International Journal of Food Sciences and Nutrition, February 2008; 59(1): 46–60

Seasonal availability and dietary intake of β-carotene-rich vegetables and fruit of 2-year-old to 5-year-old children in a rural South African setting growing these crops at household level

MIEKE FABER[1] & RIA LAUBSCHER[2]

[1]*Nutritional Intervention Research Unit and* [2]*Biostatistics Unit, South African Medical Research Council, Tygerberg, South Africa*

Abstract
This study determined the seasonal availability and dietary intake of β-carotene-rich vegetables and fruit in a rural South African community growing these crops at household level. Monitoring year-round availability of vegetables and fruit in five local shops during 2004 showed that β-carotene-rich vegetables and fruit were seldom available in the shops. The dietary intake of 2-year-old to 5-year-old children was determined during February, May, August and November in 2004 and 2005 using an unquantified food frequency questionnaire and 5-day repeated 24-h recall (2005 only). Consumption of β-carotene-rich vegetables and fruit showed seasonal variation. Inadequate dietary vitamin A intake ranged from 6% in November to 21% in February and August. β-Carotene-rich vegetables and fruit contributed 49–74% of the total vitamin A intake. It is concluded that β-carotene-rich vegetables and fruit contribute a major part of the dietary vitamin A intake. Consumption of individual β-carotene-rich vegetables and fruit fluctuated according to the season; nonetheless, an adequate dietary vitamin A intake was maintained throughout the year for the majority of the study population.

Keywords: *Seasonality, vitamin A, vegetables and fruit, dietary intake, rural, South Africa*

Introduction

In South Africa, one out of three preschool children are vitamin A deficient (Labadarios et al. 1995) and more than one-half of 1-year-old to 9-year-old children consume a diet that supplies less than 50% of the required amount of vitamin A (Labadarios et al. 2000). Vitamin A deficiency leads to reduced resistance to infectious diseases and has far-reaching consequences on growth, development and health, especially in children (Ross 1996). High-dose vitamin A supplementation is being implemented nationally for children aged 6–59 months and for post-partum mothers within 6–8 weeks of delivery. National vitamin A supplementation coverage rates are 72.8% for children 6–11 months old, and 13.9% for children 12–59 months old (Hendricks et al. 2006).

Animal products are the best sources of vitamin A, but they are expensive, especially for the poor. Fruits and vegetables are a more affordable option. Yellow/orange-fleshed

Correspondence: Mieke Faber, Medical Research Council, PO Box 19070, Tygerberg 7505, South Africa. Tel: 27 21 9380404. Fax: 27 21 9380321. E-mail: mieke.faber@mrc.ac.za

ISSN 0963-7486 print/ISSN 1465-3478 online
DOI: 10.1080/09637480701664852

vegetables and non-citrus fruit and dark-green leafy vegetables do not contain vitamin A as such, but they contain provitamin A carotenoids, predominantly β-carotene, which the human body can convert to vitamin A. The bio-efficacy of β-carotene in plant foods is much less than previously thought (West et al. 2002). Nonetheless, consumption of cooked green leafy vegetables (Takyi 1999; Haskell et al. 2004, 2005), sweet potato (Jalal et al. 1998; Haskell et al. 2004; Van Jaarsveld et al. 2005) and carrots (Haskell et al. 2005) has been shown to improve vitamin A status.

A fundamental strategy to address vitamin A deficiency in resource-poor communities is to increase the availability of, access to and, ultimately, the consumption of β-carotene-rich vegetables and fruit. This can potentially be achieved through vegetable production at a household level. Locally produced β-carotene-rich vegetables and fruit can provide a valuable contribution to vitamin A intake in communities where alternative dietary sources are scarce, as was shown in Bangladesh (Bloem et al. 1996). Seasonal variation in the consumption of β-carotene-rich vegetables may, however, result in fluctuations in vitamin A intake (Bouis & Novenario-Reese 1997; Zou et al. 2002).

In a South African study, the production and consumption of yellow/orange-fleshed vegetables and non-citrus fruit and dark-green leafy vegetables were promoted in a rural village in KwaZulu-Natal (Faber et al. 2002b). Foods that were promoted included warm weather crops (butternut squash, orange-fleshed sweet potato), cool weather crops (carrots, Swiss chard) and tropical fruit (mango, pawpaw). Seasonal patterns of vegetable and fruit production can potentially impact on dietary vitamin A intake. In view of the potentially important contribution these vegetables and fruit can make towards the vitamin A intake and the seasonal fluctuations in the availability of these vegetables and fruit, it appeared important to quantify the contribution of these vegetables and fruit to total vitamin A intake in children over seasons. Therefore, the aim of this study was to determine the seasonal availability of β-carotene-rich vegetables and fruit, and the contribution of these vegetables and fruit to total vitamin A intake of 2-year-old to 5-year-old children in a rural community growing these vegetables at a household level.

Subjects and methods

Population

The study population resided in Ndunakazi and Bhasobha, two neighbouring rural villages in the Valley of a Thousand Hills in KwaZulu-Natal, South Africa. The population density is low and the households are scattered over a large mountainous area. The Ndunakazi village, for example, is estimated to be 11 km long and 1 km wide with approximately 200 households and, on average, eight persons per household. The lack of health facilities within the area prompted the implementation of community-based growth-monitoring activities in 1995 (Faber 2002). Approximately 90% of children aged 5 years and younger are covered by these growth-monitoring activities (Faber et al. 2003). The high prevalence of vitamin A deficiency (45.9% of preschool children; Oelofse et al. 1999) in the area prompted the establishment of a home-garden project that focused on β-carotene-rich vegetables and fruit. The community-based growth-monitoring activities were used as platform to promote the production of β-carotene-rich vegetables and fruit for household consumption in Ndunakazi since 1999 and in Bhasobha since 2001.

Preliminary survey

From February to December 2003, caregivers of 2-year-old to 5-year-old children who attended monthly community-based growth monitoring sessions completed a short questionnaire on the child's consumption of β-carotene-rich vegetables the previous week. If not consumed, the reasons were recorded. Availability of β-carotene-rich vegetables was categorized as very low (0% to <25% of households had access), low (25% to <50% of households had access), moderate (50% to <75% of households had access) and high (75–100% of households had access).

Availability of vegetables and fruit in local shops

The availability of vegetables and fruit in the five most accessible local shops were recorded during 2004. Nutrition monitors visited the shops daily, or as often as possible. Vegetables and fruit available in these shops were observed and recorded.

Dietary intake of 2-year-old to 5-year-old children

A repeated cross-sectional dietary study was performed during February, May, August and November in 2004 and 2005. Caregivers of registered 2-year-old to 5-year-old children of the community-based growth-monitoring project were recruited. Experienced nutrition monitors interviewed the caregivers in their own language (Zulu). The mothers gave their consent after the purpose and the nature of the study were explained to them. The Ethics Committee of the Medical Research Council approved the study.

An unquantified food frequency questionnaire was used for qualitative assessment of vegetable and fruit intake during 2004 and 2005 (Ndunakazi only). The caregiver had a choice of five options to describe the child's usual intake of listed foods. The five options were: (i) every day; (ii) most days (not every day but at least 4 days per week); (iii) once a week (at least once a week, but less often than 4 days a week); (iv) seldom (less than once a week/infrequently); and (v) never.

Dietary intake was quantified using a 24-h recall. The original plan was a single 24-h recall in 2004. However, for vitamin A, which is generally found in high concentrations in a few foods that are consumed sporadically, within-subject variation is high, making it difficult to obtain precise estimates of usual intakes in a population group. Increasing the number of measurement days minimizes within-subject variation (Gibson 2005). Therefore, five repeated 24-h recalls were done in the Ndunakazi village for each month that dietary data were collected (February, May, August and November) in 2005. The interviews were from Monday to Friday. The period covered by the 24-h dietary recall included one weekend and four weekdays (Sunday–Thursday).

Fresh food, plastic food models, household utensils, and three-dimensional sponge models were used to quantify and record food consumption for the previous day. In addition, dry oats was used to quantify portion sizes of certain food items, especially cooked food. The caregiver used the dry oats to indicate the quantity resembling the amount of food that the child ate. The fieldworker quantified the dry oats with a measuring cup. Food intake reported in household measures was converted into weight using the MRC Food Quantities Manual (Langenhoven et al. 1991a). The SAS software package (version 9.1; SAS Institute Inc., Cary, NC, USA) was used to convert food intake to macronutrients and micronutrients, using the MRC Food Composition Tables (Langenhoven et al. 1991b) as the food database. The MRC Food Composition Tables (database) serve as the main reference source for nutritional professionals and the food industry, and are used by nutrition and dietetic training institutions in South Africa.

The prevalence of inadequate dietary vitamin A intake was determined by calculating the proportion of children with intakes below the estimated average requirement (EAR) that was published by the Institute of Medicine (National Academy of Sciences 2000a).

Results

Preliminary survey

Data were collected for 187 children aged 2–5 years. Figure 1 shows the percentage of children who consumed β-carotene-rich vegetables the preceding week for February–December 2003. Unavailability was the main reason for not consuming these vegetables during the off-season. The availability of these vegetables throughout the year is presented in Table I. For butternut squash, consumption was highest during the first quarter of the year; the majority of households did not have access to butternut squash for the period April–December. For pumpkin and orange-fleshed sweet potato, consumption was highest during the first half of the year; the majority of households did not have access to these vegetables during the second half of the year. For carrots and spinach, consumption was highest during the second half of the year; the majority of households did not have access to these vegetables during the first half of the year.

Availability of vegetables and fruit in local shops

Table II presents the number of days per month each shop was visited. Figures 2 and 3 show the proportion of days certain vegetables and fruits were observed in the shops. Potato, cabbage, onions and tomato were available most of the time in all five shops. For yellow/orange-fleshed vegetables, pumpkin was never available, butternut squash was available for 2% of the recordings during February, and carrots for 5% during March. In terms of fruit, apples and bananas were available for most of the time, while the availability of oranges fluctuated. For yellow/orange-fleshed non-citrus fruit, mangoes were never available, some yellow peaches were available during February (20%), March (22%) and April (5%), and some pawpaws were available during July (2%), August (1%) and December (13%).

Dietary intake of 2-year-old to 5-year-old children

In total, caregivers of 139 and 56 children were interviewed during 2004 and 2005, respectively. During 2005, a 5-day repeated 24-h recall was carried out in Ndunakazi (not Bhasobha), and only caregivers who were able and willing to be interviewed on five consecutive days were included. This explains the smaller sample size for 2005 compared with 2004. Because of logistics it was not possible to interview caregivers of all the children each month.

Figure 4 shows the proportion of children who consumed β-carotene-rich vegetables and fruit at least once per week. Although the absolute values differed

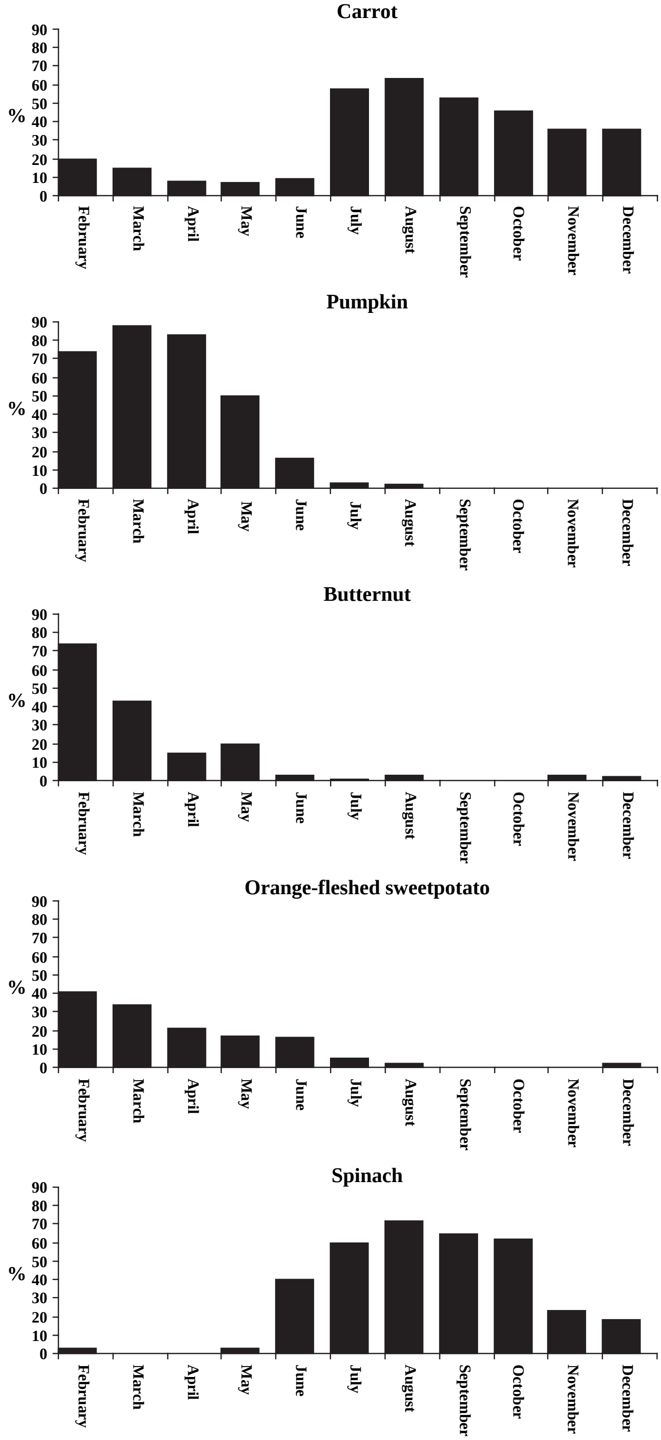

Figure 1. Proportion of 2-year-old to 5-year-old children who consumed β-carotene-rich vegetables the previous week during 2003.

Table I. Availability of β-carotene-rich vegetables for household consumption in 2003.

	First quarter	Second quarter	Third quarter	Fourth quarter
Carrots	−	−	++	++
Butternut squash	++	−	−	−
Pumpkin	+++	+	−	−
Orange-fleshed sweet potato	++	+	−	−
Spinach	−	−	+++	++

−, very low availability (0% to <25% of households); +, low availability (25% to <50% of households); ++, moderate availability (50% to <75% of households); +++, high availability (75–100% of households).

slightly between 2004 and 2005, the seasonal pattern within the two years was similar. Butternut squash was consumed mostly in the first quarter of the year. Although carrots were consumed throughout the year, the highest consumption was during November. Consumption of orange-fleshed sweet potato was low throughout the year. Of the dark-green leafy vegetables, spinach was consumed mostly during the second half of the year, and *imifino* (a collection of various dark-green leaves eaten as a vegetable; the leaves either grow wild or come from vegetables such as pumpkin, beetroot and sweet potato) at the beginning and at the end of the year. Paw-paw was consumed mostly during the latter part of the year.

Quantified dietary intake was measured by a 5-day repeated 24-h recall for a total of 56 children in Ndunakazi during 2005. Because of logistics not all the children were included on all four occasions (47–48 children per month).

The distribution of some nutrients was skewed. Table III therefore presents the micronutrient intakes as the median and interquartile range, namely Q1 (25th percentile) and Q3 (75th percentile). Dietary analysis was repeated, excluding all β-carotene-rich vegetables and fruit. These vegetables and fruit contributed between 49% and 74% of the total vitamin A intake (Table III).

The EAR of the Dietary Reference Intakes published by the Institute of Medicine (National Academy of Sciences 1997, 1998, 2000a, 2000b) is presented in Table III. The EAR is the average daily nutrient intake level estimated to meet the requirement of one-half of the population. As there is no EAR for calcium, the adequate intake is given. Dietary intake for the group is considered nutritionally adequate if the mean intake for the group is at or above the adequate intake. Table IV shows that the

Table II. Number of days per month each shop was visited in 2004.

	Shop 1	Shop 2	Shop 3	Shop 4	Shop 5
January	–	–	16	14	5
February	5	12	16	4	19
March	17	16	17	14	23
April	14	18	15	10	22
May	9	14	10	10	18
June	12	14	12	10	22
July	19	22	19	11	22
August	12	16	11	10	22
September	13	19	15	9	24
October	14	20	19	9	21
November	14	21	16	11	21
December	4	–	–	4	22

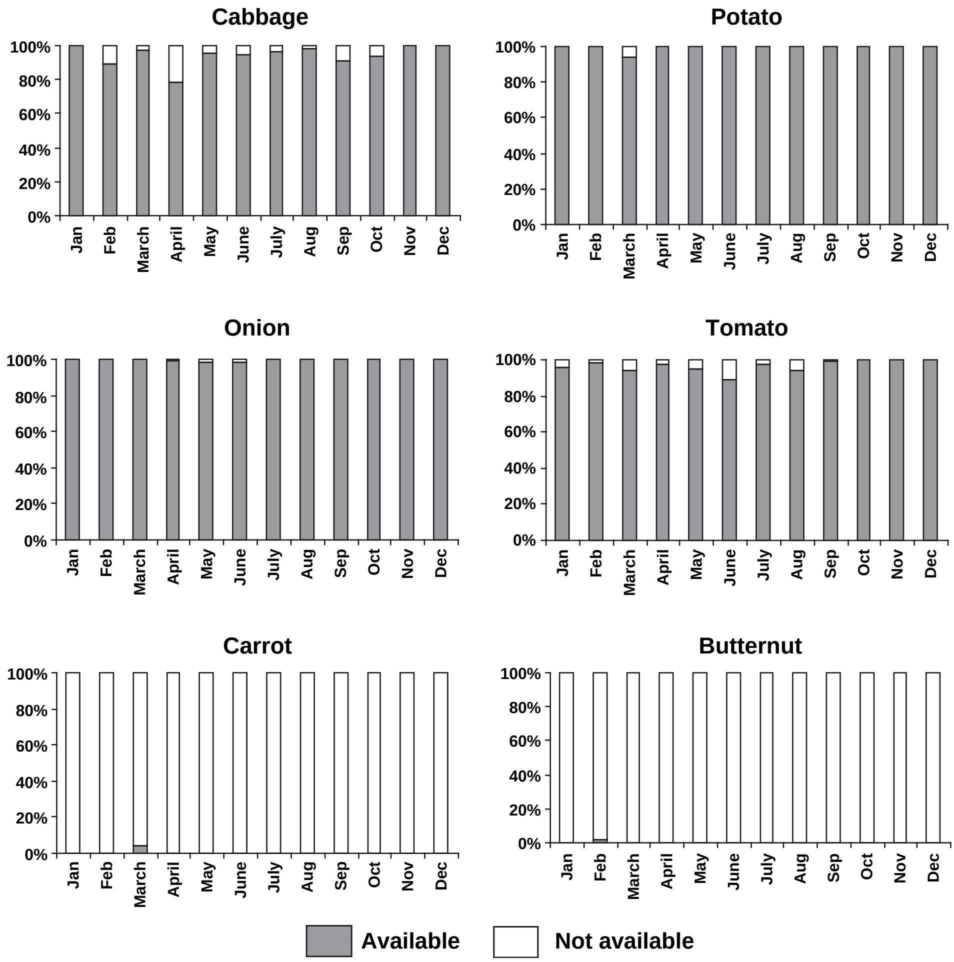

Figure 2. Proportion of days certain vegetables were observed in five local shops in 2004.

prevalence of inadequate dietary vitamin A intake (below the EAR of 210 Retinol Equivalents (RE) for 3-year-old and 275 RE for 4-year-old children) was approximately 20% or less, with the lowest prevalence during the last quarter of the year (November, 6%). When β-carotene-rich vegetables and fruit were excluded from the dietary analysis, more than 70% of children had an inadequate dietary vitamin A intake, with the highest prevalence in the first quarter of the year (February, 90%).

Table V presents the frequency at which vegetables and fruit were reported for the 4 months separately. Butternut squash and pumpkin are reported together, as the food database did not distinguish between these two foods.

Discussion

Yellow/orange-fleshed vegetables and fruit and dark-green leafy vegetables were not widely available in the local shops in this rural village. The unavailability of these β-carotene-rich vegetables and fruit in rural areas should be taken into account when

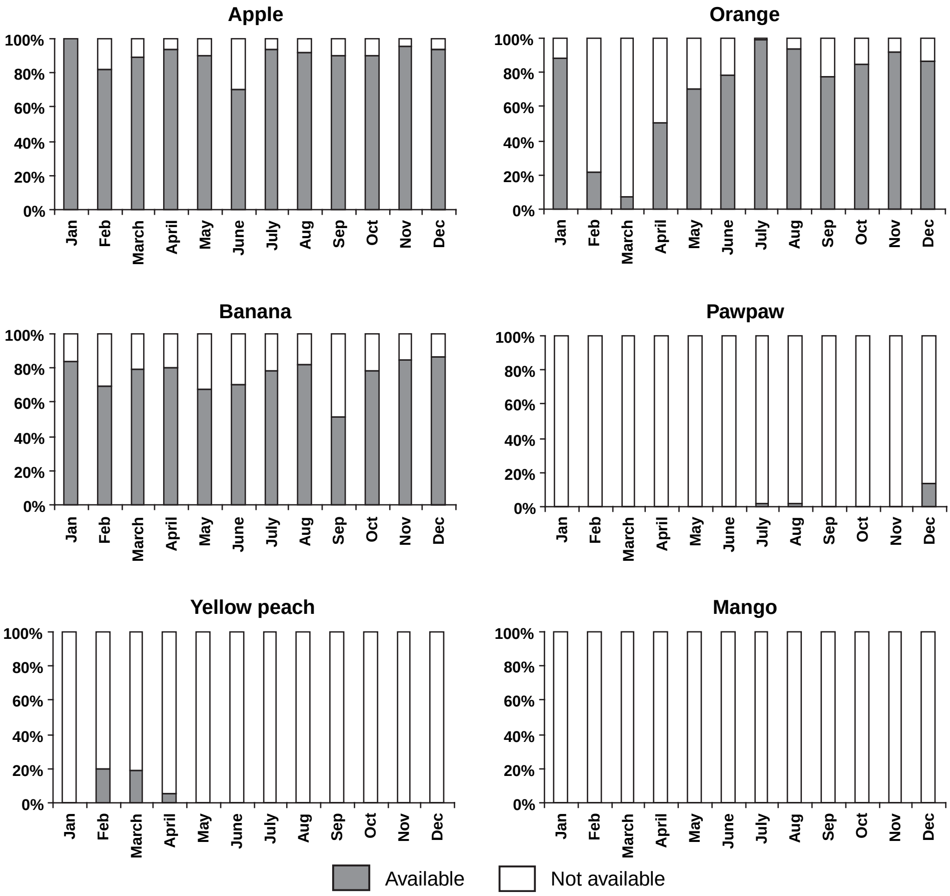

Figure 3. Proportion of days certain fruits were observed in five local shops in 2004.

vegetable and fruit consumption is promoted. Yellow/orange-fleshed vegetables and fruit and dark-green leafy vegetables are often promoted because of their potential favourable effect on vitamin A status. South Africa has a set of food-based dietary guidelines that forms the core of the Government's nutrition education messages to promote healthy eating habits among South Africans. Within the guideline 'Eat plenty of fruit and vegetables', it is suggested that, for example, a yellow and a green vegetable are eaten with the main meal of the day (Department of Health 2004). South Africa has also adopted the 5-a-day programme, and the mission of the '5-a-Day for Better Health Trust' is, through promotion and education, to increase the consumption of fresh fruit and vegetables by South Africans (About 5-a-day 2004).

In areas where β-carotene-rich vegetables and fruit are not available in local shops, the community will not have easy access to these foods unless they produce it locally. Production of β-carotene-rich vegetables and fruit for household consumption was promoted in the area, and a favourable effect on vitamin A intake has previously been reported (Faber et al. 2002a). Vegetable-garden projects should take into account that climatic and seasonal patterns affect the production of β-carotene-rich vegetables and can therefore impact on dietary vitamin A intake.

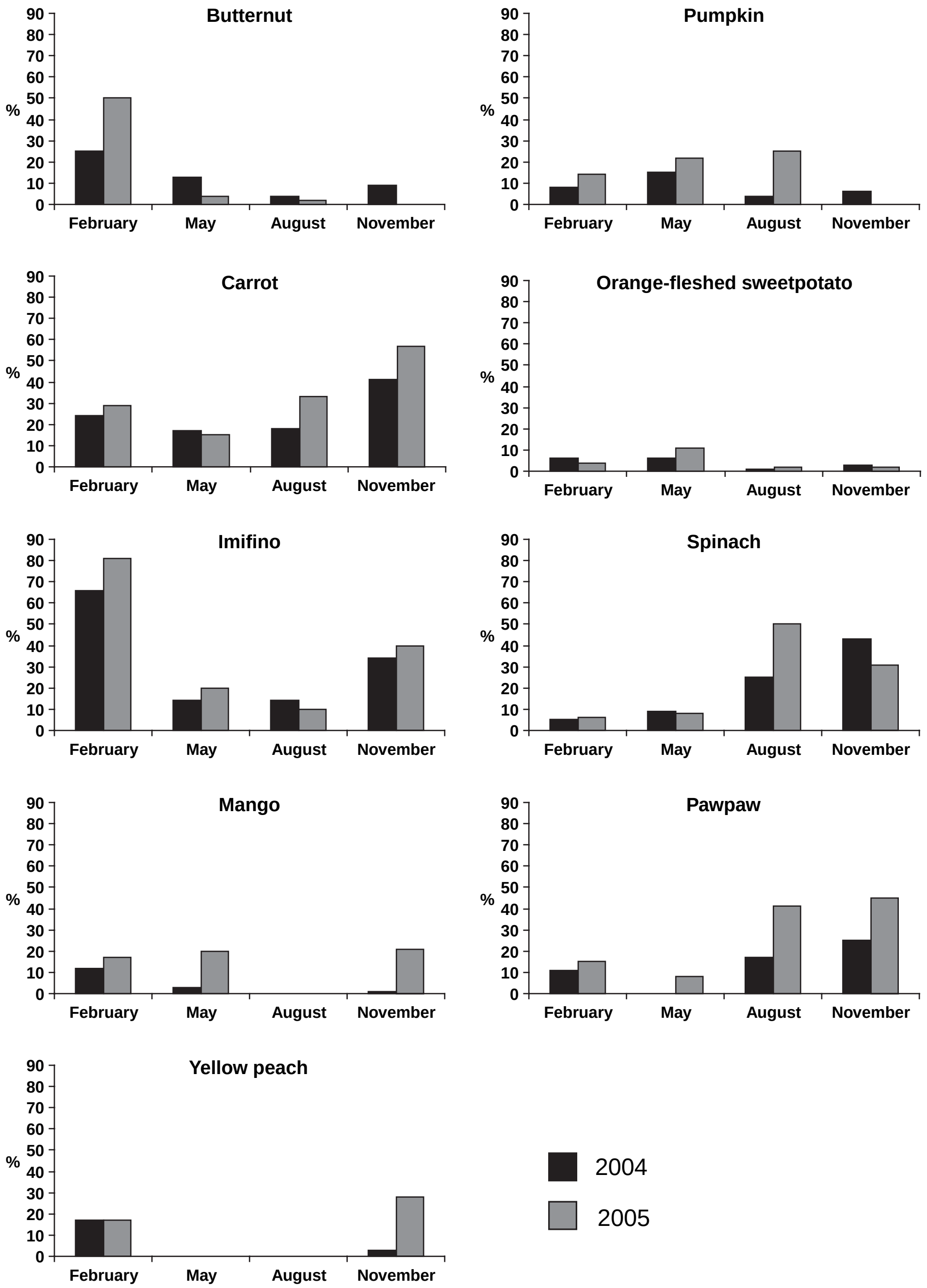

Figure 4. Proportion of children who consumed β-carotene-rich vegetables and fruit at least once a week during 2004 (in Ndunakazi and Bhasobha) and 2005 (in Ndunakazi).

Seasonal variation in the availability and consumption of β-carotene-rich vegetables and fruits was observed in the study population. Of the yellow/orange-fleshed vegetables, butternut squash, pumpkin and orange-fleshed sweet potato are warm weather crops and were consumed mostly during the first half of the year, while

Table III. Micronutrient intake of 2-year-old to 5-year-old children during February, May, August and November 2005, as determined by a 5-day repeated 24-h dietary recall.

			February 2005 ($n = 48$)		May 2005 ($n = 47$)		August 2005 ($n = 48$)		November 2005 ($n = 48$)	
Nutrient	EAR		Median	Q1; Q3	Median	Q1; Q3	Median	Q1; Q3	Median	Q1; Q3
Calcium (mg)	500[a]	Total[c]	202	(161; 258)	201	(136; 252)	195	(171; 247)	265	(218; 322)
	800[b]	Excl[d]	130	(107; 195)	164	(121; 211)	162	(138; 192)	189	(150; 235)
		%[e]		64		81		83	71	
Iron (mg)	3.0[f]	Total	5.9	(4.9; 8.3)	5.5	(4.8; 6.6)	6.1	(5.0; 7.2)	8.0	(6.3; 9.9)
	4.1[g]	Excl	4.4	(3.4; 5.8)	4.8	(4.2; 5.7)	4.9	(3.8; 5.9)	5.5	(4.8; 6.7)
		%		74		87		80	69	
Magnesium (mg)	65[f]	Total	191	(156; 229)	188	(164; 224)	194	(167; 236)	218	(201; 260)
	110[g]	Excl	164	(140; 199)	172	(153; 208)	171	(150; 213)	185	(166; 225)
		%		86		91		88	85	
Zinc (mg)	2.2[f]	Total	3.9	(3.2; 5.1)	4.2	(3.7; 4.9)	4.1	(3.4; 5.5)	4.7	(4.1; 5.8)
	4.0[g]	Excl	3.5	(2.8; 4.7)	4.2	(3.6; 4.8)	3.9	(3.1; 5.4)	4.4	(3.9; 5.6)
		%		90		100		95	94	
Vitamin A (RE)	210[f]	Total	382	(382; 591)	328	(223; 442)	482	(241; 562)	488	(488; 771)
	275[g]	Excl	99	(62; 161)	168	(92; 260)	130	(80; 162)	150	(106; 420)
		%		26		51		27	31	
Thiamine (mg)	0.4[f]	Total	0.62	(0.53; 0.74)	0.66	(0.57; 0.77)	0.62	(0.59; 0.77)	0.69	(0.60; 0.80)
	0.5[g]	Excl	0.61	(0.50; 0.70)	0.63	(0.53; 0.77)	0.60	(0.53; 0.72)	0.66	(0.57; 0.76)
		%		98		95		97	96	
Riboflavin (mg)	0.4[f]	Total	0.80	(0.59; 1.15)	0.80	(0.62; 1.04)	0.86	(0.65; 0.18)	0.92	(0.71; 1.19)
	0.5[g]	Excl	0.68	(0.46; 1.05)	0.74	(0.59; 0.95)	0.72	(0.49; 1.10)	0.77	(0.53; 1.04)
		%		85		92		84	84	
Niacin (mg)	5.0[f]	Total	4.5	(3.9; 5.9)	5.2	(4.5; 7.0)	4.8	(3.9; 6.3)	5.7	(5.1; 7.0)
	6.0[g]	Excl	4.4	(3.5; 5.6)	5.1	(4.3; 6.9)	4.7	(3.8; 6.1)	5.6	(4.8; 6.9)
		%		98		98		98	98	

Table III (*Continued*)

			February 2005 ($n = 48$)		May 2005 ($n = 47$)		August 2005 ($n = 48$)		November 2005 ($n = 48$)	
Nutrient	EAR		Median	Q1; Q3	Median	Q1; Q3	Median	Q1; Q3	Median	Q1; Q3
Vitamin B_6 (mg)	0.4[f]	Total	0.68	(0.58; 0.95)	0.82	(0.68; 0.96)	0.78	(0.66; 1.04)	0.85	(0.73; 1.03)
	0.5[g]	Excl	0.66	(0.55; 0.94)	0.79	(0.65; 0.90)	0.76	(0.61; 0.95)	0.79	(0.71; 1.01)
		%		97		96		97	93	
Vitamin B_{12} (μg)	0.7[f]	Total	0.36	(0.22; 0.63)	0.73	(0.36; 1.83)	0.48	(0.26; 1.05)	0.54	(0.20; 2.77)
	1.0[g]	Excl	0.36	(0.22; 0.63)	0.73	(0.36; 1.83)	0.48	(0.26; 1.05)	0.54	(0.20; 2.77)
		%		100		100		100	100	
Folic acid (μg)	120[f]	Total	169	(133; 239)	173	(145; 215)	229	(181; 287)	225	(187; 298)
	160[g]	Excl	162	(126; 237)	160	(128; 199)	200	(153; 234)	221	(174; 288)
		%		96		92		87	98	
Vitamin C (mg)	13[f]	Total	29	(19; 39)	37	(29; 56)	40	(29; 58)	52	(42; 65)
	22[g]	Excl	23	(16; 32)	33	(26; 54)	36	(23; 47)	44	(33; 54)
		%		79		89		90	85	

Data presented as the median and interquartile range (Q1; Q3). [a]Adequate intake for age 2 and 3 years. [b]Adequate intake for age 4 and 5 years. [c]Total dietary intake. [d]Excluding β-carotene-rich vegetables and fruit. [e]Percentage of total intake – nutrient supplied by dietary sources other than β-carotene-rich vegetables and fruit. [f]EAR for age 2 and 3 years. [g]EAR for age 4 and 5 years.

Table IV. Prevalence of inadequate dietary vitamin A intake of 2-year-old to 5-year-old children during February, May, August and November 2005, as determined by a 5-day repeated 24-h dietary recall.

Vitamin A intake <EAR[a]	February 2005 ($n=48$)	May 2005 ($n=47$)	August 2005 ($n=48$)	November 2005 ($n=48$)
Total[b]	21	19	21	6
Excl[c]	90	72	83	73

Data presented as percentages. [a]EAR = 210 for 3 year olds and EAR = 275 for 4 year olds (National Academy of Science 2000a). [b]Total dietary intake. [c]Excluding β-carotene-rich vegetables and fruit.

carrots were consumed mostly during the second half of the year. The period of availability of spinach and *imifino* complemented each other, with spinach being available during the latter part of the year, and *imifino* mostly during the first half of the year. Locally produced spinach (Swiss chard), together with indigenous wild greens and the leaves of pumpkin and sweet potato, can therefore provide a continuous supply of dark-green leafy vegetables throughout the year. This highlights the importance of promoting a variety of β-carotene-rich vegetables to ensure year-round availability.

South Africa is one of the partner countries in the Vitamin A for Africa initiative, which promotes the production and consumption of orange-fleshed sweet potato to alleviate vitamin A deficiency in sub-Saharan African countries. In KwaZulu-Natal (the province where the study population resided), the planting season for the orange-fleshed sweet potato is from September to January (Faber et al. 2006), although this may vary according to climatic fluctuations. The sweet potato can be harvested 5 months after the planting date. Provided that the planting is staggered during the

Table V. Number of times vegetables and fruit were reported during the 5-day repeated recall period for 2-year-old to 5-year-old children.

Food	February 2005 ($n=48$)	May 2005 ($n=47$)	August 2005 ($n=48$)	November 2005 ($n=48$)
Fruit				
Apple	34	37	24	50
Banana	42	37	43	21
Grapes	17	–	–	–
Mango	–	–	–	7
Naartjie	–	3	2	
Orange	8	34	44	43
Paw-paw	3	4	20	36
Peach	7	–	–	6
Pear	11	8	9	2
Plum	1	–	–	–
Mango juice	5	4	–	–
Peach juice	2	–	–	–
Vegetables				
Cabbage	54	81	71	74
Carrots	4	2	3	9
Pumpkin or butternut squash	58	40	7	–
Orange-fleshed sweet potato	3	2	–	–
Imifino	77	20	21	62
Spinach	–	15	63	14

planting season, locally produced orange-fleshed sweet potato should be available from March to July. This should have been reflected in the May survey, which was not the case. The disappointingly very low intake of orange-fleshed sweet potato during May could possibly be explained by the facts that: the households did not practice staggered planting; the orange-fleshed sweet potato is a newly introduced crop and a stronger promotion campaign may be needed to sustain a high intake over a period of time; and the orange-fleshed sweet potato does not easily blend into the traditional way of eating, emphasizing the importance of developing traditional recipes that include the orange-fleshed sweet potato.

Paw-paw trees were growing in the area before the intervention, but consumption of paw-paw was very low. Dietary intake was determined by a single 24-h recall during February 1999 and 2000, and November 2000 (Faber et al. 2001b). None of the children consumed paw-paw in the February 1999 survey. Two per cent of the children consumed paw-paw in the February and November 2000 surveys. It is therefore encouraging that 36% of the children in the November 2005 survey consumed paw-paw during the 5-day recall period (it should be kept in mind that the current study used a 5-day repeated recall, while the other studies used a single recall).

Seasonal patterns of vegetable production can potentially impact on dietary vitamin A intake. Although vitamin A intake was lower during May than November, this difference is not considered of major physiological importance. Throughout the year, approximately 20% or less of the children had an inadequate dietary vitamin A intake. With the exception of May, β-carotene-rich vegetables and fruit supplied almost 70% of the total vitamin A intake. This is consistent with data that suggest approximately 80% of the vitamin A intake in Africa is from plant sources (World Health Organization 1995). When excluding the contribution of β-carotene-rich vegetables and fruit to the total dietary vitamin A intake, more than 70% of the children had an inadequate dietary vitamin A intake. Within-subject variation makes it difficult to obtain precise levels for inadequate vitamin A intake, and dietary intake should thus be recorded for several days (Gibson 2005). It was not feasible to record dietary intake for more than 5 days per month. This is not seen as a major limitation as the study population consumed a monotonous cereal-based diet, which will probably reduce within-subject variation.

The β-carotene-rich vegetables and fruit also contributed towards the total dietary intake of, especially, calcium and iron, and, to a lesser extent, magnesium, riboflavin and vitamin C.

Data from the food frequency questionnaire showed that carrots were consumed throughout the year, suggesting that the study population obtained some vegetables from shops outside of the area. The consumption of carrots reported for the 5-day recall period was much lower than the consumption reported using a food frequency questionnaire. Although this discrepancy cannot be explained, it can be speculated that carrots were used in dishes, such as stews, and were not identified during the 24-h recall. Although the food frequency questionnaire and the 24-h recall data showed similar trends for most of the β-carotene-rich vegetables and fruit, it differed for some (e.g. carrot consumption). It is therefore important to include more than one dietary methodology in a survey.

In terms of individual β-carotene-rich vegetables and fruit reported during the four study periods (February, May, August and November), consumption of these foods differed according to the season. This should be taken into consideration when different studies are compared, or when before–after studies are carried out. When reporting dietary data it may be better to report the consumption of β-carotene-rich vegetables and fruit grouped together, rather than each vegetable and fruit individually.

It is important to note that this study was carried out in an area where the production and consumption of yellow/orange fleshed vegetables and fruit and dark-green leafy vegetables were promoted through a home-garden project. Before implementation of the home-garden project the intake of vitamin A-rich foods was low, resulting in a median vitamin A intake of 35% of the required amount (Faber et al. 2001a). The garden project resulted in an increased intake of yellow/orange-fleshed and dark-green leafy vegetables, and as a result the intake of vitamin A and various other essential micronutrients (e.g. calcium, iron and vitamin C) increased (Faber et al. 2002a). This study showed that production and consumption of a variety of β-carotene-rich vegetables and fruit could sustain an adequate vitamin A intake throughout the year for the majority of the population. This was achieved by local production of a variety of β-carotene-rich vegetables and fruit, and by staggered planting, which lengthens the period of availability.

Acknowledgements

The South African Sugar Association funded this study. The authors' sincere appreciation goes to Bongi Duma, Nhlanhla Hlophe, Derick Mkhize, Lindiwe Msiya, Angeline Ndlovu and France Phungula for recruiting the participants, completing the questionnaires and coding the dietary data, to Ayanda Zondi for coding the dietary data, to Lee-Ann Runcie for capturing the data, and to the children's caregivers for participating in the study.

References

About 5-a-day. 2004. Available online at: http://www.5-a-day.co.za (accessed 10 January 2007).

Bloem MW, Hug N, Gorstein J, Burger S, Kahn T, Islam N, Baker S, Davidson F. 1996. Production of fruits and vegetables at the homestead is an important source of vitamin A among women in rural Bangladesh. Eur J Clin Nutr 50(Suppl):S62–S67.

Bouis H, Novenario-Reese MJG. 1997. The determinants of demand for micronutrients: An analysis of rural households in Bangladesh. Washington, DC: International Food Policy Research Institute.

Department of Health. 2004. South African guidelines for healthy eating for adults and children over the age of seven years. Pretoria: Department of Health, Directorate of Nutrition.

Faber M. 2002. Community-based growth monitoring in a rural area that lacks health facilities. Dissertation, University of Stellenbosch, Stellenbosch.

Faber M, Jogessar VB, Benadé AJS. 2001a. Nutritional status and dietary intakes of children aged 2–5 years and their caregivers in a rural South African community. Int J Food Sci Nutr 52:401–411.

Faber M, Venter S, Phungula MAS, Benadé AJS. 2001b. An integrated primary health care and provitamin A household food production programme: Impact on food consumption patterns. Food Nutr Bull 22:370–375.

Faber M, Venter S, Benadé AJS. 2002a. Increased vitamin A intake in children aged 2–5 years through targeted home-gardens in a rural South African community. Public Health Nutr 5:11–16.

Faber M, Venter S, Phungula MAS, Dhansay MA, Benadé AJS. 2002b. Home-gardens focusing on the production of yellow and dark-green leafy vegetables increase serum retinol concentrations of 2–5-y-old children in South Africa. Am J Clin Nutr 76:1048–1054.

Faber M, Phungula MAS, Kvalsvig JD, Benadé AJS. 2003. Acceptability of community-based growth monitoring in a rural village in South Africa. Food Nutr Bull 24:350–359.

Faber M, Laurie S, Venter S. 2006. Home-gardens to address vitamin A deficiency in South Africa: A food based approach. Pretoria: Agricultural Research Council.

Gibson RS. 2005. Principles of nutritional assessment. 2nd ed. Dunedin: Oxford University Press. ch. 6.
Haskell MJ, Jamil KM, Hassan F, Peerson JM, Hossain MI, Fuchs GJ, Brown KH. 2004. Daily consumption of Indian spinach (*Basella alba*) or sweet potatoes has a positive effect on total-body vitamin A stores in Bangladeshi men. Am J Clin Nutr 80:705–714.
Haskell MJ, Pandey P, Graham JM, Peerson JM, Shrestha RK, Brown KH. 2005. Recovery from impaired dark adaptation in nightblind pregnant Nepali women who receive small daily doses of vitamin A as amaranth leaves, carrots, goat liver, vitamin A-fortified rice, or retinyl palmitate. Am J Clin Nutr 81:461–471.
Hendricks M, Bourne L, Eley B. 2006. Health and related indicators. In: Ijumba P, Padarath A, editors. South African health review 2006. Durban: Health Systems Trust. pp 203–220. Available online at: www.hst.org.za/generic/29 (accessed 8 January 2007).
Jalal F, Nesheim MC, Agus Z, Sanjur D, Habicht JP. 1998. Serum retinol concentrations in children are affected by food sources of β-carotene, fat intake, and anthelmintic drug treatment. Am J Clin Nutr 68:623–629.
Labadarios D, Van Middelkoop A, Coutsoudis A, Eggers RR, Hussey G, Ijsselmuiden C, Kotze JP. 1995. Children aged 6 to 71 months in South Africa, 1994: Their anthropometric, vitamin A, iron and immunisation coverage status. Johannesburg: South African Vitamin A Consultative Group (SAVACG).
Labadarios D, Steyn N, Maunder E, MacIntyre U, Swart R, Gericke G, Huskisson J, Dannhauser A, Varster HH, Nesamvuni AE. 2000. The national food consumption survey (NFCS): Children aged 1–9 years, South Africa, 1999. Pretoria: Department of Health, Directorate of Nutrition.
Langenhoven ML, Conradie PJ, Wolmarans P, Faber M. 1991a. MRC food quantities manual, 1991. 2nd ed. Parow: Medical Research Council.
Langenhoven ML, Kruger M, Gouws E, Faber M. 1991b. MRC food composition tables, 1991. 3rd ed. Parow: Medical Research Council.
National Academy of Sciences. 1997. Dietary reference intakes for calcium, phosphorous, magnesium, vitamin D, and fluoride. Washington, DC: National Academy of Sciences. 448 pp. Available online at: http://books.nap.edu/catalog/5776.html (accessed 10 May 2004).
National Academy of Sciences. 1998. Dietary reference intakes for thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, panthothenic acid, biotin, and choline. Washington, DC: National Academy of Sciences. 592 pp. Available online at: http://books.nap.edu/catalog/6015.html (accessed 10 May 2004).
National Academy of Sciences. 2000a. Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Washington, DC: National Academy of Sciences. 800 pp. Available online at: http://books.nap.edu/catalog/10026.html (accessed 10 May 2004).
National Academy of Sciences. 2000b. Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. Washington, DC: National Academy of Sciences. 529 pp. Available online at: http://books.nap.edu/catalog/9810.html (accessed 10 May 2004).
Oelofse A, Faber M, Benadé JG, Benadé AJS, Kenoyer DG. 1999. The nutritional status of a rural community in KwaZulu-Natal, South Africa: The Ndunakazi project. Centr Afr J Med 45:14–19.
Ross AC. 1996. The relationship between immunocompetence and vitamin A status. In: Sommer A, West KP Jr, (editors). Vitamin A deficiency: Health, survival, and vision. New York: Oxford University Press.
Takyi EEK. 1999. Children's consumption of dark green, leafy vegetables with added fat enhances serum retinol. J Nutr 129:1549–1554.
Van Jaarsveld PJ, Faber M, Tanumihardjo SA, Nestel P, Lombard CJ, Benadé AJS. 2005. β-Carotene-rich orange-fleshed sweet potato improves the vitamin A status of primary school children assessed with the modified-relative-dose-response test. Am J Clin Nutr 81:1080–1087.
West CE, Eilander A, van Lieshout M. 2002. Consequences of revised estimates of carotenoid bioefficacy for dietary control of vitamin A deficiency in developing countries. J Nutr 132:2920S–2926S.
World Health Organization. 1995. Global prevalence of vitamin A deficiency. Micronutrient deficiency information system working paper 2. Geneva: World Health Organization.
Zou XN, Taylor PR, Mark SD, Chao A, Wang W, Dawsey SM, Wu YP, Qiao YL, Zheng SF. 2002. Seasonal variation of food consumption and selected nutrient intake in Linxian, a high risk area for esophageal cancer in China. Int J Vitam Nutr Res 72:375–382.

This paper was first published online on iFirst on 27 November 2007.