Investigations into Health and Nutrition in East Africa

with 132 tables and 70 figures

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Contents

List of Tables

1. Introduction

Today it is clearly recognized in most African countries that no successful economic development can be achieved by people who live under poor conditions of health and nutrition. A survey carried out in the Highlands of Kenya in autumn 1965 (in Ichuga and Kiamariga in the administrative district of Mathira) yielded some information on the impact of the development of agricultural market production and diversification of a former subsistence economy on the state of nutrition of the rural population. The findings, though in their details not always representative due to the limited extent of the survey, may nevertheless allow some general conclusions.

2. Methods Employed

In Kiamariga and Ichuga a total of 66 households were visited. The survey refers to economic conditions, agriculture, food consumption, and some characteristics of the individual family members. External examinations for symptoms of nutrient deficiencies follow the recommendations of the World Health Organization[1]. Furthermore, statistics from WHO, the United Nations Technical Assistance Board (UNTAB), the province and district administrations, the agriculture department of Mathira Division, and the local agricultural cooperatives for coffee, milk, and pyrethrum have been analysed for basic information.

The nutrient intake absorption of food into the human body from the generally consumed foodstuffs has been calculated by means of food composition tables[2]. The loss of vitamin content in basic foodstuffs due to cooking, however, was not taken into account, as such losses can be very different according to type and duration of cooking. In many cases meals are cooked for several hours, which leads to the destruction of large amounts of the different vitamins.

Nutrient requirements were estimated from the North American recommended dietary allowances[3] and the requirement figures published by FAO, taking into account age, sex, body height and weight of the individual family member. Age and body weight served also as a basis for the estimation of protein requirements, considering an assumed net protein utilization (NPU) of 70%[4]. In order to facilitate a comparison with clinical signs, minimum

1 Expert Committee on Medical Assessment of Nutritional Status, WHO, Techn. Rep. Ser. No. 258, Geneva 1963.
2 B. S. Platt: Tables of representative values of foods commonly used in tropical countries. Med. Res. Council, Special Rep. Ser. No. 302, London H.M.S.O., 1962.
3 Recommended Dietary Allowances. National Research Council, 6th ed., Washington 1964.
4 Protein Requirements. Rep. of a joint FAO/WHO Expert Group, Rome 1965.

requirements instead of recommended allowances were used for vitamin B_1, B_2 and Niacin, i.e. 0.2 mg, 0.3 mg, and 4.4 mg respectively.
Skinfold thickness was measured with the LANGE skinfold caliper. Regarding the vitamin analyses of wild vegetables, the following methods were employed: the 2.6 dichlorophenol-indophenole method according to J. TILLMANS[5] and M. van EEKELEN[6] concerning vitamin C; the thiochrome reaction as described in BEYTHIEN-DIEMAIR[7] concerning vitamin B_1; and the carotene values spectrophotometrically determined according to A. SREENIVASAN and R. M. VAIDIYA[8].

3. Some Background Data of the Nyeri District

Agricultural development

An extract of the officer's annual report summarizing the development of production and the increase in sales value of the most important marketed agricultural products is given in table 1. Adding up the sales income, a marked increase from £355,000 in 1961 to £690,000 in 1964 becomes evident. Coffee shows an increase in output of about 80% and its sales value went up 65%. The respective figures for milk production were 500% and 220% respectively, the production of tea increased almost three-fold and pyrethrum by 50%. In 1964 these four products represented 69% of the total sales income, the share of the individual products being 47.9% for coffee, 10.4% for milk, 5.4% for tea, and 5.1% for pyrethrum. In 1961 the share of these products had been as high as 86%. This decline provides clear evidence that the process of diversification is now under way. Coffee still remains the most important single crop, though its share dropped from 55.5% in 1961 to 47.9% in 1964. Milk production, especially, will play an important role in the future. As the domestic cattle breeds of Kenya (Zebu) are less efficient milk producers in comparison to interbred and European stock, better breeding methods in the future make a further increase likely. At present, the Government of Kenya is already supporting a programme of artificial insemination of domestic cattle, using the sperm of highly efficient European breeds. Large scale attempts are also under way for better cultivation of tobacco, sugar cane, and wheat, as well as increasing meat production by the raising of pigs. It can be assumed, therefore, that future increases in production as well as in sales value will bring about further development in diversification.

5 J. TILLMANS: Zeitschrift zur Untersuchung von Lebensmitteln, 54 (1927), 33.
6 M. VAN EEKELEN et al.: Zeitschrift für Vitaminforschung 6 (1937), 150.
7 BEYTHIEN-DIEMAIR: Laboratoriumsbuch für den Lebensmittelchemiker. Dresden–Leipzig 1963.
8 A. SREENIVASAN and R. M. VAIDIYA: In: E. KNOBLOCH: Physikalisch-chemische Vitaminbestimmungsmethoden. Berlin 1963.

Table 1. *Development of Output and Sales Value of Important Marketed Agricultural Products from 1961 to 1964*

Product	1961	1962	1963	1964
Coffee (tons)	552	692	1,089	1,004
sales value in £	200,663	209,084	280,190	330,813
Tea (owt)	2,212	2,708	3,991	6,551 [a]
sales value in £	48,060	57,660	44,700	37,290
Pyrethrum (tons)	112	126	189	172
sales value in £	33,051	40,160	34,025	35,220
Tobacco (tons)	88	104	61	90
sales value in £	3,527	7,834	10,065	11,112
Wattle Bark (tons)	1,301	1,919	1,834	1,098
sales value in £	10,027	16,858	16,673	10,198
Onions (tons)	41	12	23	45
sales value in £	1,845	556	690	900
Sugar cane (tons)	31	81	98	430
sales value in £	124	324	392	860
Wheat (bags)	61	–	17	75
sales value in £	122	–	400	1,800
Potatoes (bags)	546	700	166 (t)	–
sales value in £	546	700	1,660	–
Sweet Potatoes (bags)	29	42	106 (t)	15
sales value in £	29	42	1,325	96
Vegetables (tons)	678	760	161	98
sales value in £	14,916	16,858	1,932	100
Eggs (doz)	13,737	12,000	14,800	22,780
sales value in £	1,373	1,200	1,850	2,849
Hides and Skins	29,277	36,590	47,695	30,130
sales value in £	4,391	5,489	7,743	2,900
Milk (gal.)	205,156	255,998	735,518	1,040,690
sales value in £	22,294	25,138	55,146	72,245
Pigs	–	1,050	1,690	2,329
sales value in £	–	5,545	12,600	13,765

[a] 11 months.
Sources: Agriculture officer's Annual Reports, Nyeri, 1962/64.

Health Services

Health services for the rural population are still insufficient and in some areas even not yet available. The last years have shown an increase in the number of patients treated at the Provincial and District Hospital at Nyeri. Admissions into Hospital went up from 4,335 in 1962 to 5,733 in 1964, representing 2% of the total population of Nyeri District. First and repeated attendances

at outpatients' clinics rose from 28,039 to 44,138 and from 30,832 to 86,308 respectively, i.e. 16% and 31% of the total population[9]. Due to the classification of diseases used for hospital statistics as well as to diagnostic difficulties (malnutrition superseded by infections) available figures only occasionally indicated malnutrition as the main cause of illness. In 1964 5.6% of all outpatients were children below the age of 2 years and admitted for gastro-intestinal infections, 1.6% were children admitted with kwashiorkor. A recent dietary survey carried out by a WHO team in Nyeri District, however, showed an intake of almost all nutrients which is insufficient if compared to standards from industrialized countries.

4. Characteristics of the Sublocations Ichuga and Kiamariga

Land Utilisation, Cultivation of Crops and Cattle Breeding

In spite of the fact that Kiamariga and Ichuga are very near the equator, the temperature of this region is mild due to the high altitude of 4,500 to 6,300 feet above sea level. Only a few sites are unfavourable for growing tropical plants. While the highest points of the sloping lands are usually still grass-land, further below terraces of coffee plants and bananas follow, while at the bottom, as a rule, a mixed cultivation of corn is found. This sequence follows a recommendation by the Government to avoid soil erosion.

In most of the farms investigated a clear distinction between subsistence economy and the cultivation of cash crops was evident. Market production generally consists of coffee, pyrethrum, onions, potatoes, tomatoes and from time to time bananas and cabbage. Principally the high altitude would be ideal for the cultivation of tea, but unfortunately the scarcity of rainfall and the lack of water for irrigation purposes makes the growing of tea impossible.

Climate and altitude of Ichuga make this region a natural area for growing coffee. Coffee cultivation, therefore, started in 1950 only one year after the introduction of coffee in the agriculture of Kenya. In most parts of Kiamariga, however, the cultivation of coffee did not start until after 1959. Today, coffee plantations in Ichuga consist of 240 acres and in Kiamariga of 160 acres. The coffee plants of Ichuga are now in full production, while those in Kiamariga still yield less because they were started later. Methods for the cultivation of coffee are prescribed by the Coffee Co-operative Society. These include terraces on sloping lands as protection against soil erosion, the improvement of soil fertility by organic manure every year, and the use of mineral fertilizers after the first harvest (usually three or four years after planting). Young plants are sold to the farmers by the Society, which is also

9 Personal communication by Provincial Medical Officer, Nyeri 1965.

responsible for all financial transactions and operates a very well organized advisory service. From time to time advisory personnel of the Society is visiting the individual coffee plantations, giving advice as well as practical and financial aid. Fertilizers, which are distributed by the Society, can be obtained on easy terms of credit, if needed, and the individual farmer can receive advance payment for his yet unharvested crop.

Though the Society, mindful of sluggish world demand, had recommended that from 1963 onwards coffee-plantations should not be expanded this recommendation was only partly followed. In a recent survey quite a number of new coffee-plants were discovered and the farmers, when questioned about their future plans for development, expressed their desire to plant more coffee. In accordance to this, the number of coffee growers in the Mathira-Division has been growing steadily from 475 in June 1952 to 8,710 in October 1965. In 1964, 415,000 lbs. of coffee were harvested in Ichuga and about 270,000 lbs. in Kiamariga. Expectations for 1965 are in the range of 500,000 and 300,000 lbs. respectively.

Pyrethrum has been cultivated in Kiamariga and Ichuga since 1962, the respective yields in 1964 being 2,750 lbs. (Kiamariga) and 2,600 lbs. (Ichuga). In most cases the increased cultivation of pyrethrum was considered a response to the restrictions placed upon coffee growing. Compared with 1962, when 6 acres were planted with pyrethrum, 22 acres were found in 1965 and a further expansion is expected.

Onions belong to the more important cash crops as well and are partly planted between the rows of corn, partly on separate fields, which normally receive better care. The same applies to potatoes and tomatoes. Among the more important subsistence crops corn, beans, potatoes, sweet potatoes, bananas, onions, cabbage, peas, and yams may be mentioned; they are grown to a much smaller extent than cash crops. Food crops are never planted in rows, seldom fertilized and hardly ever kept free of weeds. Just before the rainy season and immediately before planting the soil is tilled to a depth of 4 to 6 inches only with the hoe.

Due to the moderate climate it takes on the average from 7 to 8 months to grow corn. Immediately after the first harvest in July corn is, however, planted a second time and cut green in October as feed for the animals. More than half of the farms investigated used this method of raising corn. All other crops can normally be planted and harvested twice a year.

As can be expected, the survey revealed large differences in yields which are attributable to differences in soil and location as well as to differing methods of cultivation. With regard to corn the highest yield was 20 bags per acre on the most advanced farms where corn is grown unmixed as single crop, planted in rows and fertilized regularly. In contrast to this, the average yield was only five bags per acre. Potatoes, which are grown separately and cultivated rather intensively, yielded from 40 to 50 bags per acre. Sweet

potatoes, though not as intensively cultivated, even showed an average yield of 80 to 100 bags per acre, the leaves and buds not included, which are used for feeding purposes. In most cases only corn as the most important daily foodstuff is stored in wooden barns. It is not usual to provide storage for any other foodstuffs, as with regard to these only the daily needed quantities are harvested. Cash crops have often to be sold immediately to meet expenses and to pay back accumulated debts.

Most of the farmers questioned in Kiamariga and Ichuga were cattle raisers as well. Most widespread are Zebu breeds and cross-breeds with European stock, while the very progressive ones are more and more raising European pure breeds for the purpose of increasing milk production. During the rainy season a quantity of 4 pints of milk a day can be expected of Zebu cows, while cross-bred ones produce 12 to 32 pints and pure European stock up to 5 gallons (40 pints) a day. European and cross-breeded stock, however, require a good deal of extra care like desinfecting baths and a regulated water supply.

In 1965 (up to September) milk production in Kiamariga delivered to the co-operative totalled 22,800 gallons compared to 38,900 gallons in Ichuga. As against the same period in 1964, a 20% rise in production and a 30% rise in milk prices paid to the producers resulted in an overall increase of income of 36%, which clearly demonstrates the importance of milk production for the farmers, even if the quantity of milk delivered by individual farmers was relatively low. Whenever asked how they intend to use their increased incomes, all farmers decided on further purchases of grade cattle. Only occasionally the farmers raise sheep, goats, and chickens along with cattle for meat production.

Income of the Farmers

Although some of the statistics of the UNTAB survey in Kiamariga are somewhat outdated, as the survey was carried out in 1963, they still allow to assess the prevailing economic conditions. The author's own survey in spring and autumn 1965, in contrast, concentrated on qualitative aspects.

In the examined households incomes from the sale of the aforementioned cash crops ranged from 24 to 11,000 shillings per household. A correlation between size of farm and size of income could not be established. Although farmers who owned more land occasionally had larger incomes from the cultivation of cash crops or the raising of grade cattle, they generally had to feed larger families and employed more workers on their fields. Smaller families usually live on smaller farms. The relationship between the number of people to be fed and the size of land is in most cases more favourable on smaller farms than on large ones. In fact it was established that owners of smaller farms produced higher yields per acre by means of intensive cultivation

than the larger land owners. Just under 70% of the questioned households earned only up to 1,500 shillings per year.

If the sales proceeds from non-agricultural goods (mostly baskets woven by women) are added as well as the incomes of both men and women earned by outside employment, total income increases to a maximum of about 20,000 shillings. Especially low income households showed an additional income of up to 1,000 shs a year. All sources of income combined, nearly 80% of the households earned more than 1,000 shs per year. These figures indicate that the majority of small farmers have regular jobs as well as their farming. More than half of the farmers questioned stated that they were employed as craftsmen, merchants, or as officials in the municipal administration, while most of the farmwork is done by their wives and children. The extra money earned often does not exceed 2 to 3 shs a day. Only one person, the chief of the sublocation of Kiamariga, earned a total income of about 20,000 shs, but this, of course, is an exception to the rule.

Many households receive considerable financial support from family members living and working at other places even as far away as Nairobi. Such member would only occasionally live with his family. Older children already working often support their younger brothers and sisters, e.g. paying the high tuition fees required for attendance of elementary school. Analyzing household expenditures in the whole, larger parts of the total income were also expended on clothing and food, the latter being the biggest amount. This demonstrates that subsistence economy does not at all meet the farmer's needs even for food alone any more.

Regular taxes paid by the farmers were at least 58 shs a year. In addition, all civil service employees such as teachers, chiefs, and subchiefs have to pay income tax. Craftsmen and merchants are bound to pay licence fees. The heavy burden of school tuition in some cases even consumes the entire income of the family. This applies especially for High Schools, which include boarding fees and often charge more than 100 shs a year per child.

Market conditions

The local market in Kiamariga is held on mondays, wednesdays and fridays and frequented by all women in the vicinity. The market in the small town of Karatina (approx. 13 miles from Kiamariga), however, held on tuesdays, thursdays, and sundays, is of greater importance. Being near Ichuga, no further market takes place in this small village. The market place itself is divided into sections for different goods, each merchant having a designated place. In contrast to most other places in Kenya men do most of the buying and selling. Due to the bigger variety offered and higher prices paid for agricultural products (Karatina being one of the supply centres of Nairobi merchants), this market attracts even the more distant villages despite the

long way of travel involved. In the fenced-off markets of Kiamariga and Karatina a fee of sh –.20 is charged from each merchant by the municipal administration for cleaning.

In Kiamariga and Ichuga more than 60 shops, collecting centres, repair workshops (for bicycles) and bars are situated. All retail shops offer domestic agricultural products as well as treated domestic and foreign food like canned meat, flour, cigarettes, beer, lemonade, sweets, toilet articles, simple medicines, textiles and other small utensils. All shops were run by Africans as an exception to the rule that generally all trade is handled by Asians. This perhaps demonstrates the special enthusiasm Kikuyus have for farming and trading. While the prices for cash crops are set by the co-operatives, prices for all other products correspond along certain guidelines to the laws of supply and demand.

Co-operatives

All coffee- and pyrethrum-growers are by law members of the respective co-operatives, which supply the farmers with the necessary plants and fertilizers as well as handling their harvested crops. The same applies to milk producers. Milk prices are set by the co-operative and farmers are bound to deliver all milk not privately consumed. The milk price set by the co-operative fluctuates from 1.70 to 2.- shs per gallon (1 gallon = 4.45 litres) according to the season. As privately sold milk realizes prices of almost 4 shs a gallon, smaller producers prefer to sell their milk in the neighbourhood though such transactions are forbidden.

In December 1964 the Kiamariga Farmers' Co-operative Society was founded, which in autumn 1965 comprised 70 members, for the most part onion and cabbage growers. The Society collects all local foods offered, which in turn is sold to merchants from Nairobi. Two stores are operated by members of the co-operative, the profits being distributed among members every three months.

Transport

Transportation facilities in the region of Ichuga and Kiamariga are adequate. On market days buses and small trucks connect the villages with Karatina and the District Capital Nyeri.

5. The Nutrition Situation

In Ichuga and Kiamariga the one day's food consumption has been calculated for a total of 66 families, i.e. 84 cooking units (41 in Ichuga and 43 in Kiamariga). Foods used or to be used were weighed, while quantities of purchased food like maize flour were calculated from their prices.

Quality of Diet and Frequency of Food Consumption

In most cases the intake comprises three meals a day. Breakfast generally consists of tea (with milk, sugar or both) or a thin soup of maize flour and salt *(uji)*, sometimes with milk or sugar. Some families drank coffee, other cocoa. Only small differences were noted between the mid-day and evening meals except that the former was often no more than a snack. Typically, it was a stew of maize, beans, and vegetables, to which fried onions were added as well as cabbages, potatoes, bananas, and wild vegetables, single or in combination. Other meals consisted of maize flour porridge *(ugali)* with milk or vegetables or of potatoes with vegetables. For lunch sometimes nothing but sweet potatoes, yams, arrow root with potatoes, roasted maize on the cob, a piece of sugar cane or a cup of *uji* or tea was consumed. In many cases the mid-day and evening meals or the next day evening meal were cooked at the same time. Regarding the frequency of food consumption, certain differences between the two villages could be noted. In Kiamariga breakfast equally consisted of tea and *uji*, while in Ichuga tea was taken twice as often as *uji*. In Kiamariga the consumption of wild vegetables surpassed the respective quantity consumed in Ichuga. Table 2 gives an overall impression regarding the frequency of different foods consumed in the two villages. The figures state the number of cooking units using the respective food on the survey day. In addition, the following foods were found once: arrow root, sugar cane, yams, lablab beans, leek, peas, tomatoes, carrots, wheat flour, cocoa, bread,

Table 2. *Number of Cooking Units in Each of the Two Villages Serving Various Foods on the Survey Day* [a]

Food	Ichuga (41 cooking units)	Kiamariga (43 cooking units)	Total (84 cooking units)
Maize	35	34	69
Maize flour	12	27	39
Beans	36	29	65
Sugar	17	17	34
Milk	24	27	51
Potatoes	13	12	25
Cabbage	10	10	20
Wild vegetables	3	14	17
Bananas	6	2	8
Onions	5	5	10
Cooking fat	12	4	16
Sweet potatoes	3	2	5
Millet flour	2	–	2
Meat	2	2	4
Eggs	1	1	2

[a] Data from 84 cooking units (= 66 families). Each family is composed of an average of 6–8 persons.

butter, and different wild vegetables (see table 4). Milk has been the only animal product regularly consumed, though almost exclusively with tea and occasionally in *uji*. Meat consumption was found in the two wealthiest families only, while with regard to all others meat is consumed only once or twice a month or even never. Eggs, usually sold in the market, are another rare delicacy.

Nutrient Intake and Adequacy of Diets

The average nutrient intakes expressed as adequacy in percent were as follows, though large differences from one family to another occurred: calories 94%, protein 164%, calcium 44%, iron 169%, vitamin A 28%, thiamin 485%, riboflavin 143%, niacin 126% and vitamin C 89%. As stated above, the requirements of thiamin, riboflavin and niacin were based on minimum values, otherwise the adequate percentages would be considerably lower. As no marked under- or overweight could be stated, we may assume that over a number of days or weeks the caloric intake was in balance.

Regarding basic foods, the recorded composition of the great majority of meals was very similar. Maize and beans supplied most of the calories as well as most of the protein, iron, and B-vitamines. These nutrients may, therefore, be expected to vary with the caloric content of the diet as well as their respective adequacies. To test this hypothesis, the co-efficients between the adequacy of caloric intake and the respective adequacy of other nutrient intakes were calculated (see table 3).

In the first column the correlation co-efficient for the correlations between caloric adequacy and adequacy in other nutrients is listed, while the second column indicates the probability of the null hypothesis or significance. Correlations with adequacy of the dietary composition regarding protein, iron, thiamin, riboflavin, and niacin are highly significant and rather close. No significant correlation is found with the adequacy of intake for calcium, vitamin A, and vitamin C, usually not contained in basic foods.

Table 3. *Correlation between Caloric Adequacy and Adequacy of Nutrient Intakes*
n = 62

Parameter	r	Po	b
Protein	0.76	0.001	1.23 ± 0.13
Calcium	0.16	0.1	
Iron	0.82	0.001	1.58 ± 0.14
Vitamin A	0.05	0.1	
Thiamin	0.90	0.001	4.97 ± 0.90
Riboflavin	0.85	0.001	1.58 ± 0.11
Niacin	0.86	0.001	1.21 ± 0.09
Vitamin C	0.10	0.1	

In order to test whether requirements in different nutrients would be met at intakes of identical diets at levels of 100% caloric adequacy, the regressions of adequacy in protein, iron, thiamin, riboflavin, and niacin were calculated. The slopes b of the regressions are given in column 3 of table 3 with their standard deviation. The results can be summed up as follows: assuming 100% caloric adequacy, the present type of diet is able to meet the requirements for protein (172%) and iron (178%) only, at the same time it prevents deficiency signs of thiamin, riboflavin, and niacin, while with regard to vitamin A, vitamin C and possibly calcium requirements are insufficiently met.

Apart from wild vegetables, the mean vitamin A and carotene intake met only 3% of the requirements. Since wild vegetables contain considerable amounts of carotene and its consumption was found to be rather frequent (especially in Kiamariga), the carotene content in a number of samples has been calculated (see table 4). As a result, wild vegetables including the average adequacy of vitamin A and carotene intake rose to 28%. Thus, carotene being mainly supplied by wild vegetables, housewives stated that wild vegetables are a regular part of the meal especially towards the end of the rainy season. Since excess vitamin A can be stored in the body, over longer periods of time an adequate supply seems possible. This takes not into account, of course, that with increasingly intensive land use wild vegetables may become less and less available. They should be replaced in time, therefore, by the cultivation of other plants with a high vitamin, especially vitamin A, content.

6. Nutritional Status

Deficiency Signs

As so far no simple and generally applicable method for the assessment of the nutritional status has been developed, any attempt must choose among quite a number of criteria. In this study the following three methods were used: fast examination for deficiency signs according to the recommendations of the WHO, measurement of body height and body weight, and measurement of the sub-scapular skinfold thickness. All willing members of the sample household were examined, in total 449 persons (198 males, 251 females). The age distribution was as follows:

Years of age	0—5	6—10	11—15	16—20	21—25	26+	Total
Number	103	74	80	38	14	140	449
Percent	*23*	*17*	*18*	*8*	*3*	*31*	*100*

Table 4. *Vitamin Content of Wild Vegetables from the Kenya Highlands*

Local name	Botanical name	Uncooked		Cooking	Cooked			
		Dry matter	Vitamin C mg%	time min.	Vitamin C mg%	Vitamin B_1 mcg%	Vitamin B_2 mcg%	β-Carotene mcg%
Inagu-Managu	Solanum nigrum/L Solanaceae	10.7	(93–103)	15	(51–53)	2.1	(26–32)	(290– 308)
Mathoroko	Vigna unguiculata/Walp Papiionaceae	13.2	(29– 35)	20	(10–12)	0.4	(35–43)	(199– 207)
Terere wa kigombe	Amaranthus hypochondriacus/ L Amaranthaceae	12.0	(84– 88)	5	(68–75)	0.7	(38–44)	(145– 155)
Mujuju	Chenopodium opulifolium/Schrad Chenopodiaceae	13.6	(63– 69)	10	(48–50)	2.1	(24–26)	(1015–1045)
New Zealand Spinach	Tetragonia expansa/L Aizoaceae	8.1	(36– 40)	10	(24–26)	2.1	(18–22)	(145– 153)
Mohika	Asystasia schimperi (T. Anders) Acanthaceae	16.8	(43– 49)	5	(37–39)	0.9	(45–47)	(430– 446)
Nowee	Phaseolus lunatus/L Papilionaceae	14.3	(21– 27)	25	(7– 9)	0.8	(56–58)	(394– 402)
Sukumawiki	Brassica integrifolia (West) O. E. Schulze Cruciferae	12.9	(116–128)	25	(64–68)	0.8	(17–21)	(555– 564)
Togotia	Erucastrum arabicum/Fisch. u. Mey. Cruciferae	12.5	(86– 94)	10	(63–65)	1.2	(57–59)	(270– 278)
Terere wa umburi	Amaranthus angustifolius/L	13.2	(85– 91)	5	(74–76)	0.4	(52–54)	(207– 215)
Kanjuria	Cucurbita spec. Cucurbitaceae	9.8	(48– 54)	5	(44–46)	0.5	(97–99)	(1050–1088)
Hatha	Urtica massaica/Milbr. Urticaceae	13.5	(58– 62)	8	(43–47)	0.5	(91–95)	(359– 369)

Table 5 lists the most common clinical findings. More than 40% of the persons examined showed an enlarged liver, which was more frequent in females than in males. The aetiology is not known. According to table 6, hepatomegaly was found in more than 50% of the children and 20% of the adults respectively.

Table 5. *Most Common Clinical Findings among 449 Persons*

	Total		Kiamariga		Ichuga		Males		Females	
	n	%	n	%	n	%	n	%	n	%
Hepatomegaly	191	*42*	88	*41*	103	*44*	99	*50*	92	*37*
Goitre	71	*16*	14	*7*	57	*25*	25	*13*	46	*18*
Atrophic lingual papillae	52	*12*	21	*10*	31	*13*	17	*9*	35	*14*
Depigmentation of hair	41	*9*	31	*14*	10	*4*	23	*12*	18	*7*
Follicular hyperkeratosis	31	*7*	14	*6*	17	*7*	13	*7*	18	*7*
Dental fluorosis	28	*6*	20	*9*	8	*3*	12	*6*	16	*6*

As among 172 students of Bantu origin at the Police School in Nyeri only 5 per cent had enlarged livers, this fact may point towards a nutritional origin with regard to the village population. The diet at the Police School was ample and balanced. All examined students had joined six months before, but at the initial medical check-up their livers had not been examined. Malaria (which might cause an increase in the size of liver and spleen) is extremely rare in the Nyeri District. Spenomegaly was found only twice in the village population examined.

Table 6. *Most Common Clinical Findings Weighed for Age-Groups*

Age groups in years	0—5 %	6—10 %	11—15 %	16—20 %	21—25 %	26+ %
Hepatomegaly	*56*	*65*	*50*	*26*	*21*	*22*
Goitre	*4*	*4*	*24*	*26*	*14*	*24*
Atrophic lingual papillae	*7*	*4*	*10*	*8*	*0*	*23*
Depigmentation of hair	*25*	*11*	*6*	*0*	*0*	*1*
Follicular hyperkeratosis	*5*	*15*	*15*	*5*	*7*	*1*
Dental fluorosis	*0*	*8*	*14*	*3*	*7*	*6*
Number Examined	103	74	80	38	14	140

Seventy-one persons (16 per cent) showed enlargement of the thyroid, with a marked difference from one village to the other, viz. 7% and 25% in Kiamariga and Ichuga respectively. No additional information regarding

iodine intake or excretion was obtainable. The prevalence rate is similar to other areas in Kenya. For children up to 10 years of age it was definitely lower. Atrophic lingual papillae were seen in 52 cases (12%), 35 of them female and 17 male. No definite age differences were found. Atrophic papillae are considered to be a result of deficiency in riboflavin or niacin. Depigmentation of hair was found in 41 cases (9%), 63% therefrom children under 5, 83% children under 10, and 95% children under 15 years of age. Depigmentation is considered a typical sign of protein deficiency in children and persists for a considerable time after the deficiency has disappeared.
Follicular hyperkeratosis of the skin was found in 31 persons (7%). Its significance as an indicator of vitamin A deficiency, however, is doubtful. Dental fluorosis or mottled teeth were seen in 28 cases (6%), 20 of them in Kiamariga. The high fluorine content of water in many places on the slope of Mount Kenya is known.

Weights and heights

Body height and body weight of children and adolescents were generally slightly below the averages given by VOGT for south German children[10]. In view of the relatively few data available, the following procedure was adopted for comparison: the height/weight relation of German averages for ages 1 to 17 years (75 to 175 cm) for both sexes follows the function

$$\text{Weight} = A \times e^{B \times \text{Height}}$$

the value of A being 2.64 and of B 0.018. Linearized, the height/weight relation in this range can be expressed as a quotient

$$1000 \frac{\text{Lg Weight}}{\text{Height} + 54} = 7.8$$

In this way, heights and weights of children in different age groups may be treated together[11]. Deviations of the quotient occur almost symmetrically; standard deviations are the same for the whole range and independant of height and weight. Therefore, a deviation from the mean body weight of a small child leads to a larger change in the quotient than the same weight deviation in a taller child. Thus, a quotient of 7.7 or 7.9 means a deviation of weight from the mean of 0.3 kg for a child of 75 cm height, but of 0.9 kg for a child of 120 cm, and of 2.9kg for a child of 170 cm height. This is exactly proportional to the deviations found by VOGT in German children

10 D. VOGT: Über den gegenwärtigen Stand der Akzeleration in Bayern. Arch. Kinderh. 159 (1959), 141.
11 W. KELLER: Height-Weight Relation and Standard of Living among Kikuyu Farmers in Kenya. Human Biology (in press).

and corresponds to the clinical assessing of over- or underweight[12]. The normal range of twice the standard deviation as suggested by VOGT would mean a change of the above quotient by 0.5 to 0.7 (7.1 to 8.3).
The average quotient of the height/weight relation for the 248 persons between 2 and 20 years of age was 7.75.

	Male			Female			Total		
	n	Quotient	± s	n	Quotient	± s	n	Quotient	± s
Kiamariga	63	7.69	0.24	79	7.72	0.35	142	7.71	0.31
Ichuga	51	7.78	0.23	55	7.84	0.32	106	7.81	0.28
Total	114			134			248	7.75	0.30

There are small differences in the mean values for the two sublocations as well as by sex, girls having a somewhat higher quotient than boys. The standard deviations are within the ranges given by VOGT for body weights. Therefore, there is no difference between the German values and the mean weight/height-relation found here.
As the ages given are often unreliable, no definite statement can be made on growth. However, if compared to German values for height at different ages, there was an average difference of – 8.2 cm (s = ± 6.9) independent of age, sex and sublocation. The large standard deviation is obviously caused by the uncertainty of age statements. The mean difference of 8 cm, however, corresponds approximately to the shorter stature of adults with an average of 166 cm in males and 158 cm in females, as compared to 173 cm for West German males at 20 years of age (FINGER u. HARBECK). There does not appear to be major growth retardation or stunting as has been reported from other parts of East Africa.

Skinfolds

Skinfold thickness taken at the lower of the scapula were compared with values found by TANNER and WHITEHOUSE for British children[13] (n>5,000) The British values rise until the first year of life, thereafter they decrease and raise again with the 6th and 7th year. Because of this dependence on age, we have juxtaposed in table 7 the data of the relatively small group of African children and the percentages for the British children.
85% of skinfold values of African boys and 72% of the girls are below the 50 percentile of British children. At no age there was a particularly large

12 Th. HELLBRÜGGE und D. VOGT: Zur Beurteilung des Wachstumsstandes mit Hilfe von Somatogrammen. In: HELLBRÜGGE (Hrsg.) – Voruntersuchungen bei Jugendlichen, Köln 1961.
13 J. M. TANNER and R. H. WHITEHOUSE: Standards for subcutaneous fat in British children. In: Biol. Med. J. 1 (1962), 446–450.

Table 7. *Subscapular Skinfold Thickness*
(Frequencies in % at the percentiles of TANNER and WHITEHOUSE)

Number of British children	African children % Male n = 105	African children % Female n = 124
Up to 3	*22*	*14*
10	*37*	*32*
25	*70*	*48*
50	*85*	*72*
75	*94*	*90*
90	*98*	*96*
97	*99*	*98*

or small deviation from the British means. Even within families, deviations from these means varied considerably.
NEWMAN has shown that American negro recruits had less subcutaneous fat than white recruits[14]. Until more is known about this subject the possibility cannot be excluded that the low skinfold thicknesses of the Kitenya children at least partly due to genetic differences.

7. Relation Between Economic Situation, Diet, and Nutritional Status

It is well known that the economic situation of a family will influence its diet only below a certain level of income. Certainly the Kikuyu families in question have not yet reached this level. For reasons of a representative average the few families with large land holdings and large cash expenditures on food have in the following been excluded. Naturally in the present context economic data like acreage, income, and expenses only become meaningful if related to the size of family. The simplest way would be dividing these data by the number of family members, in such a case, however, no allowances are made for the different individual dietary needs related to age and sex. In this survey the requirements for calories per person were taken as a basis. Acreage of land holdings and economic data of each family were, therefore, divided by the calculated calorie requirements of that family and, for convenience, multiplied by 1,000. All following economic data were expressed in shillings or in acres per 1,000 calories requirement. (With regard to one family in Ichuga with a holding of 41 acres, of which only 7.5 acres were in use for pasture or cultivation, the second value was taken.) A few families, whose data proved to be incomplete, had

14 R. W. NEWMAN: Skinfold measurements in young American males. In: J. BROZEK (ed.): Body measurements and human nutrition. Wayne Univ. Press, 1956.

to be excluded, leaving a total number of 55 families for this analysis (see table 10).
The parameters available for calculations were the following (all economic data having been adjusted for family size in the described manner):

1. size of land holding
2. total income per year
3. income from sale of agricultural products
4. total expenditure per year
5. expenditure for food and clothing
6. cash balance at end of year
7. adequacy of diet (%)
8. clinical findings
9. body weight related to body height
10. skinfold thickness.

First, the relation between the economic data 1 to 6 and the adequacy of the diet was tested. In view of the high correlation in the adequacies for the different nutrients described above, only adequacy of caloric intake was used. The co-efficients of the correlations of caloric adequacy to the economic data of the 55 families were

1. land holding	$r = 0.451^{c}$
2. total income	$r = 0.396^{b}$
3. income from sales	$r = 0.293^{a}$
4. total expenditure	$r = 0.0442^{c}$
5. expenditure for food and clothing	$r = 0.378^{b}$
6. cash balance	$r = 0.173$

[a] $P < 0.05$
[b] $P < 0.01$
[c] $P < 0.001$

Except for the cash balance at the end of the year, all tests show significant correlations to caloric adequacy, which is closest for land holding and total expenditure.
For the range covered by the sample, a linear function was assumed for further considerations, as a certain degree of non-linearity would not necessarily exclude application of a linear equation[15].
Taking caloric adequacy of the diet (CA) as the dependent variable, the regression equations for land holding (L), total expenditures (T) and expenditures for food and clothing (E) are

$$CA = 62.63 + 72.31\ L$$
$$CA = 64.21 + 0.288\ T$$
$$CA = 66.64 + 0.434\ E$$

15 J. TILLMANS: op. cit.

Consequently, caloric adequacy (100%) could be attained at either 0.5 acres of land, 125 shillings total annual expenditure or 77 shillings expenditure for food and clothing per person and 1000 kcal per day. Taking the daily caput caloric requirement with 2,000 kcal per day (2,011 kcal being the average per caput requirement of all families), then either 1 acre, 250 shillings or 154 shillings respectively would be required on average to obtain adequate caloric intakes per person.

The highest co-efficients are found for land holding (L) and expenditure for food and clothing (E). Table 8 reveals no significant correlation between the two parameters. Therefore, their combined influence on the caloric adequacy of the diet was tested by calculating the multiple linear equation

$$CA = 45.95 + 0.33\ E + 61.49\ L$$

using again the adjusted figures for E and L. The co-efficient of regression $R = 0.531$ is highly significant, but somewhat above the correlation co-efficient $r = 0.451$ for CA and L alone. Apparently other unknown variables play a role for dietary intakes of calories. It has been shown in India, for example, that the available calories per caput decrease with increasing family size (C. Gopalan, personal communication). This sample, however, was too limited to be analysed in this respect.

By giving CA a fixed value of 100, a level of expenditure for food and clothing can be calculated for any size of land holding at which caloric adequacy should be attained:

acres	*shillings*
0	159
0.1	141
0.2	122
0.3	104
0.4	85
0.5	67
0.6	48
0.7	30
0.8	12
0.86	0

In other words, within the range studied, 0.1 acre would be equivalent to 18.5 shillings annual expenditure for food and clothing for the attainment of caloric adequacy of the diet. In fact, of the 18 families meeting or exceeding these conditions, 14, or 78%, had a diet with 100 per cent or more of caloric adequacy.

Table 8 gives the co-efficients of the correlations between different economic variables. Land holding and expenditure for food and clothing, which have the highest correlations with caloric adequacy, do not correlate significantly

Table 8. *Co-efficients of Correlations between Economic Variables* (data adjusted for family size)

	Total income	Income from sales	Total expenditures	Expenditures for food and clothing	Money available
land holding	0.29 [a]	0.46 [c]	0.39 [b]	0.23	0.40 [b]
total income	–	0.60 [c]	0.85 [c]	0.53 [c]	0.80 [c]
sales	0.60 [c]	–	0.37 [b]	0.12	0.66 [c]
total expenditures	0.85 [c]	0.37 [b]	–	0.80 [c]	0.58 [c]
expenditures for food and clothing	0.53 [c]	0.12	0.80 [c]	–	0.15

[a] $P < 0.05$
[b] $P < 0.01$
[c] $P < 0.001$

with each other, but all other economic observations are rather closely correlated to one or both of the former.

The increasingly important role of cash crops may be reflected in the high correlation of income from sales with total income and available money. While the size of land holdings is closely related to income from sales of agricultural products, the low significance of the relation of land holdings to total income may reflect the importance of non-agricultural incomes. Expenditures for food and clothing are not correlated with land size, nor with income from sales and available money, but they form a major part of total expenditures, which demonstrates their importance to the correlation of these expenses with the caloric adequacy of the diets.

One should expect that an improvement of the diet with increasing prosperity would be reflected in the nutritional status of the persons involved. Clinical signs of deficiency, however, showed no significant correlation with caloric adequacy or adequacy of other nutrients, nor was there a significant correlation to size of land or to expenditures for food and clothing. However, among the six clinical signs listed in table 6, goitre and fluorosis were not dependent on differences in diet or economy, and the low frequency of the other deficiency signs will not make possible relationships with dietary intakes of nutrients evident due to the limited sample. Moreover, the papillary atrophy may have been due to deficiencies that had occurred long ago.

The nutritional status expressed as a relation of height and weight provided a set of observations in digital form which could be used for statistical analysis. The weight-height ratio appears to be largely independent of age and sex, at least during childhood and early adolescence. Preliminary tests revealed correlations for the females (P 0.05), but no significance for the males and for the combined sample. It was decided, therefore, to use the family means of the weight-height indices for comparison with the economic parameters and the dietary data. In addition, all calculations were repeated

using the individual weight-height ratios of the males with essentially the same results in terms of significance of correlation. Table 9 gives the co-efficients of correlation between the family means of the weight-height indices and the different parameters. Significant positive correlations were found with caloric adequacy of diet, size of land holding, and available cash and income from the sale of agricultural products. Surprisingly, expenditures for food and clothing were not significantly correlated to nutritional status as expressed by the weight-height index, though they were correlated with caloric adequacy as shown above. Of the economic parameters, land size appears to be most closely associated with the weight-height index. The regression equation for the weight-height index over land size,

$$K = 7.7 + 0.3252\ L;$$
$$r = 0.428$$

can be used to estimate that per 1,000 kcal dietary requirements, 0.3 acres of land would be needed to attain a weight-height index of 7.8 as found for the German data, or, for the average person with 2,000 kcal requirements, 0.6 acres. The low but significant co-efficient indicates that only part of the differences in the weight-height index can be accounted for by differences in land holding. We have been able to show that other economic factors are related to nutrition and nutritional status, and these influences can be less easily assessed. Therefore, one should not give too much importance to a figure for the size of land necessary for adequate nutrition. However, some support can be given to the figure of about 0.6 acres by taking into consideration the production capacity of the land.

At an average yield of 5 bags (approx. 500 kg) of maize per acre in mixed maize and beans planting, 0.2 acres are required to produce a daily ration of 2,000 kcal from maize. The average land holding of the group studied is in the order of 0.4 acres per 1,000 kcal requirement, which is four times as much. Taking into account the necessity of growing a certain amount of marketable

Table 9. *Co-efficients of Correlations of the Weight-Height Index (Family Mean), to Caloric Adequacy of Diet and Economic Data (Data Adjusted for Family Size)* n = 55

Parameter	r
Caloric adequacy	0.392 [b]
Land size	0.428 [b]
Sale of agricultural products	0.293 [a]
Total income	0.117
Expenditures for food and clothing	–0.070
Total expenditures	–0.206
Available cash	0.366 [b]

[a] $P < 0.05$
[b] $P < 0.01$

crops in order to obtain the necessary cash, the use of some land for pastures, lanes and buildings, the unavoidable storage losses and the need for seed, the basis for nutritional subsistence appears to be rather small. Moreover, 60% of the families are below this average of 0.4 acres per 1,000 kcal, often considerably lower.

As long as only a few comparable studies of a similar nature are available, there is ample room for speculation on the obtained results. Thus, if expenditures (for food and clothing) correlate with the caloric adequacy of the diet but not with the weight-height index, while land size correlates with both, this may be ascribed to the fact that land holdings have remained largely unchanged for some time, while the expenditures have increased only recently. Accordingly, while land size can be assumed to have had an effect on diet as well as body weights, which take longer to adjust, expenditures may have changed too recently to have influenced body weights, although the influence on diet is obvious.

Though limited studies like this one may appear futile to the scientist as well as to the planner, we are confident that they will ultimately lead to the development of tools better capable of analyzing the interrelated factors influencing nutrition and create a better understanding of nutritional needs in the overall context of development.

Table 10. *Data of 55 Families Used for Calculation of Correlations. Economic Data are Weighed for Caloric Requirements, the Weight-Height Index Figures are Family Means*

No.	Caloric adequacy %	Weight-Height index	Acres	Total cash income sh	Sales sh	Total expenditures sh	Food and clothing sh	Available cash sh
1	*61*	7.94	0.108	32	4	38	30	– 6
2	*32*	7.82	0.276	135	52	66	41	73
3	*74*	7.78	0.133	110	6	107	96	3
4	*101*	7.79	0.195	57	23	68	53	–12
5	*92*	7.91	0.180	203	42	130	110	73
6	*20*	8.04	0.045	70	0	65	56	5
7	*92*	7.73	0.349	266	266	144	96	135
8	*100*	8.08	0.248	74	53	32	22	38
9	*30*	7.65	0.180	81	31	38	23	44
10	*129*	8.00	0.121	56	21	34	29	25
11	*40*	8.03	0.602	114	20	27	27	87
12	*34*	7.86	0.339	42	2	55	54	–12
13	*65*	7.82	0.412	36	0	65	61	–29
14	*24*	7.63	0.332	159	110	44	34	115
15	*109*	8.08	0.585	79	33	50	29	30
16	*132*	7.82	0.233	123	110	82	34	42
17	*58*	7.87	0.274	81	60	75	23	7
18	*81*	8.15	0.543	174	174	76	49	100
19	*94*	8.02	0.433	203	196	53	33	127
20	*128*	7.88	0.382	109	109	31	6	102

No.	Caloric adequacy %	Weight-Height index	Acres	Total cash income sh	Sales sh	Total expenditures sh	Food and clothing sh	Available cash sh
21	*74*	7.90	0.115	1	1	4	1	0
22	*58*	7.96	0.824	52	27	54	32	– 2
23	*147*	7.74	0.648	307	159	200	49	222
24	*103*	7.84	0.895	283	283	171	32	182
25	*98*	8.11	0.557	170	167	60	39	109
26	*134*	8.00	0.889	72	5	45	33	53
27	*83*	8.18	0.359	206	126	200	81	308
28	*50*	8.01	0.333	48	48	23	14	24
29	*67*	7.88	0.946	68	54	38	22	102
30	*105*	7.88	0.113	306	15	221	125	85
31	*61*	7.34	0.372	165	110	78	66	87
32	*73*	7.45	0.056	46	6	48	46	– 2
33	*127*	7.59	0.270	154	96	134	108	19
34	*111*	7.53	0.270	245	21	203	153	42
35	*39*	7.55	0.030	45	12	42	41	3
36	*119*	7.54	0.217	76	33	75	70	1
37	*121*	7.69	0.398	88	47	88	78	0
38	*107*	7.66	0.316	72	59	61	48	11
39	*108*	7.97	0.448	474	85	276	116	265
40	*62*	7.18	0.150	78	1	60	35	18
41	*74*	7.84	0.170	101	24	76	60	23
42	*116*	7.57	0.778	185	141	140	113	46
43	*78*	7.65	0.186	87	44	99	65	– 2
44	*190*	7.91	0.805	318	104	249	127	114
45	*163*	7.91	0.706	205	105	128	84	77
46	*29*	7.95	0.745	118	92	66	63	55
47	*155*	7.85	0.838	270	142	197	150	73
48	*215*	7.76	0.713	178	113	121	71	57
49	*124*	7.90	0.727	181	0	187	68	20
50	*141*	8.13	1.089	280	117	231	121	121
51	*59*	7.71	0.168	58	27	61	37	21
52	*51*	7.83	0.511	82	70	74	53	8
53	*207*	7.93	0.616	103	55	72	28	10
54	*76*	7.98	0.526	70	35	190	166	–16
55	*106*	8.22	0.930	483	153	251	71	246

8. Summary

A survey of economic conditions, food consumption and nutritional status was carried out in 66 rural households of two neighbouring villages in Nyeri district of the central province of Kenya. Agricultural and general economic conditions, incomes, expenditures, markets, prices of agricultural products, co-operative organisations, consumption of different foods, nutrient intakes, adequacy of diet, and nutritional status including nutritional deficiency signs were described.

A definite tendency towards increased production of cash crops and intensive cultivation was found.

The average food consumption provided more than the minimum, but less than optimum requirements, except for vitamin A which was deficient. Analyses of a number of collected wild vegetables showed considerable contents of carotene, which seemed to provide most of the carotene supply available.

Statistical analysis of the data of 55 families showed the caloric adequacy of the diet being positively correlated to total cash income, income from the sale of agricultural products, expenditures for food and clothing and land size, if these quantities were weighed for the caloric requirements of the individual families. Clinical signs of deficiency showed no correlation with any of the other observations.

A weight-height index was formed from the logarithmic expression of the weight-height relation of West German data, using the slope as an index, and applied to the heights and weights of the Kikuyu families. The index was found to be correlated with the caloric adequacy of the diet and with land holding, but not with the expenditures for food and clothing.

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