</b>	1.6 (0.5)	0.3–2.5 mg	1.0 mg	0.6 mg
<b>Vitamin B12 (µg)</b>	6.0 (4.9)	0.6–30.2 µg	0.7 µg	5.3 µg
<b>Thiamin (mg)</b>	1.0 (0.4)	0.3–.9 mg	0.7 mg	0.3 mg
<b>Riboflavin (mg)</b>	1.2 (0.5)	0.2–2.3 mg	0.7 mg	0.5 mg
<b>Niacin (mg)</b>	12 (5.2)	2.5–22.5 mg	9.0 mg	3.0 mg
<b>Folate (µg)</b>	325.9 (160.6)	62.6–709.4 µg	150 µg	175.9 µg
<b>Lysine (g)</b>	3.4 (1.3)	0.7–.0 g	64 mg/kg body weight per day	

<sup>1</sup>Nutrient surplus/deficit = Actual Nutrient Intake - Recommended Dietary Allowance (RDA)

<sup>2</sup> Acceptable Macronutrient Distribution Ranges (AMDR)—a range of intake for a particular energy source that has a lower and upper boundary, associated with reduced risk of chronic disease while providing adequate intakes of essential nutrients (NICUS, 2003).

**Table 3.7: The mean amount of nutrients consumed from the total diet of children aged 4-5 years old in selected rural communities in western Kenya**

<b>Nutrient</b>	<b>Mean (standard deviation) intake from the total diet</b>	<b>Range of nutrient intake (minimum – maximum)</b>	<b>RDA value</b>	<b>Nutrient surplus/deficit<sup>1</sup></b>
<b>Total fat (g)</b>	56.4 (28.3)	15.9–146.1 g	23.0–25.0 g (AMRD)	33.4–31.4 g
<b>Iodine (µg)</b>	34.3 (15.1)	9.9–82.0 µg	90.0 µg	- 24.3 µg
<b>Vitamin C (mg)</b>	298.3 (485.0)	33.9–2476.8 mg	20.0 mg	278.3 mg
<b>Vitamin D (µg)</b>	1.6 (1.1)	0.1–5.7 µg	1.7 µg	- 0.1µg
<b>Vitamin B6 (mg)</b>	1.3 (0.5)	0.5–2.6 mg	1.0 mg	0.3 mg
<b>Vitamin B12 (µg)</b>	5.8 (4.4)	0.4–19.1 µg	1.0 µg	4.8 µg
<b>Thiamin (mg)</b>	1.1 (0.4)	0.4–2.3 mg	0.9 mg	0.2 mg
<b>Riboflavin (mg)</b>	1.1 (0.4)	0.4 – 2.0 mg	0.9 mg	0.2 mg
<b>Niacin (mg)</b>	13.6 (5.7)	4.3–30.8 mg	12.0 mg	1.6 mg
<b>Folate (µg)</b>	353.3 (129.1)	136.4–746.8 µg	200 µg	153.3 µg
<b>Lysine (g)</b>	3.4 g (1.3)	1.3–7.3 g	64 mg/kg body weight per day	

<sup>1</sup>Nutrient surplus/deficit = Actual Nutrient Intake - Recommended Dietary Allowance (RDA)

<sup>2</sup> Acceptable Macronutrient Distribution Ranges (AMDR)–a range of intake for a particular energy source that has a lower and upper boundary, associated with reduced risk of chronic disease while providing adequate intakes of essential nutrients (NICUS, 2003).

- Total fat - The mean total fat intake for the children was rather higher at 53.6 g than the recommended Acceptable Macronutrient Distribution Range

(AMRD) (NICUS, 2003) of 30-40 g for the 2-3 years age group (Table 3.6) and 23-35 g for the 4-5 years age group (Table 3.7). The AMRD is the range of acceptable intake of particular energy sources associated with reduced risks of chronic diseases. The total fat intake for the 2-3 years age group was 49.7 g and 56.4 g for the 4-5 years age group. A total of 12.7% of the population had a total fat intake that was below the AMRD. The children aged 2-3 years had the highest percentage with an intake below the AMRD, (19%) and 8.3% of the children aged 4-5 years, 8.3% had inadequate fat intake from the diet.

- Iodine - The children had a mean iodine intake of 34.4 µg. The intake of iodine for all the children ranged between 9.9 µg to 82 µg. The mean intake of iodine for the 4–5 years age group was 34.3 µg (Table 3.7) with the lowest iodine intake of 9.9 µg and the highest intake of 82 µg. The children in the 2-3 years age group had a mean intake of 35 µg (Table 3.6) ranging between 10 µg and 74.3 µg. The iodine intake for the whole population did not meet the RDA of 90 µg for both age groups. With 98% of the children in the study having iodine intake below their EAR's, there was a risk of iodine deficiency in the population.

- Vitamins C and D - The children consumed an average of 276 mg of Vitamin C. The intake range was also very wide, ranging between 7.9 mg and 2510.7 mg. The mean Vitamin C intake for the 2-3 years age group was 237.7 mg with a minimum intake of 7.9 mg and a maximum of 1687.9 mg (Table 3.6). The mean intake for this age group was more than fifteen fold higher than the recommended intake of 15 mg. The same was also observed with the 4-5 years age group, the mean amount of Vitamin C consumed by this age group was 298.3 mg with a minimum intake of 33.8 mg and a maximum of 2476.8 mg (Table 3.7). The intake was almost 20 fold higher than the recommended intake of 20 mg.

The children's mean Vitamin D intake (1.7 µg) was very low when compared to the recommended intake of 10 µg for both age groups. The 2-3 years age group

had a mean intake of 1.6  $\mu\text{g}$  ranging between 0.3  $\mu\text{g}$  and 5  $\mu\text{g}$  (Table 3.6). Also for the 4-5 years age group the mean intake was low at 1.6  $\mu\text{g}$  ranging between 0.1  $\mu\text{g}$  and 5.7  $\mu\text{g}$  (Table 3.7).

- The B Vitamins (niacin, thiamin, riboflavin, B6 and B12) - The mean intake for Vitamin B6 for all the children was 1.3 mg with the lowest intake value of 0.3 mg and the highest intake of 2.6 mg. For the 2-3 year age group, the mean intake was 1.6 mg with intake ranging from a low 0.3 mg and to the highest intake of 2.5 mg (Table 3.6). For the 4-5 years age group, the mean Vitamin B6 intake was 1.3 mg. The range from the lowest to the highest intake was 0.5 mg to 2.6 mg (Table 3.7). The average intake for both age groups met their RDA. The RDA for the 2-3 years age group was 1.0 mg and for the 4-5 years age group, 1.1 mg. Only 2% of the children aged 2-3 years and 3% for those aged 4-5 years did not meet their recommended Vitamin B 6 intake from the diet.

The mean Vitamin B12 intake for all the children was 5.8  $\mu\text{g}$ . The lowest intake was 0.4  $\mu\text{g}$  and the highest 30.2  $\mu\text{g}$ . Children aged 2-3 years consumed an average of 6  $\mu\text{g}$  (Table 3.6) while the 4–5 years age group consumed 5.8  $\mu\text{g}$  (Table 3.7). The range between the highest and the lowest intake of Vitamin B12 for the 2-3 years age group was very wide when compared to the 4-5 years age group. Vitamin B12 intake for children age 2-3 years ranged between a low 0.6  $\mu\text{g}$  to a 30.2  $\mu\text{g}$  maximum. For children aged 4-5 years, Vitamin B12 intake ranged from a minimum of 0.4  $\mu\text{g}$  to a maximum intake value of 19.1  $\mu\text{g}$ . Both age groups mean Vitamin B12 intake met their RDA's of 0.7  $\mu\text{g}$  for the 2-3 years age group and 1.0  $\mu\text{g}$  for the 3-4 years age group. 40% of the children aged 4-5 years, however, had an intake below their RDA. 28.6% of the children in the 2-3 years age group were below their RDA. When the EAR measure was used, 50% of the children aged 4-5 years and 10% of those aged 2-3 years were below their EAR's. A total of 33.3% of all the sampled children were at risk of being Vitamin B12 deficient.

The children consumed an average of 1.1 mg of thiamin from the diet and the lowest thiamin intake was 0.3 mg while the highest was 2.3 mg. The children aged 2-3 years consumed an average of 1 mg thiamin in the diet (Table 3.6). The lowest thiamin intake was 0.3 mg while the highest was 1.9 mg in the 2-3 years age group. Children in the 4-5 years age group consumed an average of 1.1 mg thiamin in the diet (Table 3.7). The lowest intake value from this age group was 0.4 mg while the highest was 2.3 mg. Both age groups had an average thiamin intake within their RDA's of 0.7 mg for 2-3 years and 0.9 mg for 4-5 years.

The children consumed an average of 1.1 mg of riboflavin in the diet. The lowest intake of riboflavin from the children's diet was 0.2 mg and the highest intake value was 2.3 mg. Children aged 2-3 years consumed an average of 1.2 mg riboflavin from their diet while the lowest amount from the 2-3 years diet was 0.2 mg and the highest was 2.3 mg (Table 3.6). The 4-5 years age group had an average intake of 1.1 mg (Table 3.7). The lowest value for the 4-5 years age group was 0.4 mg while the highest amount was 2 mg.

The mean amount of niacin that the children consumed was 13 mg with the lowest and highest niacin intake value of 2.5 mg and 30.8 mg respectively. Children aged 2-3 years consumed an average of 12 mg (Table 3.6) while those aged 4-5 years consumed an average of 13.6 mg (Table 3.7). Niacin intake for the 2-3 years age group ranged between 2.5 mg and 22.5 mg. For the 4-5 years age group, intake ranged between 4.3 mg and 30.8 mg. Both the means for the 2-3 years age group and the 4-5 years met the RDA intake of 9 mg (2-3 years) and 12 mg (4-5 years).

- Folate - The children consumed a very high amount of folate from their diet. The mean intake for all children was 341.7 µg with a minimum intake of 62.6 µg and a maximum intake of 746.8 µg. All the met their RDA for folate (50 µg for the 2-3 year olds and 75 µg for the 4-5 year olds). The 2-3 years age group consumed an average of 325.9 µg of folate from their diet (Table 3.6) while the 4-

5 years age group consumed an average of 353.2 µg (Table 3.7). The lowest amount of folate consumed by the children aged 2-3 years was 62.6 µg while the highest amount was 709.4 µg. The 4-5 years age group consumed a minimum amount of 136.4 µg of folate and the highest amount was 746.8 µg.

- Lysine - The mean amount of lysine consumed by the children was 3.4 g with a minimum of 0.8 g and a maximum of 7.3 g. The lysine intake for both age groups was the same at 3.4 g for both age groups. The lowest amount of lysine in the children's diet was 0.7 g for children aged 2-3 years (Table 3.6) and 1.3 g for children aged 4-5 years (Table 3.7). The highest amount of lysine consumed was 7 g and 7.3 g for the 4-5 year old children. According to the World Health Organization (1985), the estimated requirements of the amino acid lysine for children 2–5 years (pre-school children), is 64 mg/kg per day. This means that for a child weighing 15 kg the estimated required amount of lysine would be (64 mg x 15 kg = 960 mg (0.96 g) per day).

### 3.3.4 Focus Groups

#### ➤ General food and sorghum production

- What crops do you plant on the fields?

When asked about what crops were grown and how much land these crops cover, the most common response given was that “it depends on the size of the land we have available”. The participants, however, mentioned that the crops grown on the field are almost the same every year. The participants identified maize, cassava and sorghum as staple crops grown almost every year. The maize, cassava and sorghum, were planted in varying proportions on the fields. The participants also mentioned that these staple crops were often intercropped with each other or with other minor crops. According to the participants, when the staple crops were ranked in order of importance from the most important to the

least important, cassava was ranked number one, sorghum second and maize was the third important staple crop.

Beans, potatoes, sweet potatoes and local vegetables were referred to by the participants as minor crops but were still considered as important crops. The minor crops were grown on smaller portions of land when compared to the staple crops. When land was very limited, the minor crops were also planted on the yard, very close to the houses on the compound.

- How much sorghum do you grow?

The participants were asked how much of the available land sorghum occupies. Before responding to this question, some respondents indicated that the area was suitable for growing sorghum mainly because of the high rainfalls and flooding that the area receives which sorghum can survive. When asked to elaborate why sorghum was considered a suitable crop for the area, some participants said that sorghum was more useful as other crops such as maize and beans were sometimes unable to survive the drought, high rainfall and flooding that the areas sometimes experience.

The respondents mentioned that sorghum was best planted during the long rain season. Some said that even though other crops would sometimes fail due to flooding, the participants still insisted on planting the other crops together with the sorghum (intercropping). In the Matayos division, respondents mentioned that even though sorghum was an important crop, in order for them to plant it, “the mother in law has to be the first to plant it in the family before anyone else can plant sorghum in that cropping season. If she does not do it, no one else in the family will do it”.

Going back to the question on how much of the land sorghum takes up; many respondents mentioned that sorghum in most cases was given more land than the minor crops. Even though the participants regarded sorghum as an important



crop, there were only a few fields that were observed with sorghum. The sorghum observed on the fields occupied relatively smaller portions of the land compared to maize. The participants, however, said that even though more sorghum was planted compared to the minor crops, more land was used for planting maize. The area that sorghum occupied was far less than that occupied by the maize.

The participants said that in the field, sorghum was cultivated together with other crops such as maize, finger millet, beans, cassava, groundnuts sweet potatoes, potatoes and some local green leafy vegetables. Selection of which crops were planted together with the sorghum differed from field to field as well as the size of land the crop takes up. According to the participants, on average, sorghum occupied one to two acres (0.4 to 0.8 ha). The participants in the focus group with older women, however, indicated that they cultivated more sorghum (in terms of the size of the land used) than the younger women.

- On the mentioned area of land, how much do you harvest?

Most of the participants said that sorghum was planted once a year, during the long rain season. At harvesting, however, the amount of sorghum harvested varied depending on factors such as the use of fertilizer on the field, the crop being eaten by birds or the sorghum variety used. One participant said, “In one acre (0.4 ha) of sorghum without using fertilizer, I normally get up to two bags (90 kg/bag) of sorghum Nakhlori (a local variety)”. On the same note of fertilizer application, another participant had almost the same outcome saying that “on one acre (0.4 ha) when I plant without fertilizer I get fifty gorogoros which is almost equivalent to one bag (90 kg/bag), when I apply fertilizer I get two to two and a half bags of Nakhadhabo (a local variety)”. Some participants said the crop yield varied from year to year due to the above mentioned factors. The participants then discussed the factors that have an impact on the yield and mentioned weather, birds, poor land practices and a few mentioned lack of interest in sorghum.

A number of the participants blamed birds for the low yield they receive. According to the participants, this was more common with the “sweet” sorghum varieties. Birds liked these varieties. These “sweet” sorghum varieties, according to the respondents are the relief seed supplied by the Ministry of Agriculture to the farmers. One participant further elaborated on the relief seed issue by saying “Usually when we get these seeds from the extension officers the officers can give farmers the seeds very early and the seeds get eaten by birds and sometimes we receive the seeds very late and they are still eaten by birds, so we prefer to get seeds ourselves during mid season and plant when we know the time is right”.

- What sorghum varieties do you grow?

When asked about the most popular varieties, in Busia district (Kadibo division), these were the popular varieties: Ochuti-a local black variety (a purple traditional type III tannin variety, which is a goose neck type), Seredo-brown in colour (is a light brown, type III tannin sorghum improved variety) and Andiwo-a dark brown variety (this is brown, type III traditional variety). The variety was selected based on how fast it grows. Respondents mentioned that there were varieties that grow fast such as Seredo, followed by Andiwo but Ochuti was the slowest. The participants mentioned that when these varieties are planted at the same time, Seredo and Andiwo grow very quickly and when birds come they only find Ochuti on the fields, which is a bitter variety that the birds do not like and will not feed on it. Other participants however mentioned that sometimes their timing was wrong and the birds feed on Seredo on the fields before it is ready for harvesting. A number of the participants viewed this occurrence as “damage” and others said it was a “crisis”.

Three varieties were mentioned by the participants as those grown in the Matayos division. These varieties were Nakhadhabo- a local red type III tannin variety that grows to a certain height and then droops, a local white variety called

Nakhalori and a big headed whitish variety almost similar to Nakhadhabo called Nastali sia gugu. When asked why the participants chose to grow these varieties, the reason given was that the birds do not like Nakhadhabo. Nakhadhabo was able to grow to its full potential without having to worry about it being attacked by birds. Because of its early maturing traits, the participants favoured Nakhalori. A few participants said that they had recently discovered that Nastali sia gugu does very well on poor soils, even when the soils were infertile, hence they also preferred it.



**Figure 3.8: Some sorghum varieties found in western Kenya** (Picture courtesy of Prof. J.R.N. Taylor)

In the Homa bay district Serena, Seredo and Ochuti were the popular varieties. The likelihood of birds feeding on the grains on the field was still a determining factor in choosing a variety in this area. Respondents mentioned that they made their choice of variety based on the possibility of birds feeding on the grain while

it is still on the fields. The respondents said that they tried to avoid growing “sweet” sorghum varieties that are liked by birds because they tend to receive smaller yield. A few respondents however mentioned that they still grew the “sweet” sorghum varieties most liked by birds as they were tastier but their disadvantage was that these varieties were less filling than the other varieties.

➤ Means and methods of storage

- What processing method does the sorghum go through from harvesting to storage?

The method of processing sorghum was the same for all the participants in all three focus groups. The harvesting was also done at almost the same time in all the three focus groups with a difference of about three to four weeks between some individuals. The sorghum head is cut off from the rest of the plant, and then depending on the weather conditions it is laid out in the sun to dry, threshed, winnowed and then its is stored in sacks or drums. It was, however, observed in some households that were visited that instead of removing the seed and storing it in sacks or drums as the participants mentioned, the sorghum heads were stored with the grain still attached to the panicle (Figure 3.9).





**Figure 3.9: Sorghum heads with grain still attached to the panicle stored inside a traditional storage**

Some participants mentioned that the storage of the grain differed. Some participants stored their grains in sacks, while some used empty drums for storage of the grain. When asked to describe the drums, they said that they were the big empty oil tin containers that they clean and use for storing the grain. Only a few mentioned using drums for storing the grain, most of the participants said that it was not easy to get the drum, hence most participants used sacks to store the grain. In addition, participants said that the advantage of using the sacks was that sewing them up on the top can seal them and if there were a number of sacks to store, they could be stacked up in a room against the wall.

- How do you preserve your sorghum grain?

Respondents were asked how they preserve the sorghum grains. The participants said that they used different traditional preservation methods. Only a few respondents said they used chemicals from the Agro vet shops (stockists of agricultural and veterinary supplies) with most of them saying that they could not

afford the chemicals. Others described the traditional method of using cow dung that had been dried, and then burnt into ash. The ash from the burnt cow dung was then used as the preservative by sprinkling it over the grain. A majority of the respondents said they used wood ash to preserve the grain. They said that they collect the wood ash from the cooking area, sieve it and then sprinkle it over the grain. There was no specific type of wood used for this ash. The participants said that they would use whatever wood ash was found in the cooking area. One respondent said that these methods were those used to preserve the grain to be used for food. There was one other method used for preserving the grains kept aside for planting. The grains to be used in the next cropping season are preserved by adding paraffin, which acts as an insect repellent, preventing the seed from being eaten by insects. This method of preserving the seeds was popular mainly in the Kadibo district.



**Figure 3.10: Sorghum heads with grain still attached to the panicle stored inside a traditional storage, which has been smeared with cow dung on the inside in order to preserve the grain from infestation.**

- How often is sorghum processed for consumption purposes?

The amount of sorghum processed was found to be dependent on the end uses of the sorghum, the size of the family and the composition of the family. The sorghum flour was processed and used or mixed with other cereals or vegetables in order to make ugali or uji. The combinations and proportions of cereals and vegetables were based on individual preference. It was also based what other items were available to make the flour. The participants also mentioned that when the flour combination was composed of several ingredients, the amount of sorghum used was just enough to alter the appearance and sometimes taste of the product being prepared. Other respondents said that on most occasions, only a small amount of sorghum was required if the sorghum variety to be used was “strong-usually the red type”. If the variety used were the white “sweet” variety, a larger amount would have to be used to make the flour.

Most respondents with large families said that they processed more sorghum than the smaller sized families. The frequency of processing with the larger families was also higher than the smaller sized families. The participants, however, stated that the amount processed and frequency of processing the sorghum was dependent on the sorghum variety to be used. Some respondents claimed that the red variety lasted longer because only a little bit of it was required to make a “satisfying meal”.

Participants with more male members in their families said that they tend to process more than those families composed mainly of females or those with fewer males. The participants said that this was mainly because men eat more than females. Some participants said this was because men require real food. Most respondents preferred to use the red sorghum variety as one respondent said that, “if you eat sorghum in the morning you get the strength to go out and do heavy duties and this can last you almost half the day”. In support of this statement another participant mentioned that men like the red sorghum more



than women because it can sustain them the whole day giving them a lot of energy.

- What processing method do you use for sorghum?

Although most respondents were still very much aware of the old methods of processing which are the grinding stone and the pestle and mortar, the electrical hammer mill popularly known as the “Posho mill” (Figure 3.11) was the method of choice for all the respondents. Some of the respondents, however, mentioned that in cases where only a small amount of the flour was required, the grinding stone was the best milling method to use. Most of the participants, however, stated that using the “Posho mill” was more convenient than using the grinding stone which is time consuming and requires a lot of energy.



**Figure 3.11: The electrical hammer mill popularly known as the “Posho mill” which is used for milling sorghum grain into flour (Picture courtesy of Prof. J.R.N. Taylor)**



➤ Food consumption

- Who is responsible for meal preparation in your family?

Often the first response without any hesitation given when they were asked who decides what should be prepared and how much was “the mother decides” or “I do”. These responses were frequent and concise without any hesitation. They said that it was the duty of women in the family to make sure that there is food for the whole family. However, some participants mentioned that there were situations where they have to go to their husbands and ask for money to buy food.

When asked at which meals sorghum was used, they indicated that it was used three times depending on availability. Sorghum was eaten at breakfast, mid-day and at suppertime. Some respondents said that in most cases the presence of sorghum even in small quantities completes the meal. The younger women mentioned that at times sorghum is only served twice at breakfast and at suppertime. During the day when most of the family members were away, they would serve the children Irish potatoes, maize or sweet potatoes with some tea. The older women on the other hand would not hear of having a meal without any sorghum.



**Figure 3.12: Women preparing sorghum uji inside a hut**

- What are the preferred sorghum varieties?

The participants mentioned taste, consistency, familiarity with variety, appearance and how the food will be prepared as some determining factors for choosing a variety to use. Taste and consistency after cooking appeared to be the most important factors as the participants mentioned them over and over again. The participants said that they made their decisions about the preferred variety based on how it tastes and the consistency of the product after cooking. For example, one participant from the Matayos division said that “Nakhadhabo (red variety) is the best variety because you do not use too much of it when making either uji or ugali, you can use a very small amount to satisfy the whole family”. Another respondent from Busia district said, “One can use a small amount of flour from Ochuti (red variety) to make a lot of uji or ugali. This is because it is a strong variety that quickly thickens during cooking. For those that preferred the “sweet sorghum variety”, they said that they preferred it mainly

because it tasted better. The participants who preferred the sweeter varieties said that the red variety was too strong and tasted bitter.



**Figure 3.13: Sorghum ugali (centre of the table behind the teapot), sorghum ugi (far right inside the tilted bowl) and sorghum tea (inside the mug) made from the red sorghum variety all ready for serving**

- What are the common sorghum preparation methods?

When the participants were asked what the common sorghum dishes were. They said they always mix sorghum with other cereals or vegetables. Some said although at times sorghum on its own would be eaten as porridge together with a relish, this presentation of sorghum was not a popular one. They said it was difficult to eat sorghum on its own because of the strong taste. It was much easier if they mixed it together with other cereals, which give a better milder taste.

Uji and ugali were mentioned as the most common foods made using sorghum. As the respondents had mentioned before, they only use a small portion of the sorghum flour together with other cereals to make the uji and ugali. This, however, appeared to contradict the information the participants had given before about sorghum being considered as one of the staple crops. The participants said that the most common ingredients used to make the flour mixture together with sorghum to make either uji or ugali were cassava, beans, maize, finger millet, groundnuts, fish, Soya beans and rice. Some participants said that the combination of these food items was not the same for either uji or ugali. The flour prepared for making ugali had a different combination than the one used to make uji. The participants said that usually to make uji, they used mainly flour made from cereals alone. To make ugali, the flour was made from a combination of cereals, legumes, cassava and dried fish.

The participants also talked about a number of other common sorghum dishes. These were “nyoyo” which is a combination of sorghum grain, maize grain and beans. Another common sorghum dish was “sokotas” which is originally made from a mixture of maize and beans. However, when either beans or maize are not available, they could be substituted by using sorghum. Other participants also mentioned that sorghum flour mixed together with wheat flour is used to make chapattis and sometimes cakes. Some participants mentioned that they also prepared sorghum beer and also some sorghum tea made from roasted sorghum grains instead of using tea leaves.

- Do you know of any new/commercial sorghum products?

When this question was asked most of the participants had nothing to say. Some mentioned that it was not a common occurrence for them to go in a shop searching for new products in the market. They said that when one goes into a shop, they go to buy specific items. Some participants mentioned that most of the shops they go to stock specific items that are commonly used by the people in



the area. From this discussion the participants were clearly not aware of any new sorghum products in the market and they did not have much to say about it.



**Figure 3.14: A commercial food product for children made from a combination of maize, sorghum, green grams, soya beans, millet and ground nuts**

What are the common sorghum products served to children (2 to 5 years) and how are they served?

Most participants answered that the children ate whatever was offered to them. They mentioned that the children basically had no choice. The participants said that the main food given to children were uji and ugali. Some participants mentioned that some of the younger children were very picky eaters making it difficult to get them to eat at times. They said that this was one of the reasons why the children were mainly fed uji and ugali as they were common foods to them.

The participants mentioned that the accompaniment served with the ugali was dependent on whatever food was available. Most of them mentioned freshwater fish (omona, tilapia, ngege and Nile perch) and local green leafy vegetables. A few participants mentioned preparing beans especially for children. The participants said that usually when they served beans to the children, the beans were in the form of “nyoyo” or “sokotas”.

- What status does sorghum hold in the area (culturally or traditionally)?

All the participants mentioned that they perceive sorghum as a traditional crop. Most of them mentioned that even though the area that sorghum takes up is not large enough to qualify sorghum as a staple crop, it was still part of their tradition to have a small portion of their land dedicated to sorghum. Other participants did not agree completely, saying that they would like to have more maize than sorghum because with maize you get more from the crop compared to sorghum. Maize can be picked while still not ripe to steam or roast and eat from the cob, and when it dries the grain can then be used to make flour. Those participants that preferred maize said that they used sorghum because at times they did not have enough maize so they use the sorghum to supplement for the maize. The participants appeared to contradict the information they had given earlier about sorghum being a staple crop.

The older participants stressed that to them sorghum was more important than most crops. They mentioned that there are traditional activities that require sorghum preparation such as during weddings and when the husband goes to meet his in-laws. Some participants indicated that sorghum was used for medicinal purposes such as to stop diarrhoea especially in children.

- How is sorghum perceived?

Most of the participants said that they depended on sorghum a lot, especially when food was scarce. Sorghum can be used as a substitute for other foods

when they are not available. Sorghum can be used as a substitute when there is no tea, when there is no bread, as a nourishing beverage, as rice, to make cakes, in fact anything one can think of. A few participants mentioned that men often prefer sorghum to other cereals, as they believe it gives them a lot of energy. Most participants said that when they have had a meal that has sorghum in it, they believe that they have eaten correctly. Some participants, however, were concerned with the rate at which sorghum use was declining. They said that other cereals have replaced sorghum use and to them they saw no future for sorghum.

In summary, sorghum in western Kenya is minimally processed to a rough coarse consistency. The grain is not debranned. Sorghum, is, however, not consumed alone. It is mixed together with other cereals, legumes, nuts, roots, and fish and is milled to the desired consistency to be used for making uji or ugali porridges. The use of a variety of food groups to make the ugali and uji flour, ensures a diverse diet of high nutritional quality for the children.

### 3.4 Discussion

- Cereals consumption

The children in western Kenya consumed a diet consisting of a variety of foods. This was completely different from the diet in other parts of the country, such as in the eastern part where the diet is monotonous. In the eastern part of the country, near the coast, the diet was found to be monotonous consisting mostly of cereals (Klaver & Mwadime, 1998). The composition of the children's diet in western Kenya is in accordance with suggestions set by the South African Food Based Dietary Guidelines (FBDG), which advocate for a varied diet (Maunder, Matji & Hlatshwayo-Molea, 2001). The recommendations set in the FBDG suggest that in order to achieve optimal nutrition, it is important to consume a diet that contains food items from the five main food groups, which are fruits, vegetables, grains/cereals, meat/legumes and oils.

The main cereals, which contributed the highest amount in terms of quantity to the children's diet, were maize, rice and white bread. Other cereals that were consumed by the children and did not make much of a contribution in terms of quantity and energy contribution were sorghum, finger millet, brown bread and chapatti. Even though the cereals food group was the major component of the children's diet as suggested by the FBDG, all the cereals were served in relatively small amounts individually. The western Kenya diet only provided 45.1% of energy from the cereal food group compared to the 55% as suggested by the FBDG. The guidelines suggest that the starchy foods should form the main part of the meal and the rest of the meal can then be planned around the starchy component (Vorster & Nell, 2002).

The percentage of the children consuming the major cereals was much higher than those children that were consuming the minor cereals, apart from sorghum. Because of the small amount of sorghum in the diet, its contribution to the nutrient intake was hardly recognisable. The main sorghum use in the western Kenya diet was to add it together with other food items to form part of the ingredient for making the flour for uji and ugali. Sorghum was added in small amounts and mixed with other food ingredients in order to lessen the unacceptable sensory characteristics in the sorghum. In a study to determine consumer acceptable proportions of sorghum and maize or sorghum, maize and cassava that can be used in composite flours, it was found that the incorporation of sorghum flour at less than 10% and over 30% of the total amount of flour was less acceptable (Bangu, Mtebe & Nzallawahe, 1994). Consumers preferred products made using between 10% and 30% sorghum flour and not more or less. This shows that the use of smaller amounts of sorghum gives more acceptable product than using larger amounts of the sorghum especially in the preparation of composite flour.



Sorghum on its own or as a staple food was rarely used, more especially in the children's diet. This was mainly due to the bitterness and astringency of some sorghum varieties that some consumers find unfavourable. In a study to determine differences in the sensory attributes of sorghums containing different levels of total phenolic compounds, it was found that even though not all sorghum varieties containing condensed-tannins have unpleasant sensory characteristic, but all sorghum, non-tannin as well as tannin types, were perceived as bitter and astringent (Kobue-Lekalake, Taylor & De Kock, 2007). Sensory attributes are an important measure and are often used by consumers to determine if a product is acceptable or not.

The decrease in the use of sorghum in western Kenya has been seen as an indication of the effects of the nutrition transition. This was seen by the decreased intake of cereals deemed to be of lower quality such as sorghum and millet to the increased use of those regarded to be of higher quality such as maize, wheat and rice (Popkin, 1998).

A similar situation with regard to sorghum consumption was also found in South Africa. The National Food Consumption Survey (NFCS) found that the mean amount of sorghum that was consumed by children aged 1–5 years nationally was 16.2 g per day per child (Labadarios, Steyn, Maunder, Macintyre, Swart, Gericke, Huskisson, Dannhauser, Voster & Nesamvuni, 2000).

It is, however, important to mention that even though most people are going through the nutrition transition phase, it is more likely to have an effect on the younger generation than the older generation, as was gathered during the focus group interviews. The younger mothers and caregivers were not as keen on using sorghum in the children's diet as the older participants. In a study to determine the consumption patterns of traditional foods in the Canadian Arctic, it was found that participants from the older age group (41-60 years) consumed

significantly more traditional foods than the younger age group (20–40 years old) (Kuhnlein, Receveur, Soueida & Egeland, 2004).

According to Oniang'o & Komokoti (1999), due to development, the diet of the people in Kenya is caught between traditional and modern. The traditional practices that are performed in Kenya that require sorghum, have contributed to the deliberate keeping of sorghum even though it is cultivated in smaller quantities every cropping season. In Ghana, it was found that even though sorghum was slowly losing popularity in as far as being the leading cereal, it still had some important functions culturally, socially and for religious purposes (Kudadje, Struik, Richards & Offei, 2004). The use of sorghum in the feed, food and brewing industry is limited and has been hindered by factors such as unreliable supply, high tannin content of some varieties, sand contamination and insufficient quantities for processing (Laswai, Shayo & Kundi, 2003).

- Nutrient intake

Due to the consumption of a varied diet, on average the children managed to meet the requirements for all the nutrients except for iodine. Similar findings on the importance and the effects that dietary diversity has on the improvement of children's nutritional status have been reported for Kenya (Onyango, Koski, & Tucker, 1998). In the present study, more than fifty percent of the children managed to meet the recommended nutrient intake for all the nutrients. It was, however, notable that the older children aged 4–5 years old had lower intake averages reported for all the nutrients than the children aged 2–3 years old.

The reason for the younger children's relatively higher intake values could have been that the mothers of the younger children overestimated their intake. The mothers could have been reporting food intake for the younger children to be equivalent to that of the older children. It could also be because the mothers of the younger children gave the children the same portions as older children. This

resulted in the average intake for the children to be higher than the RDA for their age group.

It should also be borne in mind that dietary assessment methods are not accurate (Szostak, 1994). Due to limitations in time and money, pre-existing questionnaires were modified and used for the dietary assessment in Kenya. The questionnaire used for the South Africa's NFCS (Labadarios *et al*, 2000) and the THUSA study questionnaire (Macintyre, 1998) were modified and used. Since both had been validated and acceptable, the questionnaire used for the Kenya study was only pre-tested in a sorghum consuming area in the Limpopo province on mothers and caregivers of children aged between 2 to 5 years. This might have also has an effect on the outcome of the results of the younger children having relatively higher nutrient intake values.

With that having been said, it is important to point out that even though an average number of children obtained adequate nutrition from the diet, there was a large percentage of the children whose nutrient intake fell far below the recommended intake. This was an indication that even though the children's diet was varied, for some of the children the diet was still inadequate. It could therefore be suggested that for those children whose nutrient intake fell below the RDA, they were at risk of suffering from nutritional deficiencies of these nutrients.

For those children in western Kenya that did not meet their nutrient requirements, it was because of the low amount of food given to the children and to a lesser extent the quality of the food. For these children, even though their diet was varied, the energy content of the diet was relatively low, also resulting in a low micronutrient profile as the results show. In most developing countries, cereals and/or starchy roots and tubers, which form the major part of children's diets, are often watered-down in order to increase the quantity of the meal (Gibson, Ferguson & Lehrfeld, 1998). This has a negative impact on the energy and

nutrient density of the meal. The same was found in the diet of children in South Africa, which was found to have a low energy and micronutrient content (Vorster, Oosthuizen, Jerling, Veldman & Burger, 1997; Labadarious, *et al*, 2000).

As stated by NICUS (2003), the RDA is used to define intakes and the risk of inadequacy is considered negligible when only 2–3% of the population is below the RDA for a particular nutrient. The risk of an inadequate intake often arises when the percentage of the population meeting the RDA is less than 97%.

- Energy - The cereals food group, which was the major component of the children's diet, was the biggest contributor to the energy intake. The consumption of a varied diet, which is often associated with an increased intake of energy (Gibson & Hotz, 2001), also assisted in slightly increasing the energy levels. Due to the varied nature of the children's diet, the average energy intake for both age groups was more than enough.

The biggest energy contributors among the cereals consumed by the children were maize and rice. Based on the information gathered from the food consumed by the children, sorghum was not one of the main staple foods in western Kenya. Even though sorghum was consumed in western Kenya, the quantity or portion of sorghum consumed was relatively small for sorghum to contribute significantly to energy intake. Likewise, in the North West Province of South Africa, food intake also showed a shift where sorghum consumption was completely replaced by maize, which made the highest energy contribution in the whole diet (MacIntyre, Kruger, Venter & Vorster, 2002)

As stated, in western Kenya, the average daily energy contribution of the cereals food group in the children's diet was 3155.6 kJ. Maize as one of the main cereals contributed 538.8 kJ and sorghum only contributed 140 kJ per day. Similarly, the NFCS found that South African children obtained an average of 1490 kJ from

maize and 64.1 kJ from sorghum (Labadarios, *et al*, 2000). In both studies, maize was the highest energy contributor in the children's diet.

The findings on the children's energy intake in western Kenya were similar to those of children in South Africa. The NFCS revealed that 26% of the children aged 1–3 years living in rural areas had an energy intake less than two thirds of their requirement (Labadarios *et al*, 2000). In western Kenya, the percentage of children whose intake fell below the RDA was slightly higher, 36.3% of the population. This is a typical scenario for most rural settings, especially in developing countries.

For those children that received an insufficient diet shown by the low energy values, it can be assumed that they were given a diet whose cereal component was less viscous. Children are given a limited diet most probably because energy foods are usually costly and although they are suppose to form the major part of the diet, most households choose to ration the cereals so that they can last the family longer (Rabiee & Geissler, 1992). In addition to rationing, in order to increase the quantity of the cereal, the cereal mixtures (gruels) were watered down which, results in the low energy (Gibson *et al*, 1998).

In a study to determine the effects of cereal viscosity and energy density on total energy consumption (Bennett, Morales, Gonzalez, Peerson, de Romana & Brown, 1999), it was found that children consumed a higher amount of the food when it was a low density, low viscosity diet. This means that even though the diet may be of low energy, if it is given in large amounts the required energy intake can be reached. Adequate energy is usually achieved by increasing the amount of the staple food consumed (Onofiok & Nnanyelugo, 1998). This is, however, not the case in most developing countries. Children are usually given a limited amount of the low density, high viscosity diet resulting in low energy and micronutrient intake from the diet (Brown, 1997). The cooked cereal is cooled down before being served to the children. Cooling the cereal increases the

viscosity of the cereal giving an impression of a bulky/energy dense cereal (Walker & Pavitt, 1989). A high density and high viscosity diet would, however, be a much better option to give to children as it would result in increased energy intake (Bennett *et al*, 1999).

- Protein - On average the children had a protein intake that met the required amount. Like energy intake, about half of the protein was derived from the cereals food group. Sorghum, however, barely contributed anything to the total protein intake, contributing only 0.9 g (1.7%). Cereals are generally poor protein sources and are especially low in the essential amino acids lysine and tryptophan (Onofiok & Nnanyelugo, 1998). The remainder of the protein in the children's diet came from animal food sources. Unlike the energy intake, a smaller percentage of the children did not meet their protein requirements.

The animal protein sources consumed by the children were eggs, milk, fish, beef and chicken. The main animal protein source that was consumed on a daily basis by a majority of the children was fish. Even though the portion of the fish served to the children daily was relatively small, it was an important protein source from the diet. The other animal protein sources were less frequently consumed in smaller amounts and were not frequently available. Fish on the other hand was more readily available because the areas included in the study were all situated close to Lake Victoria, which is a source of fresh water fish.

The fish was either dried or added as part of the ingredients for making ugali flour, or it was taken fresh together with ugali, rice or chapatti. This combination of cereal with fish assisted in improving the protein quality of the diet. The same effect on protein in children's diets was observed in Malawi, when their maize-based diet was improved by adding soft-boned fish (Gibson, Yeudall, Drost, Mtitimuni & Cullinan, 2003). This improvement in the children's diet resulted in a maize-based diet with enhanced protein bioavailability.

Even though the majority of the children met their required protein intake, 1% of the sample was below their EAR. It is possible that the protein consumed by the children was used in part to substitute for the low energy obtained in the diet, as described by the FAO (1985).

- Iron - On average, the iron in the diet met the recommended intake. In fact, if the mean intake of the children is compared against the EAR, the proportion of the children at risk was reduced. There were still, however, some concerns that a significant number of the children were still at a risk of being iron deficient.

Considering that the children consumed a diet that was low in animal products but high in plant-based products, this increased the likelihood of the children having poorly available iron in the diet. A diet, which is predominantly plant based, results in the poor intake of bioavailable non-haem iron (FAO/WHO, 2001). Considering the components of the children's diet, as there was a relatively small amount of animal food sources, the bioavailability of iron would be classified as being between low (5%) and intermediate (10%).

The intake of both forms of iron (haem- and non-haem) from a high cereal, legume, fruits and vegetable diet is supposed to be enhanced by the presence of ascorbic acid in the diet (Calloway, Murphy, Beaton & Lein, 1993). The ascorbic acid in fruits assists in absorbing the haem iron. Furthermore, bearing in mind that iron absorption also depends on the subject's iron store, non-haem iron in vegetarian diets is more readily absorbed than haem iron in people with low haem iron stores (Hunt, 2003).

The fish in the children's diet was also expected to have an impact on the iron intake. In a study conducted to determine the importance of fish consumption to the nutrient intake in Cambodia and Bangladesh, fish was found to contribute a

significant amount of absorbable iron (Roos, Wahab, Chamnan & Thilsted, 2007).

The iron status of the children was, however, possibly subject to being compromised by the children's high tea intake. Tea, which contains tannins, increases the likelihood of interference in the proper absorption of the iron from the diet (Calloway *et al*, 1993). However, due to the fact that the children had a high fruit and vegetable intake, the iron intake from the children's diet was expected to be good. This improvement depends on the effects of a counterbalance that the ascorbic acid in the fruits and vegetables exerts on the phytic acid from the cereals and legumes and as well as the tannins from the tea (Hunt, 2003). This, however, also depends on the level of other iron inhibiting factors in the diet (FAO/WHO, 2001). If the levels of the inhibiting factors exceeded the enhancing factors such as the ascorbic acid, the likelihood of the children receiving enhanced levels of iron from the diet was poor. This was also found in a study conducted in Mexico to determine the availability of nutrients in rural and urban diets (Rosado, Lopez, Morales, Munoz & Allen, 1992).

Some factors need to be taken into consideration when estimating the enhancing effects of ascorbic acid from the fruits on iron bioavailability. The enhancing effects of ascorbic acid can be achieved if the ascorbic acid is consumed during meal times (Murphy, Beaton & Calloway, 1992). This should also serve true for the inhibiting effects of tea in the children's diet. Children in Kenya generally consume fruits as in-between meals snacks as opposed to having them with meals (Murphy *et al*, 1992). Since the enhancing effect of fruits is most effective when taken together with a meal, in the case of the children this enhancing effect of the fruits might not be as effective.

- Zinc - Zinc bioavailability is also dependent on the type of diet consumed. Higher protein intake in the diet increases zinc intake and bioavailability (Lonnerdal, 2000). Zinc is more readily absorbed from a meat-based diet than it



is from a plant-based diet (Murphy & Allen, 2003). Based on this, for the majority of the children in western Kenya, the dietary zinc intake was fairly low.

The children obtained an average of 6.1 mg of zinc from the diet, which was adequate for both the 2–3 years and 4–5 years age groups. However, only 79.4% of the population managed to obtain the recommended zinc intake from the diet. Thus, a substantial percentage of the children were unable to meet the recommended zinc intake. Based on the recommendation by NICUS (2003), since more than 3% of the population were unable to meet the RDA for zinc, the children in western Kenya are thus at risk of having zinc deficiency. As the major component of the children's diet, the cereals food group was the main zinc contributor. According to Brown, Wuehler & Peerson (2001), zinc availability from the cereals food group is intermediate.

Unlike other starchy staples such as roots and tubers consumed in developing countries, cereals are often an important and a much better source of zinc when animal food products are unavailable (Gibson, 1994). The major problem is that the zinc in cereals is not well available since it complexes with phytate (Thompson, 1993). The negatively charged phytate in the bran of wholegrain cereals and the cotyledons of legumes reacts with positively charged ions such as iron and zinc in the grain, thus forming insoluble complexes which are poorly bioavailable (Harland & Oberleas, 1987).

Without completely disregarding the other animal sources in the children's diet, the fish was the main zinc contributor. The zinc in fish is considered to be more easily absorbable than the zinc obtained from cereals (FAO/WHO, 2001). The addition of fish in the composite flour used for making uji and ugali improved the quality, absorption and bioavailability of the zinc acquired from fish and the cereals in the flour. In a study to determine the effects of protein levels and protein sources on zinc absorption, the protein content in a bean diet was doubled and enhanced by the addition of fish and chicken (Sandstrom, Almgren,

Kivisto & Cederblad, 1989). The addition of fish significantly increased the absorption of zinc by 50-70% from the bean diet.

The children also consumed a very high amount of milk in their diet, which enhanced the zinc absorption from the diet. In a study in Mexico to determine the effects of using milk and yoghurt in a plant based diet on zinc bioavailability (Rosado, Diaz, Gonzalez, Griffin, Abrams & Preciado, 2005). A fifty percent increase in zinc absorption was found when 250 ml of milk was taken in the diet.

Looking at the composition of the children's diet, the bioavailability of zinc would be classified as either low (5%) or intermediate (10%) (FAO/WHO, 2001), because of the presence of fish, which acted as a dietary enhancer (Gibson, 1994). The high fruit and vegetable consumption resulted in a high ascorbic acid intake from the diet, would also assist in enhancing the zinc absorption (Murphy *et al*, 1992).

- Vitamins A and E - As with all the other nutrients already discussed, on average the children met their recommended Vitamin A intake. However, a very high proportion of the population (46.1%), did not meet the recommended Vitamin A intake. Due to this, it is safe to assume that a large percentage of the children in the selected communities in western Kenya are possibly at risk of being Vitamin A deficient.

As stated, the major component of the children's diet was the cereals food group, which did not contribute much Vitamin A to the diet. This is because cereals are not very good dietary sources of Vitamin A (FAO/WHO, 2001). Food groups that contributed to the children's Vitamin A intake were the dairy, meats, fruits and vegetables food groups. Even though the diet in western Kenya was diverse, it had a poor Vitamin A composition. The main Vitamin A source was the milk and fish.

The fish was first dried before preparation, which may have resulted in the loss of Vitamin A. Exposure to the sun, and oxygen affects Vitamin A stability (Wirakartakusumah & Hariyadi, 1998). Moreover, a high amount of the pre-formed Vitamin A, which is stored inside the intestinal walls of the fish, gets lost during cleaning and during cooking (Booth, Johns & Kuhnlein, 1992). Since the children consumed a significantly high amount of milk in the diet with and without tea, the milk was probably the main source of Vitamin A.

The children in western Kenya were also privileged to have access to some wild and free growing fruits from vegetable gardens. Fruits are often consumed throughout the day as snacks (Calloway *et al*, 1993). The children had access to fruits such as mangoes and guavas growing on trees. Other fruits that they consumed but were bought from the market include paw paws, oranges, pineapples and bananas.

There was also a high intake of local green leafy vegetables, which were, consumed daily. These leafy vegetables also contributed to the children's Vitamin A intake. The only constraint in acquiring Vitamin A from the traditional green leafy vegetables is the preparation method used, which affects the level of Vitamin A in the vegetables. The preferred preparation method for vegetables in Kenya is to make them slimy, which requires that the vegetables be over cooked (Owor & Olaimer-Anyara, 2007). This method of preparation usually causes a great reduction in the pro-Vitamin A content (Booth *et al*, 1992).

The wide range in Vitamin A intake among the children can be attributed to a number of reasons, including availability of finances, seasonality of the foods, preparation method and beliefs about consumption (Nana, Brouwer, Zagr , Kok, & Traor , 2005). The availability of fruits and vegetables in the different households also varies greatly. This is because some households have vegetable gardens where they have a variety of fruits and vegetables growing.

With regard to Vitamin E intake, an average of 82.4% of the children managed to obtain enough Vitamin E to meet their recommended intake. A substantial percentage of the children did not meet their recommended Vitamin E intake. Looking at the diet, however, there were good Vitamin E sources. Fruits and vegetables are generally considered to be good sources of Vitamin E (Hanninen, Kaartinen, Rauma, Nenonen, Torronen, Hakkinen, Adlercreutz, & Laakso, 2000). As seen, there was a significant amount of fruits and vegetables consumed by the children.

In a study to determine the interaction of Vitamin C and Vitamin E, it was found that the levels of Vitamin E increased when the diet was supplemented with ascorbic acid (Hamilton, Gilmore, Benzie, Mulholland & Strain, 2000). From this study, it can be postulated that the high fruit intake giving high levels of ascorbic acid in the children's diet, which aids the Vitamin E intake. The fish found in the children's diet also contributed to the Vitamin E levels as described by Egaland & Middaugh (1997).

- Other nutrients - In addition to the nutrients discussed above, the total fat, iodine, Vitamin C, Vitamin D, Vitamin B6, Vitamin B12, thiamin, riboflavin, niacin, folate and lysine intakes were also assessed. Even though an average number of the children met the requirements for these nutrients, as with all the other nutrients that have already been discussed, there were still a significant percentage of the children that had inadequate intake of all the above mentioned nutrients with the exception of iodine and Vitamin C.

The high Vitamin C intake by all the children was taken from the milk, fruit and vegetables consumed in the diet. In most developing countries, however, this nutrient is affected by seasonality (FAO/WHO, 2001). High intake values are achieved when most fruits and vegetables are in season. Populations with low fruits and vegetables experience risks of Vitamin C deficiency. Milk also plays an important role in contributing to the high Vitamin C content in the diet (FAO,

1990). The high Vitamin C intake was helpful in promoting the absorption of minerals such as zinc and iron from the diet.

There was an inadequate intake of iodine for all the children. This means that there was an iodine deficiency in the children's diet in the area. The low iodine intake may be attributed to the deficiency of the nutrient in the soil. The soil is regarded as the primary natural source of iodine especially in developing countries (UNICEF, 1998). The area was also prone to heavy rain and flooding. Flooding causes leaching of iodine present in the upper soil layer (FAO/WHO, 2001). Another dietary factor that could have contributed to the low iodine intake in the diet is the high cassava consumption. Cassava is used mainly as one of the ingredients for making uji and ugali flour in western Kenya. Cassava can interfere with iodine metabolism in the thyroid gland (FAO/WHO, 2001).

- Focus Groups

Based on the observations made during the visits to the different locations where the focus group interviews were conducted, it was observed that there is low sorghum production in the area. This was shown by the proportion of land allocated to sorghum on those farms that cultivated sorghum. The sorghum crop on the fields was not well cultivated and it had a high population of weeds and striga, which was affecting the crop's growth. In addition to this, a number of the farms in the areas visited did not have any visible sorghum crops.

With regard to the interviews, there was an evident difference between the older and younger participants concerning sorghum use. The younger participants preferred the white sorghum and the older participants preferred the red type. The younger participants were not as dedicated to using sorghum, as the older participants appeared to be. The reason given by the younger participants for using less sorghum was that birds on the field ate the white type, hence giving lower yields. One commonality among the participants about sorghum, however,

was that both young and old, viewed sorghum as an important crop, which was demonstrated by the fact that it was still in use, even though in small amounts.

- General food and sorghum production - The climate in western Kenya is a tropical equatorial climate, which is suitable for a variety of crops (Ministry of Planning and National Development, 2002). The participants identified maize, cassava and sorghum as the main crops grown in western Kenya. These crops, according to the participants, occupied the majority of the fields in the area. The participants recognized these crops as crops that have to be cultivated every cropping season. According to the information given by the District Agricultural Officers (DAO), the major crops from the different districts in western Kenya (in no particular order) are,

- Cereals – maize, sorghum, finger millet and rice,
- Legumes – beans, green grams and cowpeas,
- Root crops – cassava and sweet potatoes.

In a study conducted to determine the role of agricultural biodiversity on dietary intake and nutrition status of preschool children in western Kenya, the main food crops produced in the area in order of importance were: maize, beans, sweet potatoes, cassava, sorghum, finger millet, and groundnuts (Ekesa, Walingo & Onyango, 2008). In the study, white maize was the most important crop grown by a majority of the households (97.2%). Cassava was regarded as the second important crop grown by 59% of the households in the area. Sorghum, on the other hand, was grown by less than 30% of the households and is regarded to have the same importance as finger millet (Ekesa *et al*, 2008).

Maize is liked because it requires less attention on the field, especially considering the issue of birds (Ekesa *et al*, 2008). Surprisingly though, when the focus groups participants were asked to rank in order of importance the three major crops they had mentioned, the crop occupying the most area and most frequently cultivated by the majority of the participants in the area, they ranked

cassava as number one; sorghum was ranked second and maize third. The ranking of the staple crops in order of importance by the participants was not in line with the information that was gathered from the QFFQ. The questionnaire revealed that maize was more important than sorghum. The amount and portion size of maize consumed daily by a majority of the children when compared to sorghum, gave an idea that maize was more important.

Other crops that were considered by the participants as important even though their production was low were beans, Irish potatoes and local green leafy vegetables. These crops assisted in contributing to the diversity of the diet in the area, and also improved nutritional status. In an investigation to determine the effects of a banana-based and a grain-based (maize and sorghum) cropping system on its nutritional contribution to children's diet, grain-based cropping systems had the potential to provide adequate nutrition to children's diet if other crops that are rich in essential micronutrients (such as zinc and calcium) are cropped together with the cereals (McIntyre, Bouldin, Urey & Kizito, 2001).

Sorghum was considered by most of the participants as a staple crop, which at times they have to cultivate on smaller portions of the field. Sorghum, however, has for some time now been seen as a poor mans crop when compared to other improved cereals (Matlon & Spencer, 1984). This may be related to the fact that sorghum and millet are generally not considered as food crops in developed countries (Maredia, Byerlee & Pee, 2000). Because of this, crop improvement in terms of research and development of these crops has been very slow. The lack of improvement in sorghum contributes to its neglect even in developing countries where it is required as a staple crop.

The reduction in the area of cultivated sorghum in developing countries has led to lower sorghum yields (Atokple, 2003; Deb, Bantilan, Roy & Parthasarathy Rao, 2004). According to the participants, the low sorghum yield obtained was due to bird infestation especially on the sweet sorghum varieties. Because of this, the



tendency for most participants was to grow more of the darker coloured varieties than the whiter ones. It was also found that those that did not use fertilizer on the sorghum reported even lower yields.

Even though the Ministry of Agriculture in Kenya has provided new improved sorghum seeds, they are not being used because the participants claim that these improved seed varieties are more problematic than the indigenous varieties. The participants said that some of the problems that they experienced with the improved varieties include the tendency of the variety to require fertile soils, matures late and as a result becomes subject to bird damage. This was also reported in Ghana where adoption of an improved high yielding sorghum seed variety (Naga white) by farmers in Ghana was reported to be poor (Kudadje *et al*, 2004). In this case, the reasons given were that the variety required fertilizer application, the grain was of poor quality for food use and hence there was no market for it.

The participants said that they prefer to cultivate the local varieties. The seeds used by the participants are acquired from superior quality seeds from the previous cropping season. Neighbours who are in ownership of the desired seeds are also used as another source of seeds. This tendency was also observed in eastern Uganda where farmers did not buy their seeds but relied on superior varieties obtained from neighbours, friends, family or tribal members (Scurrah-Ehrhart, 2003). This practice in Uganda was seen as dangerous as success in acquiring good quality seeds depended on good harvests from the previous season. Seed failure due to recurring harvest failure meant that there would be no seeds for the next cropping season.

- Means and methods of storage - Even though indigenous sorghum varieties have been found to be able to withstand insect damage better than improved varieties, stored sorghum grain still suffers attack from storage insects (Obilana, 2004). It is for this reason that stored grains have to be protected from

pest damage by means of effective storage practices. Due to high cost of storage chemicals, as stated by the participants, traditional and natural ways of storing the grains were employed for sorghum by most of the participants.

According to the participants, the post-harvest handling practices for sorghum involve harvesting of mature panicles, open sun drying on the ground, threshing by beating the dried panicles with sticks, winnowing using flat trays and milling. These traditional post harvest handling practices of sorghum from the field are similar to those used by them for finger millet. The participants store their sorghum grain mainly in sacks, granaries, which were made in the traditional way from woven branches with thatched roofs and empty drums. This is similar to the storage of finger millet in Kenya where gunny bags are used for short-term storage and while plastic and metal containers are used for long-term storage (Oduori & Kanyenji, 2007).

For long storage of grain, most of the participants used cow dung and wood ash as a type of insecticide. The effectiveness of these traditional preservation methods have been investigated and demonstrated in other studies. In one study, the insecticidal effects of eight Nigerian plant species against maize weevil *Sitophilus zeamais*, was investigated (Asawalam, Emosairue Ekeleme & Wokocha, 2007). It was found that the powders from these plant species significantly reduced emergence of the weevil, prevented grain damage under various treatments at different levels. In Ghana, some traditional plant material were evaluated to test their effectiveness as natural and cheaper pest control products on stored rice grains, they were reported to have some repellent activities on insects reducing insect pest survival to less than 25% in ten days (Owusu, 2001).

Proper post-harvest storage of cereals is essential as it reduces grain deterioration and damage from insects. The reason much attention has to be given to proper grain storage is because the effects of grain damage due to

improper storage impact on the nutritional intake of the household. In addition to loss of grain, insect infestation and growth in stored cereal grains results in increases in moisture content of grains, dust weight production, *Aspergillus flavus* infection, and aflatoxin accumulation in maize grains (Sinha & Sinha, 1992).

- Food consumption - In an attempt to enhance the micronutrient content and bioavailability of a maize based diet of rural Malawi children, dietary diversity/modification was used in the children's diet by adding soft boned fish (Gibson *et al*, 2003). The strategy assisted in reducing the prevalence of inadequate intakes of protein, calcium, zinc and Vitamin A. Addition of other cereals, tubers and roots to form the cereal component of the diet has also been found to contribute to the bulk of the diet (Onilude, Sanni & Ighalo, 1999).

The most common method of processing sorghum flour used in western Kenya is mechanical grinding using a "Posho" (village) hammer mill, which merely breaks up the grain particles. The coarseness of these ground cereals is a problem for young children. The participants mentioned fermentation as one method, which is used to prepare a different form of uji. The fermentation processing method is helpful in enhancing the nutritional quality of the cereal by reducing its phytate content. In a study to investigate the effects of milling extraction, water soaking, malting, heat-treatment and fermentation on the phytate content, of four cultivars of Sudanese sorghum, it was found that even though malting and fermentation had more effect on the phytate content, milling, soaking and heating were also effective methods in reducing the phytate content of the sorghum (Mahgoub & Elhag, 1998).

### 3.4 Conclusions

Sorghum is among the least consumed cereals in the selected rural communities in western Kenya. Its consumption was mainly limited to the two porridge types

commonly consumed in Kenya uji and ugali. Sorghum found in the diet is used in very small amounts as part of the ugali flour ingredients, at times barely even identifiable. Due to the limited intake of sorghum in the area, its inclusion in the diet and consumption does not make a significant contribution to the nutritional status of the children in the area. For the children whose nutrient intake was low, there is a need to develop nutrition intervention strategies to improve the quantity of food consumed by the children in order to improve their nutritional status. These nutrition intervention strategies include supplementation, fortification and dietary diversification (which biofortification falls under) and will be discussed in the general discussion section.

As part of the dietary diversification strategies, the biofortification of sorghum can only make a difference in the children's nutrient status if a large amount of the sorghum is consumed. Biofortification has a significant impact if the food in question is considered a staple food and consumed in large amounts. Currently, biofortifying sorghum with the deficient nutrients will not be worthwhile as it will not have any impact on the children's nutrient intake.

From the focus groups interviews, it was found that sorghum in western Kenya either directly or indirectly has got some cultural, religious, medical, nutritional and food uses. These sorghum uses have helped to maintain sorghum in the area. These practices for which sorghum is required have contributed to keep growing sorghum intentionally even in small quantities every year.

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#### 4. General discussion

This study was carried out in order to provide information regarding the consumption of sorghum as a staple food in a rural area. Seven rural communities where sorghum is consumed were selected in the Nyanza province in western Kenya for this study. The aim of the study was to establish if sorghum is consumed in these areas and also provide insight on the nutritional contributions that the sorghum makes in western Kenya. A nutrition intervention strategy to help improve the nutrition situation would then be recommended based on the findings if there is a need.

The study indicates that sorghum use in western Kenya is very low. Sorghum is mainly used as one of the ingredients for producing flour used in the making of soft and stiff porridge, respectively known as uji and ugali in Kenya. Sorghum on its own or as the main staple cereal component in a meal is rarely used. Sorghum is incorporated in the diet by mixing it together with other cereals, vegetables and fish to form the flour. The percentage of children whose nutrient intake was below the RDA was 36.3% for energy, 4.9% for protein, 48% for iron, 21.6% for zinc, 46.1% for Vitamin A and 17.6% for Vitamin E.

Based on the findings, it appears that the lack of sufficient food in terms of the amount given daily was the main reason for the insufficient nutrient intake for those children whose nutrient intake was below the required nutrient intakes. The children's diet was characterized by small amounts of food served, which resulted in the low energy and micronutrient intake. Such conditions are common among the economically and socially poor people in rural areas (Muehlhoff, Simmersbach, Baron & Egal, 1995). Low food and nutrient intake among the rural poor can be alleviated by increasing food production, improving the economic situation, reducing the poverty levels, social development and educating the rural poor. A similar situation of poor food and nutrient intake was

being experienced by the rural people in western Kenya as they relied mainly on their own agricultural produce, supplemented with food they buy from the market.

The causes of malnutrition in developing countries, which are reduced food intake and the lack of nutritionally adequate food has over the years been addressed through various nutrition intervention strategies (Muehlhoff *et al*, 1995). These nutrition intervention strategies are assessed and reviewed below in order to establish the kinds of contributions they can make if applied in western Kenya. The strategies include fortification, supplementation and dietary diversification.

- Fortification

Fortification has been applied in many developed countries using mainly rice, salt, sugar and flour as food vehicles to alleviate iron, iodine and Vitamin A deficiencies (Dexter, 1998; Ramalingaswami, 1998). Fortification is the most commonly used strategy because it does not require any changes in the consumption patterns of the targeted population (Gibson & Ferguson, 1998). Fortification has, however, been shown to be more successful in countries where the food vehicle passes through central processing or storage units where the fortification process can be monitored under well controlled conditions at minimum cost (UNICEF/UNU/WHO/MI, 1998).

Even though fortification has been demonstrated to be a successful nutrition intervention strategy in developed countries, its success in developing countries depends on the following: use of a food vehicle consumed by the whole population at risk, the food being centrally processed to ensure careful monitoring of the fortification process, proper storage and cooking practices to prevent any undesirable changes in the sensory attributes and appearance of the product, government involvement and consumer education about the benefits of the fortified product (Haas & Miller, 2006). Fortification of foods in developing countries is mainly hindered by the fact that people in developing countries

mainly consume home grown foods as opposed to people in developed countries who mainly consume foods that are industrially processed and are readily available to the target population (Yip & Ramakrishnan, 2002). This therefore confirms that providing fortified foods in developing countries would not be a feasible strategy since the fortified food is not always readily available for rural people to consume.

On the basis of this, three factors can be identified to state why fortification of sorghum is not the best strategy to use in western Kenya. Firstly, the consumption patterns and amounts of sorghum consumed do not qualify sorghum as a staple cereal. Secondly, sorghum in the area is not obtained in the shops, it is eaten either directly from the fields or purchased at the open market. Thirdly, due to the lack of proper infrastructure to support sorghum in the studied areas, sorghum is not nationally or centrally processed, instead rural people rely on the Posho mill in order to mill sorghum into flour.

Even though food fortification as a nutrition intervention strategy has the ability to provide medium to long-term solutions, in developing countries the cost, technological requirements and access to the target population are huge obstacles that hinder the success of the strategy (Adelekan, 2003). Fortified products are usually not readily available to rural areas where they are often required the most (Trowbridge & Martorell, 2002). In addition to this, the energy intake for children in developing countries is often lower than the recommended amount, which is due to the low dietary intake (Brown, 1997).

Even though it is recommended that, where inadequate quantities of food are available, fortified foods can be used (WHO, 2001). Giving the children foods containing the fortificants with inadequate energy density cannot help to meet the energy requirement, which the fortified component of the diet is, suppose to provide. For this reason, fortification can have positive results only if it is used as part of the diet, given in smaller, more frequent meals. In cases where the

children are given small yet less frequent meals containing fortified product, fortification will be less effective as a nutrition intervention and malnutrition alleviation strategy than dietary diversification, which advocates for the consumption of a varied diet. The use of a variety of foods has a positive impact in increasing the diets energy and micronutrient density (Brown, 1997)

- Supplementation

Supplementation, on the other hand, is often applied in food insecure situations where people are in need of an urgent nutrition intervention strategy. Because of this, supplementation is an expensive strategy that can only be applied in emergency situations where normal consumption patterns are unable to meet nutrient requirements (Gibson & Ferguson, 1998). In the Northern Cape Province of South Africa, a take-home Protein Energy Malnutrition (PEM) scheme, which is a supplementation programme targeting on malnourished pre-school children and pregnant and lactating women was implemented (Hendricks, Le Roux, Fernandes & Irlam, 2003). The supplementation programme proved to be unsuccessful as it was unable to reach the targeted group. When the participants took the supplements home, they were consumed by other family members they had not been intended for.

In order for supplementation to be successful it is important that measures are put in place to ensure that it is strictly directed at the population at risk and as soon as micronutrient-rich food-based strategies are introduced, supplementation must be stopped (Gopalan, 1992). The success of supplementation depends on an adequate budget for supplement supply, accessibility of the delivery system to the target group, good quality supplements, guaranteed coverage of the intended group, compliance of the target group to take supplement and impact of the supplementation (UNICEF/UNU/WHO/MI, 1998).

Supplementation would not be a suitable intervention strategy for western Kenya as the area requires an intervention that can guarantee long term results, which

can be sustained over a long period of time. Supplementation cannot be used over a long period of time (Yeudall, Gibson, Cullinan & Mtimuni, 2005). Supplementation as a nutrition strategy only offers short-term solutions, which cannot be sustained over a long-term period, mainly in developing countries (Adelekan, 2003). The most important issue that supplementation would be unable to deal with is the energy deficiency, which was one of the main deficiencies in the surveyed areas in western Kenya. The energy deficiency in the area can be addressed by making sure that the children are consuming a diet that will ensure a supply of energy.

- Dietary diversification

Dietary diversity is defined as the number of different foods or food groups consumed at a given time (Ruel, 2001). Dietary diversification is a food-based strategy that can be applied and sustained over a long period without interfering with the workload, cost, preparation and cooking time of the meal (Gibson & Ferguson, 1998). Dietary diversification's main aim is to increase the production and consumption of crops with high micronutrient content such as beans, leafy vegetables, yellow and orange vegetables, root crops like yellow sweet potato, and fruits (Bhattacharjee, Saha & Nandi, 2007).

Dietary diversification's effectiveness depends on the application and use of a number of strategies that include: improved agricultural practices, improved food production, processing and preparation methods. These strategies include the promotion of plant breeding strategies for improved micronutrient content and bioavailability of selected plant-based staples (biofortification) (Gibson & Hotz, 2001). The plant breeding strategy aims to nutritionally enhance mainly staple crops so that they can help in fighting malnutrition.

Another of the dietary diversification strategy's aim is to try and enhance the micronutrient content and bioavailability in the daily diet, by increasing the production and consumption of flesh foods such as fish (Gibson, Yendall, Drost,

Mitimuni, & Cullinan, 2003). The flesh foods can be incorporated into the diet by using village-based technologies for drying fish, preparing fish flour and incorporating flesh foods to those at a high risk of iron and zinc deficiency. Dietary diversification also advocates rural people to use traditional processing and preparation methods such as thermal processing, mechanical processing, soaking, fermentation, and germination/malting in order to enhance the bioavailability of nutrients and also decrease the antinutrients content of cereals and legumes in the diet (Hotz & Gibson, 2007).

In an effort to also increase the micronutrient density and bioavailability of the diet, the strategy also encourages the use of germinated flour especially for children's porridges as it reduces viscosity and at the same time increases the energy and nutrient density of cereal based porridges. (Gibson & Hotz, 2001). Another strategy that needs to be promoted to help enhance the absorption and to improve the bioavailability of non-haem iron and zinc in the diet is through the use of fruits and vegetables rich in ascorbic acid and pro-Vitamin A carotenoids (Bhattacharjee, Saha & Nandi, 2007 and Ali & Tsou, 1997).

The fact that dietary diversification is a long term strategy that can be sustained over a long period, is inexpensive and is a culturally acceptable strategy that can be used successfully to fight multiple micronutrient deficiencies makes it the most sustainable strategy to be used in western Kenya. As a nutrition intervention strategy, dietary diversification does not deliver immediate results in order to improving the nutrition situation. However, it uses locally available micronutrient rich foods together with nutritionally enhanced staples to improve the micronutrient intake of a population which are delivered over a longer period of time to improve the nutrition situation.

Dietary diversification is a suitable strategy to use because it can be used according to the local conditions, based on what is available in the area (Yeudall *et al*, 2005). Dietary diversification is also a suitable strategy in that it can also be



used together with fortification and supplementation (Faber & Wenhold, 2007). The only changes that are required when this strategy is implemented are in the selection of food with a high content and bioavailability of nutrients and the use of preparation and processing methods that enhance nutrient bioavailability (Gibson & Ferguson, 1998).

When a community-based dietary intervention to reduce risk of micronutrient inadequacies in high-phytate maize-based diets in Malawi was implemented, there was a reduced prevalence of inadequate intakes of protein, calcium, zinc and Vitamin B12 (Yeudall *et al*, 2005). Looking at the situation in western Kenya, the use of the dietary diversification strategy, which also includes the use of the innovative plant breeding strategy - biofortification, could yield positive results in the nutrition situation in the area provided the people start consuming significantly larger amounts of sorghum.

Biofortification ensures the production of micronutrient rich staple crops that can be produced with minimum inputs by poor people (Mayer, Pfeiffer & Beyer, 2008). Unlike fortification, biofortification is developed and incorporated into the agricultural systems through the development of micronutrient enhanced cultivars which can be cultivated and used in the diet of the rural poor (Sanghvi, Dary, & Houston, 2007). Most importantly, in order for biofortification to succeed, it must be used in conjunction with other strategies that promote indigenous knowledge, cultural systems and be gender sensitive (Johns & Eyzaguirre, 2007). Biofortification of sorghum in western Kenya would be beneficial to the rural people if the people would consume significantly larger amounts of the cereal, and make it a major component of their diet. This would ensure that in addition to improving the nutritional status of the people, their social and economic status is improved by using local staples instead of foreign ones.

The following have been identified by Timmer (2003) as the potential benefits of biofortification in the food systems of developing countries: biotechnology can

help improve crop yields, leading to agriculture growth and lower food prices. In places where the environmental conditions are unfavourable, biotechnology can assist in the development of crops that are able to survive harsh environmental conditions, which are often experienced by poor rural farmers. This will allow more rural farmers to get involved in the market and compete with other large scale producers. Biotechnology in crop development is also supposed to ensure that the crops are produced with minimum use of inputs that may have an adverse impact on the environment. Finally, the biofortification of staple foods with the deficient nutrients will ensure long term sustainability.

It has been said that people receiving insufficient food are less likely to consider one food over another on a nutritional basis (Unnevehr, Pray & Paarlberg, 2007). However, biofortifying an existing staple crop, which does not require any changes in the people's dietary patterns (Timmer, 2003), would have more significant advantages over the other intervention strategies.

It is also important that the dietary diversification intervention strategy is used in conjunction with a strong nutrition education, social marketing, and mass media campaigns (Ruel, 2001). In addition to this, the need for more education is required to make people realize that micronutrient enhanced food crops can successfully work together with both fortified foods and supplements in order to improve the micronutrient status of vulnerable people (Sanghvi *et al*, 2007).

## 5. Conclusions

The mean amount of sorghum in the diet of the children surveyed in western Kenya is very small in relation to the other food components of the children's diet. In addition to this, for a significant proportion of the children who had a nutrient intake lower than the recommended amount, the intake of the different food groups in terms of quantity is also very small. In order to deal with the proportion of the population that is not receiving enough nutrients, a multiple dietary approach involving dietary diversification that is practical and sustainable for the rural people needs to be implemented.

This approach is beneficial where food is constantly in short supply such as the areas surveyed in western Kenya. As it was found in the study, insufficient food intakes, lead to a short supply of micronutrient in the diet. The insufficient supply of a variety of micronutrients from the diet is also more likely to attack at the same time. With range of micronutrient deficiencies attacking at the same time, the signs and symptoms of each micronutrient deficiency become difficult to distinguish from one another. Introducing dietary diversity can assist to provide many micronutrients as well as energy simultaneously to the affected population (FAO/ILSI, 1997). The multiple dietary approach that dietary diversification offers is more likely to have a significant impact as it aims to provide simultaneous nutrient supply to fight off the deficiencies.

The people in western Kenya also need to be encouraged through education initiatives to adopt the dietary diversity approach because they have more control of it than the fortification and supplementation strategies. Dietary diversification will ensure that people consume a variety of locally available foods containing a rich source of micronutrients and energy. Since sorghum is one of the staple foods with a good source of energy and some micronutrients and is well adapted to cultivation in the region, there is a need for it to be promoted and incorporated as part of the food based dietary diversification strategy in western Kenya. Presently, biofortification of sorghum would not make any significant contribution

to the children's nutrient intake because of the fact that the children are consuming a very small amount of sorghum in their diet. For biofortification of sorghum to make a significant difference in the children's nutrient intake, the people need to be encouraged to consume more sorghum than they are currently consuming.

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## Appendices

Appendix A: The questionnaire

**Food Consumption Survey with particular reference to sorghum: rural Kenyan children**

<b>Interviewer's name:</b>		<b>Interviewer's code:</b>						<b>Interview Date:</b>						
----------------------------	--	----------------------------	--	--	--	--	--	------------------------	--	--	--	--	--	--

<b>Family Address:</b>													
<b>District or area code:</b>													
<b>Mother/caregivers name:</b>													
<b>Mother/caregivers age (pick range):</b>								<b>15-24</b>					
								<b>25-34</b>					
								<b>35-44</b>					
								<b>45-49</b>					
								<b>50 and above</b>					
<b>Mother/caregivers code</b>													
<b>Child's name:</b>													
<b>Childs code:</b>													
<b>Child's age:</b>													
<b>Child's gender:</b>									m		f		

Thank you for participating in this survey. We would like to find out what food products children aged 1-9 years living in this area usually consume. This information is important in finding out if children are getting a nutritionally complete diet. This will assist in determining the nutrient adequacy and inadequacy of the children's diet and help in determining what fortification or supplementation is required to make the children's diet adequate.

Please think carefully about any food product that the child participating in this survey might have consumed during the past six (6) months (for one (1) year olds during the past month). I will go through a list of products and I would like you to tell me:

- If the child eats these particular products
- How much the child consumes of the food at any given time,



- How many times a day the child consumes the product, and if she/he does not eat it every time, how many times a week or month the child consumes the product.

We will use different models to help you describe the different amounts of food, please say which model is closest to the amount eaten, or if it is smaller, between sizes or bigger than the models used. Amounts must be reported as cups (c), tablespoons (T), serving spoons (SP) or teaspoons (t).

- **There are no right or wrong answers**
- **All the information given is confidential**
- **Before we go on, do you have anything you would like to ask?**
- **ARE YOU WILLING TO GO ON WITH THE QUESTIONS?**

**SECTION A: INFORMATION ON THE CHILDS FEEDING PRACTICES**

1. **Are you the mother of the child (please state relationship)?**
  - 1) .....Yes
  - 2) .....No
  - 3) .....Other  
specify/remark:.....
  
2. **Are you responsible for the child’s feeding?**
  - 1) .....Yes
  - 2) .....No
  - 3) .....Only responsible for preparing food
  
3. **Does the child eat any sorghum products?**
  - 1) .....Yes
  - 2) .....No
  - 3) .....Don’t know
  
4. **If yes, what type is currently available in the household?**
  - 1) .....commercial
  - 2) .....cultivated
  
5. **Where do you get your sorghum from?**
  - 1) **Shop specify**  
type.....  
.....
  - 2) **Employer**.....  
.....
  - 3) **Harvest and**  
**grind**.....  
...

4) Other/specify.....

.....

5) Don't

know.....

.....

6. If sorghum is harvested from the field, what variety/colour is it?

1) Red sorghum variety.....

2) White sorghum variety.....

3) Mixed .....

**SECTION B: DIETARY INTAKE INFORMATION**

**INSTRUCTIONS TO FIELD WORKERS:**

CIRCLE THE CHOSEN ANSWER AND FILL IN THE AMOUNT AND TIMES EATEN IN THE APPROPRIATE COLUMNS.

I will ask you about the types and amount of foods the child has been eating during the last six (6) months. Please tell me if the child eats the food, how much the child eats and how often the child eats.

Food	Description	Amount	Times eaten				Code	Amount /day
			Per day	Per week	Per month	Seldom		
<b>Maize meal</b>	Soft						<b>3399</b>	
	Stiff						<b>3400</b>	
	Sour porridge						<b>3399</b>	
	Whole grains						<b>3271</b>	
<b>Sorghum</b>	Soft						<b>3241</b>	
	Stiff						<b>3241</b>	
	Sour porridge						<b>3241</b>	
	Corn rice						<b>3437</b>	
<b>Rice</b>							<b>3247</b>	
<b>Wheat</b>							<b>3249</b>	
<b>White bread</b>							<b>3210</b>	
<b>Brown bread</b>							<b>3211</b>	
<b>Chapatti</b>							<b>3358</b>	
<b>Other types of cereals:</b>								
Is milk added to the child's porridge							<b>YES</b>	<b>NO</b>



<b>If answer is NO go to the next section on sugar.</b>								
If YES, what type of milk is added?			fresh	sour	Powder	Skim milk powder(give name)		
	<b>Amount</b>	<b>Times eaten</b>				<b>Code</b>		<b>Amount/day</b>
		<b>Per day</b>	<b>Per week</b>	<b>Per month</b>	<b>Seldom</b>			
How much milk is added								
Is sugar added to the child's porridge?							<b>YES</b>	<b>NO</b>
<b>If NO, go to the next question on pastes/spreads.</b>								
<b>If yes how much and what type of sugar do you use?</b>								
Does the child take any spreads on the bread?							<b>YES</b>	<b>NO</b>
<b>If NO, go to the next section on meat.</b> If yes, what spreads do you use and how much								
<b>Food</b>	<b>Amount</b>	<b>Times eaten</b>				<b>Code</b>	<b>Amount/day</b>	
		<b>Per day</b>	<b>Per week</b>	<b>Per month</b>	<b>Seldom</b>			
Chicken	Boiled with skin					<b>2926</b>		
	Boiled without skin					<b>2963</b>		
	Chicken heads					<b>2999</b>		
	Chicken feet					<b>2997</b>		
	Chicken offal's					<b>2998</b>		
	Other preparation methods.							
Beef	Roasted with fat					<b>2933</b>		
	Roasted without fat					<b>4363</b>		
	Other preparation methods.							



Goat	Fried/roasted wit fat					<b>4281</b>	
	Other preparation methods.						
Offal's Beef	Liver					<b>2920</b>	
	Kidney					<b>2923</b>	
	Heart					<b>2968</b>	
	Lung					<b>3019</b>	
	Tripe					<b>3003</b>	
Eggs	Boiled/poached					<b>2867</b>	
	Fried in sun oil					<b>2869</b>	
Fish							

### Vegetables

Food	Amount	Times eaten				Code	Amount/day
		Per day	Per week	Per month	Seldom		
Legumes							
Cabbage	Boiled					<b>3756</b>	
	Boiled with potatoes, onion and sun oil					<b>3815</b>	
	Fried/sautéed in sun oil					<b>3812</b>	
	Others specify.						
Spinach	Boiled					<b>3915</b>	
	Other preparation methods.						
Pumpkin	Boiled					<b>4164</b>	



winter type.	Others specify						
Carrots	Boiled					3757	

Food	Amount	Times eaten				Code	Amount/day
		Per day	Per week	Per month	Seldom		
Apples						3532	
Pears						3582	
Oranges						3560	
Bananas						3540	

	Others specify						
Potatoes	Boiled					4155	
	Others specify						
Sweet potatoes	Boiled					3748	
	Others specify						
Mealies/corn	Boiled					3725	
	Others specify						
Other vegetables.							



Grapes							3550	
Peaches							3565	
Mangoes							3556	
Paw paw							3563	
Pineapple							3581	
Guavas							3551	
Other fruits								

**I am now going to ask you about the child's beverage intake.**

Food	Amount	Times eaten				Code	Amount/day
		Per day	Per week	Per month	Seldom		
Tea						4038	
Rooibos tea							
Coffee						4037	
Do you put milk in the child's tea or coffee?						YES	NO
<b>If NO ask about sugar.</b> If YES, specify what type of milk and amount is used in the child's tea or coffee.							
Food	Amount	Times eaten				Code	Amount/day
		Per day	Per week	Per month	Seldom		
Fresh milk						2718	
Others specify.							
Do you put sugar in the child's tea or coffee?						YES	NO
<b>If NO, go to the next set of questions.</b> If YES, specify what type of sugar and amount is used in the child's tea or coffee.							
sugar						3989	
Does the child take any dairy or any other type of beverage?						YES	NO
<b>If NO go to the next section.</b> If YES, specify what type and how much the child takes.							
Fresh milk						2718	
Sour milk						2787	
Other beverages.							

**In the table below, list the foods commonly consumed by the child more than one per week that have not been included in the previous sections.**

Food	Amount	Times eaten				Code	Amount/day
		Per day	Per week	Per month	Seldom		

**THANK YOU FOR YOUR CONTRIBUTION**

Appendix B  
Information about the study and consent form

Hello, I am Nokuthula Vilakati from the University of Pretoria in South Africa, and I would like to give you a summary of what the study is about.

The University of Pretoria together with other members of the Africa Biofortified Sorghum (ABS) project: Africa Harvest; Pioneer Hi Breed International, a subsidiary of DuPont; the Council for Scientific and Industrial Research (CSIR); the Africa Agricultural Technology Foundation (AATF), the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and the University of California Berkeley, have formed a consortium led by the Africa Harvest Biotech Foundation International (AHBFI). These institutions are involved in a study to establish how to address malnutrition by improving the nutritional status of the rural poor through biofortification of the sorghum grain. In order to assist us in doing this, we need to determine what the patterns of sorghum consumption are. You can play an important part in helping us to get this information when we ask you questions on how you eat sorghum through a questionnaire.



The duration of the questionnaire is approximately 45 minutes. Your participation in the study is completely voluntary and you can inform us at anytime if you feel you no longer want to participate in the study.

### **Declaration**

I Nokuthula Vilakati have read the UP Guidelines on Ethics for research on human subjects and have prepared this proposal with due cognisance of its content. Further, I will adhere to the principles expressed when conducting the proposed study.

Signature .....

date.....

### **Informed consent for parent/guardian**

I .....the undersigned  
mother/caregiver of ..... Agree to take part in  
the following study,

### **Food consumption in selected rural communities in western Kenya with special reference to sorghum.**

I have been fully informed why the study is being done, what will be done, as well as the advantages and disadvantages that might arise from the procedures that are mentioned below.

### **The following have been pointed out to me and will be done:**

- (a) I will be asked questions about my child's food intake and food habits (aged between 2 to 5 years).
- (b) I will be interviewed by the researcher/assistant involved the survey.

- (c) The information gathered will be treated with confidence and will be used for the purpose of the mentioned research.
- (d) I understand that I can recall my consent on behalf of my child mentioned above at any time without prejudicing myself or my child.

Name of parent/caregiver.....Code number.....

Child's name.....Code number.....

Residential address/area.....

Signed at.....this day of .....August 2007.

Participants signature.....Witness.....

Person who informed participant about study.....