SURVEY OF PRODUCTION AND UTILIZATION OF FRUITS AND VEGETABLES OF THE MACHAKOS DISTRICT AND THEIR NUTRITIONAL EVALUATION WITH EMPHASIS ON INDIGENOUS SPECIES

BY

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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ABSTRACT

A research study was undertaken to investigate the potential of using local fruits and vegetables (with emphasis on indigenous types) in meeting the reportedly limiting micronutrients of vitamins A, C and calcium in the diet of the rural Kenyan population.

Experimental studies consisted of: (i) a field survey component in which production and utilization of fruits and vegetables was investigated; and (ii) laboratory nutrient assays.

Machakos District was selected as a study location based on reported micronutrient deficiency problems and seasonal food deficits. It also contains a cross section of agro-ecological zones ranging from high to low potential.

Field survey data was collected through the following channels: direct interviews of agricultural extension staff, including technical staff of three selected locations; reference to annual reports, conducting market surveys and a survey with the aid of a questionnaire form of a representative sample of approximately 300 farm households in the selected locations.

A list of fruits and vegetables utilised in the three locations and identified by the local Kamba names emerged. In Iveti, a high potential location, there was a greater use of cultivated and semi-cultivated

species of both fruits and vegetables as compared to Masii and Wamunyu, medium and low potential locations respectively.

While in the high potential location climatic factor has no significant effect on availability of the crops under study, in the drier, lower potential areas, there were distinct patterns of seasonal availability, especially in respect of vegetables.

Nutrient assays revealed appreciable qualitative and quantitative differences between wild and cultivated/semi-cultivated species of fruits. Wild species were generally high in dry matter, fibre and mineral content and lower in carotene and vitamin C as compared to the cultivated/semi-cultivated types. An exception was the fruit "Maua", (Sclerocarya caffra) which was rich in vitamin C. Vegetable species showed no significant differences between the two groups.

The cultivated/semi-cultivated fruit species were generally more important in meeting recommended daily allowances (RDA's) of vitamins, but less important with regard to the RDA's of minerals, when compared to wild fruits. The vegetables on the other hand generally satisfied the RDA's of vitamins and iron. The RDA of calcium however, was only partially met.

To satisfy the requirement for the limiting micro-nutrients, both cultivated/semi-cultivated and wild species of fruits and vegetables of Machakos District have an important role to play, especially because the availability of the two groups (wild and cultivated/semi-cultivated) was found to be dependent on locations.

An attempt was made to classify species on the basis of overall nutrient profile in order to identify those with higher nutrient values to be recommended for utilization and development as field crops.

1. INTRODUCTION

A well balanced diet is one having not only macronutrients (carbohydrates, proteins and fats) but micronutrients (vitamins and minerals) as well. The utilization of either group of nutrients to a large extent depends on the other. For example group B vitamins are required for energy release from carbohydrates and fats. Proteins on the other hand are necessary for conversion of β-carotene to vitamin A. Both these are examples of micronutrient/macronutrient inter-relationship. The enhancement of absorption of calcium and iron by vitamin C is an example of micronutrient/micronutrient inter-relationship. Lack of micronutrients in the diet will ultimately result in deficiency diseases like scurvy and blindness, (when vitamin C and A, respectively are lacking). Recent research findings have further revealed that micronutrients, specifically vitamins A and C reduce the risk of getting cancer and heart disease (9, 43, 76).

In most of the African countries, vitamin and mineral deficiency diseases usually associated with protein energy deficiency have been reported (35). Anaemia is widespread in some parts (10, 11, 12, 40), and so are vitamin A deficiency diseases and goitre (7, 8, 35, 46).

In Kenya, field nutrition surveys have been carried out, problems identified and solutions suggested (7, 8, 41, 42, 44). An elaborate field survey as described by Jelliffe (39) was beyond the scope of this study since the objectives of the present study were only in part directed to assessment for nutritional status. The major part of the research consisted of nutrient evaluation. The main aim of this study was to investigate the production, utilization and nutrient value of fruits and vegetables, in Machakos District, in order to determine their potential in relation to specific nutrient deficiency problems, and make recommendations for development and use of specific species.

These objectives should not be misunderstood to be directed against the massive efforts of the agricultural breeder who has introduced and bred varieties of fruits and vegetables suitable for this country. On the contrary they should be viewed as efforts of a supplementary nature in realising the goal of alleviating nutritional problems with cheap, readily available resources.

It is hoped that the results of this study will also help to overcome prejudices against the use of indigenous species of fruits and vegetables especially among the sectors of the population who cannot afford to purchase fruits and vegetables sold in markets.

To achieve the main objectives of the study the following investigations and exercises were carried out:

(i) A field survey; in order to ascertain the production, seasonality and utilisation of fruits and vegetables in selected locations.

(ii) Nutrient content of the more commonly utilised, available species; in order to define the micronutrient profile and the dietary contribution of nutrients from such sources.

(iii) Determination of the level of oxalic acid in the vegetables.

(iv) Selection of species of vegetables and fruits, that are still wild, for recommendation for further development and use. This was done on the basis of micronutrient profile and absence or low content of oxalic acid, a substance which has an inhibitory effect on mineral absorption.

2. LITERATURE REVIEW

2.1. Nutrition Surveys in Kenya, with Special Reference to Micronutrient Deficiency Problems

2.1.1. Clinical evidence of micronutrient (vitamin A and C, calcium and iron) deficiency

Between 1964 and 1968 a nutrition survey was conducted by Bohdal *et al*. (8) in various parts of Kenya, including some locations in Nyeri, Murang'a, Nyanza, Machakos and Kitui. Clinical and biochemical findings from this survey confirmed previous findings of frequent occurrence of protein and energy malnutrition (undernutrition) mainly in children, besides problems of micronutrient deficiency. They observed vitamin A deficiency in Nyeri (8). Blankhart (7) on the other hand reported that vitamin A deficiency was a common problem in dry areas.

Apparently, vitamin A deficiency is a problem prevalent among the agricultural group of Kenyans, according to the results of Korte *et al*. (45). However, some symptoms of this deficiency can sometimes go unnoticed due to the complex interaction of infection with various types of malnutrition and deficiency diseases. When Franken (24) carried out investigations of some children with measles in Meru, he concluded that some of the symptoms like conjunctival redness and photophobia observed after an attack of measles are not a result of this infection. Instead they are a part of the xerophthalmic complex, thus implying the precipitation of the vitamin A deficiency symptoms by the measles infection.

Although clinical signs of vitamin C (and calcium) deficiencies were hardly detected by Bohdal and his team (8), Burrows (13) nonetheless reported that vitamin C deficiencies occurred nationwide.

Iron deficiencies and frequent anaemias were revealed in clinical and biochemical findings of Bohdal *et al*. (8). Wiersinga (77) also reported 16% anaemias, 7 - 8% iron deficiencies (and 65 - 75% folate deficiencies) in a sample of prisoners of different tribal groups of Kenya. Levy (48) on the other hand, when investigating the degree of anaemia in populations living in different parts of Kenya found a prevalence rate of above 90% among Coastal tribes, against a 10% frequency in high altitude areas. In the latter anaemia incidence was predominantly among infants.

Micronutrient deficiency in the area under study

Micronutrient deficiency problems of vitamins A, C, and B_2, iron and calcium have been diagnosed specifically in and around the area presently under study (i.e. Machakos district and areas bordering the district, e.g. Kitui, (8, 13, 43, 62, 76).

2.1.2. Causes of micronutrient disorders

The main reason for the presence of micronutrient deficiency diseases was because the diets were inadequate in micronutrients. But in addition, a non-dietary related factor responsible for iron deficiency diseases was the presence of infections (48).

2.1.2.1. Dietary inadequacies

Dietary surveys have revealed that the commonest staple diet in Kenya is maize and beans. Consumption of animal products, fruits and vegetables is very low (8, 42, 44).

Apart from supplying energy and proteins in substantial proportions such a diet has basic micronutritional limitations. Bohdal *et al*. (8) estimated the vitamin A adequacy of the diet to be below 30% averaging all areas surveyed. Most of the marginal vitamin A consumed was supplied in the precussor form of carotene from vegetables and fruits. In Nyeri and Mwea Tebere the adequacy of vitamin A was estimated at 28% and 8.1% respectively (42, 44).

A large number of families surveyed were found to consume less than 80% of the required vitamin C. Keller *et al*. (42) estimated the dietary adequacy of this vitamin to be 89% in Nyeri while Korte (44) had an average figure of 30.6% in Mwea.

Due to the high levels of iron in beans a diet of maize and beans might appear to be more than sufficient in iron, as was revealed in the findings of Keller (42) and Korte (44). The two researchers estimated the adequacy of the diet in relation to iron to be as high as 169% and 264% in Nyeri and Mwea respectively. In these estimations it was assumed that all the iron present in the foods was available for absorption. Such would not be the case, however, as some of the iron present in these foods would be in a bound form (of phytates mainly). The actual amount of free iron available for absorption would thus be unknown, and would be subject to preparatory practices that lead to its release from the bound form. Moreover, iron absorption would further be impaired by high dietary fibre and low dietary vitamin C. To estimate the adequacy of the diet in relation to calcium proved difficult because of the large variation of its content in foods (8). However, assuming moderate levels of calcium in maize and beans, the actual amount of calcium available for absorption would similarly be limited by inhibitory factors, like phytates, which are present in appreciable quantities in cereals and legumes.

The factors responsible for the diets lacking in micronutrients could be varied. However, two such factors, which have direct relevance to this study are seasonal shortages and lack of nutrition education.

2.1.2.1. (a) Seasonal shortages of food sources of Micronutrients

Seasonal shortages of fruits and vegetables (the main sources of micronutrients for the majority of Kenyans) were reportedly responsible for the diets lacking in micronutrients (7, 13). Korte (44) found the diet of adults to be generally poorer in all nutrients towards the end of the dry season.

(b) Lack of nutrition education

The reportedly monotonous diet of maize and beans with little else implies a lack of knowledge of the choice of foods that constitute a balanced diet. Lack of nutrition education is even more plainly revealed in connection with the feeding of infants and children (6, 56). According to Blankhart (6) the infants' dietary pattern is the same in different parts of Kenya. Blankhart (6) who interviewed a total of approximately 1,000 mothers, randomly sampled from Machakos, Kiambu and the Coast, reported that beans and greens which normally form part of the family diet were not introduced to the infant until after 18 months. Moreover, half of the children ate these essential foods only once a day. Worse still, when vegetables were given they were most frequently in the form of cabbage and tomatoes whose nutritional merit is confined to the vitamin C contribution. Even with the inclusion of a maize or millet porridge and milk such a diet would be low in iron, folate and other micronutrients. The low iron content of the children's diet might explain the high anaemia incidence among children in high altitude areas observed by Levy (48). The late incorporation of legumes into the infants diet was similarly demonstrated by van Steenbergen et al. (70) as shown in Table 2-1.

Blankhart (7) reported no significant seasonal differences in child feeding patterns when he carried out child feeding studies in five different seasons, in three years, in Mbiuni, Machakos. Similarly when van Steenbergen and his team (70) carried out some studies in Machakos they reported no significant differences between lean and postharvest periods in relation to food intake, feeding habits and the nutritional status of the Akamba infant and toddler. These results undoubtedly imply that, it was not seasonal shortages, but rather lack of education on how to combine foods which would make a balanced diet for the infants.

2.1.2.2. Presence of infection

An important underlying cause of iron deficiency, aside from dietary deficits is the presence in certain regions of infections like hookworm and malaria. The very high incidence of anaemia in coastal regions observed by Levy (48) was largely attributed to hookworm

Table 2-1: Composition of average food intake in age groups (g/day) (70).

	Age, Months				
Type of food	0-6	7-12	13-18	19-24	25-36
No. observations	142	113	123	100	195
Cows milk	120	120	75	140	130
Maize	5	70	100	160	190
Tubers	-	15	15	60	60
Legumes	-	0	5	20	30
Vegetables	-	20	30	45	50
Fruits	0	10	15	30	25
Fat	-	1	2	2	2
Sugar	1	4	7	7	10

Where - means none
0 means less than 0.6 g

infection with lack of dietary replacement. Iron in infected persons is lost due to parasitic intake and intestinal haemorhages in the case of hookworm infestation, while in the case of malaria infection, breakdown of red blood cells accounts for most of the iron lost.

2.2. Use and Nutrient Potential of Local Vegetables and Fruits

Despite wide use of various types of wild and semi-wild vegetables in traditional diets little work has been done to determine their importance in nutrition in Kenya. Little if any work has been done to improve these crops. Apparently even less work has been done on indigenous fruits, as literature on this subject is lacking.

2.2.1. Indigenous vegetables

2.2.1.1. In non-African tropical countries

Of the work reported in other tropical countries there is a dearth of information on improvement of these vegetables. They have been termed 'a tropical undevelopment' (60), and amaranthus specifically: 'a neglected vegetable' (49). Most literature on vegetables in the tropics, infact, refers to the vegetables imported from temperate and sub-tropical regions, which are under cultivation locally, little mention being made of the indigenous ones (19).

However neglected, these species of plants are reportedly richer than the exotic types in protein and essential micronutrients like vitamin A (in its pre-cussor form of carotene), vitamin C, calcium and iron (5, 57, 75). Food composition tables support this evidence. They quote medium to high micronutrient levels in the leaves of cassava, sweet potato and pumpkin (21, 65).

Amaranthus is one vegetable unique in its nutrient composition. According to Mathai (49) it has the four important components of protein, iron, vitamin C and vitamin A, which are limiting in an Indian diet. He lists A. tricolor; (with synonyms like A. gangeticus, A. tristis, A. melancholicus), A. Lividus, A. blitum and A. mangostanus as good vegetable types. Amaranthus varieties with a high content of β-carotene have been identified by Begum et al. (5), (Table 2-2). A. viridis has a fairly good nutrient profile. Downton (18) in addition identified A. edulis as a high lysine grain amaranth whose lysine content is comparable to that of soymeal, thus making it superior to maize protein. The leaves also have a high content of this essential amino acid: 5.9g/100g protein. The protein content in leaf dry matter of common, local, leafy vegetables including amaranthus is in Table 2-3.

In his article on the significance of leaf vegetables in tropical nutrition Terra (73) concluded that cassava leaf, whose average crude protein content is 7% (fresh weight basis) is a good source of supplementary protein, even for children, if boiled for at least 1½ hours, to expel all the cyanide.

2.2.1.2. In African Countries

In West Africa indigenous leafy vegetables are a frequent component of the diet (57, 59, 78). Oke (59) emphasized their nutritive importance by quoting *Myrianthus arboreus*, commonly consumed in Nigeria, which has an iron content of 9.8 mg/100g fresh leaf weight. If consumed at the rate of 100g of fresh vegetable per day (normal quantities in two meals) it would contribute up to 80% of the daily iron requirement of the adult. Woolfe *et al*. (78) reported a moderately high iron content of 3.4 mg/100g fresh weight in the leaves of cocoyam (*Xanthosoma Sagittifolium Schott*). This vegetable is commonly used in stews in Ghana.

In Tanzania, Fleuret (23), investigating the role of wild foliage plants in the diet in Lushoto, Tanzania reported that these plants are consumed more frequently than often assumed. Wild foliage plants (michicha) appeared in 32% of all the meals consumed during the survey, compared with 17.7% of European introduced cash crop vegetables. She listed at least 15 wild species in addition to cultivated ones which are generally important in the Usambara diet.

In Uganda, Tallantire *et al*. (71) listed the food plants of the West Nile and Madi districts of Nothern Uganda. Many of these plants were weeds of cultivated and waste land, while some of the more commonly used types, like species of *Amaranthus* and *Corchorus* or *Hibiscus* are now cultivated in compounds. The nutrient superiority of some of these plants compared with

Table 2-2: Nutrient composition of some leafy vegetables consumed in the tropics (in 100g fresh weight of edible portion)

Vegetable	β-Carotene (μg)	Vitamin C (mg)	Dry matter (g)	Protein (g)	Calcium (g)	Iron (mg)	Source
A. viridis	-	-	12.55	3.46	.295	6.3	(75)
"	7,160 ± 2,760	-	-	-	-	-	(5)
A. hybridus	-	153	19.5	5.85	-	7.2	(68)
"	7,416 ± 720	-	-	-	-	-	(28)
Amaranthus sp.	5,716	64	16	4.6	.410	-	(21)
A. spinosus	5,735 ± 2,815	-	-	-	-	-	(5)
A. polygonoides	5,260 ± 410	-	-	-	-	-	(5)
A. lividus	-	10 (100mcg/g)	-	-	-	-	(1)
G. gynandra	-	13	13.4	4.8	.288	-	(21)
"	8,675 ± 480	158 ± 16	-	-	-	-	(28, 29)
"	-	10-15-(100-150) mcg/g	-	-	-	-	(1)
C. brevidens	7,000 ± 842	-	-	-	-	-	(28)
"	-	10-15-(100-150) mcg/g	-	-	-	-	(1)
C. olitorious	8,750 ± 654	-	-	-	-	-	(28)
"	-	10 (100mcg/g)	-	-	-	-	(1)
S. nigrum	7,625 ± 450	142 ± 28	-	-	-	-	(28, 29)
"	6,990 ± 3,730	-	-	-	-	-	(5)
V. unguiculata	9,416 ± 1,120	92 ± 14	-	-	-	-	(28, 29)
"	-	91.93	-	-	.337	17.25	(27)
Curcubita sp.	8,291 ± 560	-	-	-	-	-	(28)
Curcubita pepo	8,375 ± 1,005	31 ± 6	-	-	-	-	(28, 29)
M. utilissima	12,237 ± 650	311 ± 15	-	-	-	-	(28, 29)
C. esculentis	9,700 ± 422	47 ± 3	-	-	-	-	(28, 29)
P. vulgaris	10,650 ± 810	131 ± 20	-	-	-	-	(28, 29)
S. tuberosum	10,652 ± 842	82 ± 10	-	-	-	-	(28, 29)
B. oleracea var. acephala	7,312 ± 1,732	200 ± 18	-	-	-	-	(28, 29)
B. oleracea var. capitata	1,156 ± 57	27 ± 9	-	-	-	-	(28, 29)
"	100	54	8.6	1.7	.047	-	(21)
S. oleracea	1,840 ± 440	-	-	-	-	-	(5)

cabbage can be seen in Table 2-2. Stafford *et al*. (68) recommended the leaves of *Amaranthus hybridus* as a good source of ascorbic acid (if not overcooked), iron, and protein for human nutrition (Table 2-2).

2.2.1.3. *In Kenya*

Agronomical work was attempted at Thika, on leaf yield potential of some leafy vegetables, indigenous vs. introduced types. The latter (sugar loaf cabbage, drum head cabbage, and "Thousand headed Kale") out-yielded the indigenous ones (cowpea, red and green amaranthus and African spider herb). However, the kales, and indigenous vegetables were reported to have supplied green leaves regularly throughout the period of evaluation (52). Further work revealed that when directly sown, amaranthus gave higher yields than when transplanted (53).

Imbamba (36) reported on protein content of some species of amaranthus, (Table 2-3). Micronutrient data, on the other hand have been investigated by Abe *et al*. (1), (Table 2-2). The vitamin C levels reported by Abe are extremely low when compared with those found by Gomez (29) who has worked with many of the commonly consumed vegetables (wild, semi-wild and cultivated types) in Kenya (Table 2-2). The levels of vitamin C reported by Gomez (29) are more than ten times those reported by Abe et al. (1), with specific reference to Gynandropsis gynandra.

From Gomez's studies the leaves of Gynandropsis gynandra and cowpea leaf were found to have a very good nutrient composition (27, 29). The nutrient profile of the two vegetables is presented in Table 2-2. Further studies were carried out on cowpea leaf in order to identify cowpea cultivars with suitable nutrient properties for development as leaf vegetable strains (32). Kisumu and Kakamega cultivars proved to be better leaf vegetable types as compared to Machakos cultivars under the culture and agronomy conditions at Thika (32).

Table 2-3: Protein content of some local leafy vegetables.

Vegetable species	% Protein in dry matter	Source
A. edulis	26.4	(18)
A. viridis	27.6	(75)
A. lividus	26.7	(36)
A. hybridus	27.8	(36)
Curcubita pepo	31.1	(36)
Solanum tuberosum	31.8	(36)
Solanum nigrum	29.3	(36)
Commelina nudiflora	15.6	(36)
Vigna unguiculata	28.5	(36)

2.2.2. Importance of oxalic acid in vegetables

In general, foods with a high content of oxalic acid contain insufficient calcium to combine with the acid. This excess oxalic acid will thus make calcium from other sources in the diet unavailable for body absorption, as it would combine with it (55).

Among 37 leafy vegetables of the Phillipines, *Amaranthus viridis* was found to contain the highest level of oxalic acid. (Over 2% of anhydrous oxalic acid, on a fresh weight basis). *Talinum triangulare*, *Portulaca oleracea*, *Corchorus olitorius* and *Basella rubra* had between 1 and 2% of the acid (55). Hodkinson (33) reported that many of the leafy vegetables eaten in Asian countries are generally high in this acid. Amaranthus species are an example (Table 2-4).

Table 2-4: Oxalic acid and calcium content of some vegetable species (mg/100g of fresh leaf).

Vegetable	Total oxalic acid	Insoluble oxalate	Calcium	Source
A. polygonoides	1,586	-	-	(33)
A. gangeticus	891	-	-	(33)
A. viridis	551	-	-	(33)
A. hybridus	2,200	-	-	(68)
Heinsia pulchella	-	80	79	(59)
Gymra amplexicaulis	-	51	49	(59)

Oke (59) carried out some studies on oxalate and calcium content of some of the commonly consumed native vegetables of Nigeria. Two of the vegetables were found to have higher amounts of insoluble oxalate than calcium. The insoluble oxalate and calcium levels are shown in Table 2-4. Such a combination, he further discussed, might lead to unavailability of calcium, in view of Fairbank's findings (20) that the calcium of spinach (0.86%) was hardly made use of by rats (oxalic acid content of spinach was 0.29 - 0.69%).

Stafford et al. (68) reported increasing levels of oxalic acid with age of the plant. Maximum levels of the acid observed are recorded in Table 2-4.

2.2.3. Tropical fruits

Research data available on fruits in Kenya is on commercial types of fruits like citrus, guava, mango, avocado, and pineapple.

Czyhrinciw (15) cited micronutrient levels of a variety of tropical fruits. The calcium content cited is of the order of 26, 24, 22 and 20 mg/100g for mombin, soursop, guava and papaya, respectively; while iron levels were 2.2, 1.8, 1.0 and 0.8 - 0.9 mg/100g of mombin, coconut, cashew and plantain/bananas respectively (15). His nutrient values were derived from the INCAP - ICNND report (38).

Mango, cashew apple and papaya contain moderate levels of vitamin A (Table 2-5). They also have high amounts of vitamin C, as does guava.

Similar figures for vitamin C content were contained in the findings of Akinyele et al. (2) in their work in Nigeria (Table 2-5). Some varieties of guava, e.g. India Hill variety and Florida Red Cattley are however, not as rich in this vitamin as others e.g. India country variety (Table 2-5).

Work done in Sudan by Nour et al. (58) on the boabab fruit revealed the nutrient superiority of the fruit pulp, especially in relation to vitamin C, calcium and iron content (Table 2-6).

The nutrient composition of some of the fruits both exotic and local species consumed in West Nile and Madi District of Uganda, as reported by Tallantire et al.(71) are given in Table 2-7.

In Kenya, Gomez et al. (31) had results supporting the work of Nour et al. (58) Table 2-6). Imungi (37) working on guava, reported vitamin C levels of 129 - 246 mg/100g of cloudy guava juice, from Machakos. Gachanja (26) reported mean ascorbic acid levels of 18.84 - 26.56 mg/100ml in purple passion fruits grown in Thika (Table 2-5).

Table 2-5: Vitamin A and C content of some tropical fruits.

Fruit	Vitamin A activity (µg/100g)	Vitamin C (mg/100g)	Source
Avocado	15 - 60	17	(15)
Cashew	120	219	(15)
Mammel apple	30	16	(15)
Mango	630	53 (128 for unripe)	(15)
Soursop	5	26	(15)
West Indian cherry	10	1790	(15)
Yellow mombin	70	-	(15)
Mombin	-	28	(15)
Cherimoya	-	30	(15)
Tamarind	20	6	(15)
Banana unripe	290	-	(15)
Banana ripe	30 - 65	15	(15)
Sweet banana (var. I)	-	12.5 ± 1.4	(2)
Sweet banana (var. II)	-	9.4 ± 1.6	(2)
Pineapple	15	61	(15)
Pineapple	-	25.2 ± 0.2	(2)
Pawpaw	110	46	(15)
Pawpaw	-	43.2 ± 5.4	(2)
Pawpaw	-	61	(75)
Guava	80	218	(15)
Guava	-	127	(75)
Guava (Florida Red Cattley)	-	29	(14)
Guava (India Hill Variety)	-	11	(14)
Guava (India Country Variety)	-	299	(14)
Guava juice	-	129 - 246	(37)
Giant granadilla	-	20	(15)
Purple passion fruits	-	18.84 - 26.56	(26)
Custard apple	-	16	(75)
Tree tomato	-	11	(75)

Table 2-6: Chemical composition of baobab fruit pulp (on dry matter basis) (58).

	mean ± standard deviation
Protein % (% NX 6.25)	2.6 ± 0.3
Fat %	0.2 ± 0.01
Crude fibre %	5.7 ± 0.2
Ash %	5.3 ± 0.02
Ascorbic acid (mg/100g)	300 ± 6.2
Iron (mg/100g)	8.6 ± 1.1
Calcium (mg/100g)	655 ± 34
Moisture %	6.7 ± 0.03
pH	3.3 ± 0.04

Table 2-7: Nutrient profile of some tropical fruits (in 100g of edible portion) (21).

Fruit (Botanical name)	Protein (g)	Calcium (mg)	β-carotene equivalent (μg)	Vitamin C (mg)	Moisture (g)
Carica papaya	0.4	21	950	52	90.8
Tamarindus indica	2.0	60	-	8	80.2
Psidium guajava	1.1	24	290	326	82.2

3. MATERIALS AND METHODS

The research studies consisted of two parts, viz:

(i) Field survey in a selected area and

(ii) Experimental work consisting of laboratory nutritional assays.

3.1. Field Survey

3.1.1. Choice of study site

Machakos District was selected for the following reasons:

- It falls under the marginal rainfall areas(District annual rainfall is 750 mm). Arising from these conditions, there have been reports of food shortages, more commonly during drought and pre-harvest seasons (8).
- Nutritional research work had already been conducted in this area under the title of "Machakos Project Studies" (69, 70). Findings from these studies have a direct relevance to the present investigations.
- It has a good representation of the range of agro-ecological zones of high, medium and low potential, in the proportions: 9%; 57%; 34% of the district respectively (51).
- Its proximity and accessibility to Nairobi. It is 80 km from Kabete Campus to Machakos town on tarmac. Such a location was important because analysis of labile nutrients and moisture had to be done within

48 hours of sample collection.

Selection of study locations in Machakos District

Contact visits were planned to the District Agricultural Office, Machakos to meet the agricultural staff. After surveying the area within easy reach of Machakos town, under the guidance of agricultural staff three locations in Central Division of the district were selected. They had characteristics as described in Table 3-1. All the three locations had an additional advantage of a good network of roads.

Table 3-1: Characteristics of the selected locations

Location	Average altitude (m)	Distance from Machakos Town to trading centre	Ecological zone	Average annual rainfall (mm)
Iveti	1,800	10 km on an all weather road	High potential	900
Masii	1,400	23 km on tarmac	medium potential	750
Wamunyu	1,400	40 km partly on tarmac, partly on murram	Low potential	600

Market location

In addition to the three locations, Machakos town market was selected as the fourth site for field work for the following reasons:

- It is situated at the district's headquarters and is a centre for produce from all parts of the district. (This was confirmed during a preliminary survey of the area).
- It is also supplied with produce from outside the district like Nairobi, Mombasa and Thika. Thus, the materials that were not available in farms for collection were likely to be found there.

3.1.2. Field survey procedure

Collection of data was done through the following channels:

3.1.2.1. Direct interviews

In these interviews the data sought was the production and utilization of indigenous vegetables and fruits. The persons interviewed included the following:

(i) District Agricultural Officer, from whom background information on Machakos District was also sought;

(ii) District Crops Officer.

(iii) Home Economist.

(iv) Agricultural extension technical staff.

(v) A random sample of seven farmers from Masii and Wamunyu locations, during preliminary visits (a month before the actual survey with the questionnaire form).

3.1.2.2. Records

Reference was made to the Machakos District annual report, 1979.

3.1.2.3. Market surveys

These were done prior to and during the period of sample collection to coincide with the seasons under study. Table 3-2 shows the schedule for these visits.

Table 3-2: Schedule of visits to the market

Year	Seasons	Month	No. of visits
1980	Post-long rains	May	1
		June	2
	Pre-short rains drought	August	2
	Short rains and post rains	October	1
		November	2
1981		January	1
		Total	9

Procedure of market studies for data collection

In order to determine seasonal availability of produce, notes on the range and supply of fruits and vegetables available in the market were made on each market visit. A random sample of vendors was interviewed for the price, sales unit and source of their produce.

3.1.2.4. Farm survey by questionnaire

(a) Selection of farm sample

Sampling in each of the three selected locations was done as follows:

- A rough estimate of the total number of farms in each location, and the number of sub-locations that make up the location was obtained from the agricultural technical staff.
- The farms were categorized into small size ($\leq$5 acres) and large size ($>$5 acres).
- With the help of agricultural technical staff a farm sample of 1-2%, incorporating a fair representation of both large and small farms was drawn from all the sub-locations in each location.

(b) Survey schedule

The farm household survey was carried out in Iveti and Masii concurrently on 11th - 13th August 1980 (inclusive). In Wamunyu the survey was performed between 29th August and beginning of September, 1980.

(c) Survey operation

Due to the large number of farms involved (approx.

300 in all the three locations), and the long distances between farms, the services of enumerators had to be engaged. These enumerators and technical staff of the project were briefed on conducting quick interviews with the questionnaire form. The agricultural technical staff assisted in supervisory work and collection of the completed forms, while the investigator handled the overall supervision.

3.2. Laboratory Experimental Work

3.2.1. Materials

These consisted of:

- Fresh samples of fruit and vegetable species identified in the field survey, which were available at the time of collection, in the three selected locations and Machakos town market (Section 4.1.5. for further qualitative description of materials).
- Specific laboratory chemicals, reagents and materials for each nutrient assay, were mainly obtained from Kobian (Kenya) Limited,, Nairobi while others were obtained from Howse & McGeorge Limited, Nairobi.

3.2.2. Methods

3.2.2.1. Experimental design

Visits were planned to the three locations (for farm sample collections) and to the market (for market samples) in such a way as to create an experimental design depicted in Table 3-3. In each visit samples were obtained from a few randomly selected farms distributed over several sub-locations. In the market samples were obtained from several vendors. Usually not more than 20 items were collected in a single trip.

Table 3-3: Schedule of visits for sample material collection.

	Dates (No. of visits)	
Location	Drought	Short/post-short rains*
Iveti	10/10/80 (1)	26/1/81; 3/2/81 (2)
Masii	10/10/80 (1)	27/11/80; 19/12/80 (2)
Wamunyu	2/10/80; 21/10/80 (2)	14/1/81; 21/1/81 (2)
Market	27/10/80; 3/11/80 (2)	24/11/80; 19/12/80; 9/1/81 (3)

The short rains arrived on 3/11/80 and continued upto 18th Dec. 1980.

With reference to Table 3-3, the availability and nutritive value of species of fruits and vegetables would be evaluated in relation to ecological zone (location) and also in relation to season.

3.2.2.2. Collection, transportation and storage of materials for laboratory analysis

Fresh sample materials were collected from farms and the market in polythene bags which were coded and dated. These samples were transported in a cool box and stored under refrigeration up to the time of analysis.

3.2.2.3. Laboratory procedures

(a) Primary sample preparation

From a random sample of several units of fruits/ vegetables a sample of about 500g was prepared by firstly removing inedible parts like stalks, rinds and seeds, washing wherever necessary followed by cutting into smaller pieces or shreds whenever necessary. This primary sample was thoroughly mixed and secondary analytical samples drawn from the mixture. All analyses were done in duplicate.

Moisture, vitamin C and β-carotene, determinations were done within 48 hours. The rest of the sample was oven dried in large porcelain evaporating dishes at 100°C, cooled, milled and stored in polythene bags or plastic bottles at room temperature.

(b) The chemical assays

- Moisture determination. The AOAC (3) method was used.
- Ascorbic acid determination (The AOAC (3) titrimetric dye method with Gomez's (29) modifications was applied. However, in the extraction with metaphosphoric acid step, the mortar and pestle was used instead of the electric mixer).
- β-carotene determination was carried out using the method of Astrup *et al*. (4) but with Gomez's (28) modifications.
- Mineral analysis for calcium and iron was carried

out using the Atomic Absorption Spectrophotometer (64).

- Antinutrient analysis for oxalates: Moir's method (54) was used.
- Proximate analysis for crude fibre, ash, crude protein, crude fat (and moisture of dry material) (3): The AOAC (3) method was applied.

3.3. Statistical Methods of Analysis of the Results

3.3.1. Field Survey by Questionnaire

- Results of Acceptance Rating of indigenous vegetables (Appendix i, Section 3 (i) and results of Table 4-1, Section d) were arrived at as follows:

  For each sub-location, vegetable species were identified which had the highest frequency at the top end of the rating list. These were cowpea leaves, pumpkin leaves, kikoowe and amaranthus. The number of times each species appeared among the top (best) three vegetables divided by the total number of households surveyed in that sub-location multiplied by 100 gave the figure presented in Table 4-1, Section d.
- Correlation coefficients were computed for data on the main characteristics studied.

3.3.2. Nutrient Assays

For all the fruits and vegetables with or without replicates a qualitative test , (Friedman's test (25) would be employed to evaluate species effect on overall nutrient composition. The species would subsequently be ranked in order of overall nutrient superiority.

4. RESULTS

4.1. Field Survey Data

4.1.1. Direct interviews of agricultural extension staff

On being interviewed the agricultural officials admitted having observed the practice of including wild and semi-wild vegetables like *Solanum nigrum* and amaranthus in diets. The eating of wild fruits had also been observed especially among children (e.g. on their way to and from school). However, the frequency of consumption of these was unknown (16, 17, 34, 72).

4.1.2. Farm survey

4.1.2.1. Preliminary visits to farms

(a) Observations made

In all the seven farms visited (in July 1980, a month before survey by questionnaire) four in Masii and three in Wamunyu, the maize crop had already been harvested, but pigeon peas and to a lesser extent cow-peas were still growing, while pumpkin vines were scattered on the fields. Behind the animal sheds, in particular, some wild vegetables, like Solanum nigrum, and amaranthus in their late stage of growth could be seen.

In each farm at least one fruit tree, especially the mango, pawpaw, guava, 'zambalau', and to a lesser extent wild ones like 'kikalwa' and 'muu', were growing behind the homestead or elsewhere in the farm, thus, providing shade. Cotton and sunflower were growing in some farms.

Each homestead had at least one grain storage shed (a raised hut with a thatched roof).

(b) Interviews

Monocropping of the main food crops viz, maize, beans, pigeon peas, and cowpeas was the normal practice, although during the short rains of October maize was sometimes intercropped with pigeon peas or cowpeas. In some cases the latter two were intercropped. Cassava, sweet potatoes, millets and pumpkin vines were cultivated in lesser degrees. These food crops, which were normally grown during the normal rains were for home consumption. Only excess produce was sold.

There was an exceptional case of a farm with irrigation facilities. In this case there was an orchard of citrus, pawpaw and banana suckers. Tomatoes, cabbages and sweet potatoes were also cultivated on the farm. Except in this farm, vegetables, although attempted during normal rains, did not thrive because of insufficiency of the rain.

The eating of wild vegetables, it was learned, was practised mainly in the absence of cultivated types like cabbage, kale, cowpea and pumpkin leaves. *Solanum nigrum* and amaranthuses were among the wild species commonly found and eaten, while the latter was also fed to animals sometimes, but in one of the farms wild vegetables were not eaten at all. The wild vegetables were mashed with 'isyo' (traditional Kamba dish consisting of whole kernel maize grains, beans or peas) or cooked separately and used as a side dish along with 'ugali' (stiff porridge of maize flour).

Fruits were eaten randomly whenever they were available. The eating of wild fruits especially, was left to the children and women to a lesser extent. Most men appeared to be prejudiced against the eating of wild fruits in particular.

4.1.2.2. Farm survey with the questionnaire form

These results are recorded in Table 4-1 and 4-2. In Table 4-1 means, modes and medians of some of the characteristics sought for are recorded. Table 4-2 represents the results of some correlation studies on some of the results of the survey.

Approximately 310 farm households were surveyed in questionnaire interviews (Appendix i). However due to spoilage of some forms the results of only 302 households are recorded. Out of these 302 households, 141 were in Iveti, 88 in Masii and 73 in Wamunyu.

Regrettably, the data sought for in the questionnaire form was not adequately supplied. In some cases such data was omitted while in others, the validity of the values recorded was questionable. The enumerators complained that the farmers neither kept such records nor did they find it easy to estimate quantities and frequencies involved. The normal practice was to use foods that were available at any given time with little regard to frequency and monotony.

(a) Background information on the sample studied

Referring to Table 4-1, Section (a) the sample studied had a mean family size of 13.2, 12.5, and 10.7 in Iveti, Masii and Wamunyu respectively. The mode for Iveti and Masii was 13. These families had an average of 2 pre-school children each.

In Iveti about 75% of the men were farmers whereas in the other two, less productive locations the proportion was less (approximately 50%). Over 75% of the women in all the three locations were farmers.

The mean annual income per family was estimated at 500 Kenya Pounds for Iveti and Wamunyu. The figures provided are very rough estimates. Figures for Masii location were either questionable or omitted altogether. The mean size of holding of 5 acres in Iveti was about one third of the mean size recorded for the other two drier locations. Almost all the farms were owner farms. The very few farms in Wamunyu, which were not, had been let to sons by fathers.

(b) Cultivation patterns (Table 4-1, Section (b)

Maize and beans were cultivated by a majority of the farmers (over 97% and 90% for maize and beans respectively, in the sample studied).

Pigeon peas and cowpeas were predominantly cultivated in Masii and Wamunyu. On the other hand, cocoyam, vegetables and fruits were grown more frequently in Iveti than in the other two locations. Wide variations of cultivation patterns within each location were observed, for example cocoyam and pigeon peas in Iveti, and vegetables in Masii (Table 4-1, Section b).

Coffee was about the only cash crop in Iveti. It was also cultivated in some parts of Masii. Cotton was cultivated mainly in Wamunyu and to a lesser extent in Masii. Sunflower, grown mostly in Masii was not as widely cultivated as the other two crops.

(c) Dietary patterns

From Table 4-1, Section (c), approximately 90% of the households commonly took three meals per day. Almost all households were taking supper (98.4%). Breakfast and lunch however, were not as frequently consumed (94.2 and 95.7% for the two respectively). 'Isyo' and 'ugali' with a side dish (usually greens) were the common foods taken at lunch/supper time, while at breakfast tea and to a lesser extent porridge was taken. Fruits were taken randomly, in between meals.

Table 4-1: Results of farm survey by questionnaire

Location		Iveti			Masii			Wamunyu			
Characteristic		Mean	Mode	Median	Mean	Mode	Median	Mean	Mode	Median	Overall Mean
(a)	Socio-Economic										
(i)	Family size	13.2	13	13	12.3	13	12.5	10.7	-	11	12.1
(ii)	No. children	9.8	9	9	9.6	8	8.5	8.0	-	8	9.2
(iii)	No. pre-school	1.8	2	2	2.2	2	2	1.4	1	1	1.80
(iv)	No. farm labour	0.9	-	1	0.8	1	1	0.7	1	1	0.80
(v)	% men farmers	74.5	60	75	52.5	-	52	53.9	-	55	60.3
(vi)	% women farmers	78.3	100	81	70.7	-	82.5	95.9	100	100	81.6
(vii)	Annual income/family (K£)	562	-	535	-	-	-	484	-	525	523
(viii)	Size of holding (acres)	4.99	-	5.25	11.5	-	10.03	10.02	-	9.49	8.84
(ix)	% owner farm	100	100	100	100	100	100	96.0	100	100	98.7
(b)	Cultivation Patterns										
Percentage farms cultivating:											
(i)	Maize	94.3	100	100	99.0	100	100	98.3	100	100	97.2
(ii)	Beans	93.5	100	100	89.5	100	96	87.3	100	95	90.1
(iii)	Pigeon peas	12.6	0	3.5	79.0	93	92.5	95.3	100	100	62.3
(iv)	Cow peas	16.8	7	13.5	64.3	-	82	78.3	-	92	53.1
(v)	Millets/sorghum	2.1	0	0	3.7	0	0	10.1	-	10	5.30
(vi)	Cocoyam	14.0	0	7	0	0	0	0	0	0	4.67
(vii)	Cassava	35.4	-	31.5	35.8	-	14.5	84.7	100	88	52.0
(viii)	Fruits	22.6	7	17	-	-	-	?	?	16	-
(ix)	Vegetables	45.2	40	40	27.5	0	19.5	0	0	0	24.2

Table 4-1 Continued

Location	Iveti			Masii			Wamunyu			
Characteristic	Mean	Mode	Median	Mean	Mode	Median	Mean	Mode	Median	Overall Mean
(x) Coffee	47.8	-	28	24.5	0	7.5	0	0	0	24.1
(xi Cotton	0.8	0	0	29.0	-	26	58.1	-	60	24.3
(xii) Sunflower	0	0	0	13.2	13	13	0	6.7	6.7	4.4
(c) Dietary										
Percentage households taking:										
(i) 3 meals per day	94.0	100	94	88.8	100	100	85.7	90	88	89.5
(ii) Breakfast	95.4	100	100	88.8	100	100	98.4	100	100	94.2
(iii) Lunch	96.7	100	97	100	100	100	90.3	90	90	95.7
(iv) Supper	98.1	100	100	100	100	100	97.0	100	100	98.4
Percentage households usually consuming:										
At breakfast										
- Tea only	47.4	-	53.5	43.2	-	46	65.9	-	70	52.2
- Tea and other food	34.2	-	29	28.6	0	7	7.7	0	9	23.5
- Porridge	49.5	-	39	28.2	-	31	42.1	-	45	39.9
At lunch/supper										
- Isyo	92.8	100	97	100	100	100	95.4	100	100	96.1
- Ugali and side dish	86.1	100	88	100	100	100	87.3	80	90	91.1
- Others	23.1	7	17	21.8	0	8	7.1	0	10	17.3
In between meals										
- Tea (4 o'clock)	32.8	27	29	23.0	-	13	12.9	10	10	22.9
- Porridge	13.2	0	0	23.8	0	13	14.4	-	13	17.1
- Fruits	48.3	-	45.1	26.4	0	23	7.4	0	8	27.5

Table 4-1 Continued

Location	Iveti			Masii			Wamunyu			
Characteristic	Mean	Mode	Median	Mean	Mode	Median	Mean	Mode	Median	Overall Mean
(d) Specifically on indigenous crops										
Percentage household including in the diet at least:										
- One type of wild*vegetable	92.0	93.0	93.5	75.8	100	80	93.3	100	100	87.0
- One type of wild* fruit	52.5	-	51.5	95.2	100	100	96.9	100	100	81.5
% whose source of vegetable is home garden	94.8	100	100	93	-	?	85.6	-	90	91.1
Acceptance rating**										
Percentage household with among first 3 best:										
- Cowpea leaves	74.8	-	79.5	58.8	-	74	-	-	-	✦ 66.8
- Pumpkin leaves	90.4	100	90	59.8	13	74	-	-	-	75.5
- Kikoowe	68.5	67	68	74.7	-	76.5	73.9	-	73	72.4
- Amaranthus	66.0	-	63.5	61.7	-	65.5	56.9	50	50	42.6
% prefering these above exotic*** types for:										
- Taste	85.0	100	89.5	73.5	-	72	36.7	-	40	65.1
- Appearance	30.1	-	28	11.3	-	7	14.7	0	17	18.7
- Texture	56.6	-	61.5	36.0	-	34.5	29.1	-	30	40.6
- Keeping quality, post harvest	19.3	-	9	22.8	-	7	20.9	10	20	21.0
- Cooking characteristics	56.8	-	55.5	24.8	-	23.5	53.9	-	50	45.2

Foot note: * Wild stands for both wild and semi wild.
** Results obtained by calculations as described in Section 3.3.1.
*** Exotic stands for cabbage in particular.

(d) Utilization of indigenous crops

The percentage of farm households which include at least one kind of wild/semi-wild vegetable was 75 and above, in all three locations. The proportion of households which include at least one wild fruit on the other hand, was higher in Wamunyu and Masii than in Iveti (mean percentage of these were 52.5, 95.2 and 95.2 and 96.9 in Iveti, Masii and Wamunyu respectively). The main source of the vegetable was home gardens, although a few households bought these commodities from the market.

Pumpkin leaves and cowpea leaves, among the cultivated vegetables and 'kikoowe' and 'amaranthus' among the semi-wild types in that order were the most popular (Table 4-1, d), but less preferred because of because of their poor keeping quality.

On utilization, no processing/preservation was practised. Fruits were usually eaten raw while vegetables were cooked before consumption.

Apart from use as foods no other use was recorded except in a few cases where some wild vegetables were used as animal feeds. No taboos were recorded.

Correlation studies on some characteristics studied

These results are summarised in Table 4-2. Almost all the correlation coefficients were not statistically significant at 0.95 probability level.

Tables 4-3 and 4-4 consist of a list of fruits and vegetables both found and eaten in the three study locations, as extracted from the completed questionnaire. (The lists include local Kamba name, common and botanical name). Species found, but not eaten in the location were not included. These tables indicate the availability of fruits and vegetables in relation to location.

In Iveti, where the climate and ecology allowed for cultivation of a wide range of crops there was a range of cultivated and semi-cultivated fruits (Table 4-3). Few wild types were recorded as eaten. In this location use was made of leaves of such cultivated crops as cocoyam, Irish potato and beans. Utilization of wild types of vegetables was minimal. In Masii and Wamunyu, on the other hand, a wider variety of wild fruits and vegetables were recorded. (Tables 4-3 and 4-4). The largest number of wild fruits was recorded in Wamunyu, the driest of the three locations.

4.1.3. <u>Market surveys</u>

Results of availability/seasonality/prices of fruits and vegetables are presented in Tables 4-5 and 4-6.

4.1.3.1. <u>Supply, prices and sources of fruits</u>

While the supply of pawpaws and passion fruits remained from fair to high, that of tree tomato,

Table 4-2: Correlation coefficients of some of the characteristics studied

	Characteristics compared	Correlation coefficient(r)	(P=.95)
1.	Family size x income	.226	n.s.
2.	Family size x % h/holds with 3 meals/day	-.267	n.s.
3.	Family size x % h/holds with at least one wild vegetable in diet	.154	n.s.
4.	No. pre-school children x % h/holds with 3 meals/day	-.453	s
5.	No. farm labour x income	.203	n.s.
6.	Income x % h/holds including at least one wild fruit in diet (in Iveti only)	-.190	n.s.
7.	% cultivating fruits x % including at least one wild fruit in diet (in Iveti only)	-.254	n.s.
8.	% cultivating fruits x % commonly eating fruits (in Iveti only)	-.373	n.s.
9.	% cultivating vegetables x % eating at least one wild vegetable (in Iveti only)	-.465	n.s.

Note: n.s. = not significant
s. = significant

Table 4-3: Some fruits found in Machakos

	Local Kamba name	Common name	*Botanical name	Cultivation status	Where found and eaten		
					Iveti	Masii	Wamunyu
1.	Maembe	Mangoes	Mangifera indica	C	+	+	+
2.	Mavera	Guavas	Psidium guajava	C	+	+	+
3.	Makundi	Passion fruits (P)	Passiflora edulis	C	+		
4.	Makundi	Passion fruits (Y)		C	+		
5.		Tree tomato	Cyphomandra betacea	C	+		
6.	Ndae	Mulberries	Morus sp.	C	+		
7.	Matomoko	Custard apples	Annona squamosa	C	+	+	
8.	Ngavu	Cape gooseberries	Physalis peruviana	SC	+		
9.	Makuyu	Figs	Ficus sp.	C	+		
10.	Makuyu	Wild figs	Ficus sp.	W	+	+	+
11.	Zambalau	Java fruit	Eugenia cumenii	SC	+	+	
12.	Ndula	Loquats	Eriobotrya japonica	C/SC	+		
13.	Ndula			W		+	+
14.	Makul[illegible]tui	Wild bananas	Musa sp.	W	+		
15.	Nthumula	Tamarinds	Tamarindus indica	W/SC			+
16.	Nguuk[illegible]ma		ni	W	+		
17.	Ngomoa/ngomole		Vangueria rotundifolia	W	+	+	+
18.			Lantana camara	W/SC		+	
19.	Matoo		Azanza garkena	W	+	+	+
20.	Ngalwa		Carissa edulis	W		+	+
21.	Maua		Sclerocarya caffra	W		+	+
22.	Mamunya		ni	W			+
23.	Nzovi/Sovisovi		ni	W			+

Table 4-3: Continued

	Local Kamba name	Common name	*Botanical name	Cultivation status	Where found and eaten		
					Iveti	Masii	Wamunyu
24.	Ndului		Balanites glabra	W		+	+
25.	Ntheu		Rhus nataleusis	W		+	+
26.	Nthei		ni	W			+
27.	Ngakaa		ni	W			+
28.	Mba		Pappea capensis	W		+	+
29.	Muu		Vitex payos	W		+	+
30.	Mitholo		ni	W			+
31.	Ngangaa		ni	W			+
32.	Nguluu		ni	W			+
33.	Maonywe		Ficus sp.	W			+
34.	Ndotoo		Laranthus uluguense	W			+
35.	Kithunda ndutu		ni	W			+
36.	Ndawa		ni	W			+
37.	Nthaana		ni	W			+
38.	Mbiiu		ni	W			+
39.	Maumbu/Mombo		Ficus capense	W			+
40.	Makwelilu			W			+
41.	Ngelenzi			W			+
42.	Ngawa			W		+	
43.	Mbisavisi/ndavasivi			W		+	
44.	Mamowe			W		+	
45.	Ndumbuu			W		+	

Foot notes: C = Cultivated   Wild = Wild   P = Purple   Y = Yellow (sweet)
SC = Semi cultivated   ni = Botanical identifications not confirmed
Source of botanical identifications: Gomez (30)

Table 4-4: <u>List of leafy vegetables found in Machakos</u>

	Local Kamba name	Common name	*Botanical name	Cultivation status	Where found and eaten +		
					Iveti	Masii	Wamunyu
1.	Nyunyi/Nthooko	Cowpea leaves	Vigna unguiculata	C	+	+	+
2.	Nenge	Pumpkin leaves	Curcubita spp.	C	+	+	+
3.		Cocoyam leaves	Colocasia esculenta	C	+		
4.		Bean leaves	Phaseolus vulgaris	C	+		
5.		Irish potato leaves	Solanum tuberosum	C	+		
6.		Sweet potato leaves	Ipomea batatas	C	+		
7.		Cassava leaves	Manihot esculenta	C	+		
8.	Ua (Woa)	Amaranthus	Amaranthus sp.	SW	+	+	+
9.	Mwianzo	African spider herb	Gynandropsis gynandra	SW		+	+
10.	Ndulu	Black night shade	Solanum nigrum	SW	+	+	+
11.	Kikoowe		Commelina sp.	W/SW	+	+	+
12.	Itula		Commelina africana	W/SW		+	+
13.	Kikungi		Cucumis dipsacens	W/SW		+	+
14.	Kimoowe			W/SW		+	
15.	Kyambatwa			W/SW		+	+
16.	Kathukambiti					+	+
17.	Kamkulutu kanini		Heliotropium somalense	W/SW			+

Foot notes: C = Cultivated SW = Semi wild W = Wild

* = Source of botanical identifications: Gomez (30).

custard apple and mulberry remained low in all the three seasons studied (spread out from May to January 1981). The supply of guavas, loquats, citrus fruits, bananas and cape gooseberries was progressively on the downward trend from May towards the end of year. Mangoes and temperate fruits on the other hand became available in the third season (December 1980 - January 1981). There was in each season studied quite a wide range of fruits of fair to high supply, as indicated by the summary footnote of Table 4-5.

The average price of fruits did not vary consistently with supply (season) presumably because of high variation observed from vendor to vendor.

Iveti was by far the major source of the fruits. They predominantly originated from owner farms.

4.1.3.2. Supply, prices and source of vegetables

Vegetables originated from various locations although Iveti still featured as a prominent source (Table 4-6). While most cabbage, green peas and green beans came from Iveti other local leafy vegetables and pigeon peas were supplied from various sources. Nairobi wholesale market was the main source of Irish potatoes and onions (stems and bulbs). The few Irish potatoes from Machakos were smaller in size and of poorer quality.

Cabbage, was available in all the three seasons

Table 4-5: Summary of market studies on fruits

Season	1. Post long rains			2. Pre-short rains			3. Short rains/post rains		
	(May - June 1980)			(August - September 1980)			(October - January 1980 - 1981)		
Fruit	S.	Av. qtty./ shilling	M.S.	S.	Av. qtty./ shilling	M.S.	S.	Av. qtty./ shilling	M.S.
1. Guavas	+++	11.4	Iveti	++	10	Iveti	+	X	Iveti
2. Loquats	+++	20	Iveti	+++	25	Iveti/Muputi	+	14	Iveti
3. Lemons	+++	7	Iveti	++	7	Iveti/Muputi	-	N/A	N/A
4. Oranges	+++	2	Iveti	+	1.5	Iveti/Kilungu	-	N/A	N/A
5. Passion fruits (P)	+++	11.1	Iveti	++	6.5	Iveti/Muputi	+++	9.8	Iveti
6. Passion fruits (Y)	+	3	Iveti	+	4.5	Iveti	++	7.3	Iveti
7. Tree tomato	++	10	Iveti	++	11.7	Iveti	+	5	Chambuko
8. Pawpaws	++	400g	X	+++	600g	Muputi	++	X	X
9. Custard apples	+	1	Muputi	X	X	X	+	1.5	Iveti
10. Cape gooseberries	+	70	X	+	X	Iveti	-	N/A	N/A
11. Mulberries	X	X	X	+	X	Iveti	++	300g	Iveti
12. Mangoes	+	1	Mombasa	-	N/A	N/A	+++	2.5	Muputi
13. Bananas	+++	4	X	++	3	Muputi	+	4	Muputi
14. Avocado	++	1.4	Iveti	++	1.2	Iveti	+	1	Iveti
15. Peaches	-	-	N/A	+	6	X	+++	10	Iveti
16. Plums	-	-	N/A	-	N/A	N/A	++	10	Iveti
Fruits available in fair (++) to large supplies (+++)	- guavas, loquats, lemons, oranges, passion fruits (p) tree tomato, pawpaws, avocado, bananas			guavas, loquats, lemons, passion fruits (p), tree tomato, pawpaws, bananas, avocado			passion fruits, pawpaws, mulberries, mangoes, peaches plums		

Foot Note: (of Table 4-5)

S = supply +++ = large, ++ = fair + = small - = none

X = omitted

Av. qtty. = Average quantity, (in units of fruits except where specified otherwise) y = yellow p = purple

M.S. = Main Source N/A = not applicable

Table 4-6: Summary of Market studies on vegetables

Season		1. Post long rains (May - June 1980)			2. Pre-short rains (August - September 1980)			3. Short rains and post (October - January 1980 - 1981)		
	Item	S.	Av. qtty./ shilling	M.S	S.	Av. qtty./ shilling	M.S.	S.	Av. qtty./ shilling	M.S.
	Leafy vegetables									
1.	(a) Cabbage (head)	+	170g	Iveti	+++	330g	Iveti	+++	350g	Iveti
	(b) Cabbage (leaves	+	8 leaves	Iveti	++	6 leaves	Iveti	++	10 leaves	Iveti
2.	Kale	+	14 leaves	Kiima	++	14 leaves	Vet. Farm	+++	14 leaves	X
3.	Spinach	+	12 leaves	X	++	12 leaves	Athi River	+	X	X
4.	Corriander shoots	+	50 shoots	X	+	?		++	125g	Mua Hills
5.	(a) Onion stems	+++	6 steams	Nairobi	+++	10 stems	Nairobi	+++	10 stems	Nairobi
.	(b) Onion bulbs	++	133g	Kilungu	+++	240g	Nairobi/kilungu	+++	275g	Nairobi
	(c) ½ bulb - ½ leaf	+	4 plants	Iveti	++	10 plants	Kilungu	++	10 plants	Iveti
6.	Cowpea leaves	++	325g	Muputi/Iveti	+	300g	Mitaboni/Iveti	+++	400g	Masii/Muputi
7.	Pumpkin leaves	+	X	X	+	300g	Muputi	-	N/A	N/A
8.	Amaranthus (shoots)	+	X	Kiima-kimwe	-	N/A	N/A	++	500g	Muputi
9.	G. gynandra (stalks)	-	N/A	N/A	-	N/A	N/A	+	2,300g	Muputi
10.	S. nigrum (stalks)	+	800g	Mua	-	N/A	N/A	+	800g	X
11.	Cocoyam leaves	+	500g	Iveti	-	N/A	N/A	-	N/A	N/A

Table 4-6: Continued

	Season	1. Post long rains (May - June 1980)			2. Pre-short rains (August - September 1980)			3. Short rains and post (October - January 1980 - 1981		
	Item	S.	Av. qtty./ shilling	M.S.	S.	Av. qtty./ shilling	M.S.	S.	Av. qtty./ shilling	M.S.
	Green legumes									
12.	Green pigeon peas	++	280g	Kalama/Iveti	+++	390g	Masii/Kiteta	-	N/A	N/A
13.	Green peas	+	250g	Iveti	++	300g	Iveti	+	125g	Iveti
14.	Green beans	++	300g	Iveti	+	300	Iveti	+	250g	Iveti
	Root vegetables									
15.	Cocoyams	+++	500g	Iveti	++	300g	Iveti	X	X	X
16	Cassava	-	N/A	N/A	++	500g	Iveti	-	N/A	N/A
17.	Sweet potatoes	-	N/A	N/A	++	480g	Muputi/Iveti	++	N/A	N/A
18	Irish potatoes	++	230g	Nairobi	+++	500g	Nairobi	++	500g	X
19.	Carrots	+	150g	Iveti	+	200g	Iveti	X	X	X
	Other vegetables									
20.	Pumpkins	+	600g	X	+	X	X	-	N/A	N/A
21.	Green maize	+	½ cob, medium sized	Mua	++	3 small cobs	Iveti	+	½ cob, medium sized	Iveti
22.	Plantains	+	6(small)	Muputi	+	5 (small)	Chambuko	+	4 (large)	Iveti
23.	Tomatoes	+	250g	Iveti	+++	550g	Iveti	++	350g	Iveti

Note: Abbreviations same as those in Table 4-5 studied. Its cost, like that of many other vegetables fluctuated with supply/season (e.g. in season 1, around May, one shilling was worth only 170g cabbage compared with 350g in season 3 (December - January)). Though there was a seasonal variation in the supply of wild vegetables e.g. *Solanum nigrum* and *Gynandropsis gynandra*, the actual supply was not comparable with that of the cultivated types like cowpea leaves. The latter appeared in larger quantities during seasons of availability. The prices of the wild types, however, were much lower compared to the cultivated types (1 shilling was worth 2,300 g of *G. gynandra* - Table 4-6).

4.1.4. Availability of fruits and vegetables in farms/market for collection

Not all the species of fruits and vegetables listed in Table 4-3 and 4-4 were available at the farms for collection and identification during the seasons under study. Of the available species, due to time limitations, collections were limited to the lesser known species and those for which limited or no nutrient data was available. Thus, citrus fruits, mangoes, avocado pears, brassicas, potatoes and carrots, which were available in the market and in some farms were not collected. The species collected are listed in Table 4-7 and 4-8.

In the pre-short rains drought season leafy vegetables were not available in Masii and Wamunyu.

Sample collections from these locations consisted of wild fruits only. In Iveti and the market, on the other hand, some vegetable collections of e.g. cocoyam and pumpkin leaves were made. Cultivated and semi-cultivated fruits made up the bulk of the fruit collections from the latter locations.

After the rains, semi-wild and wild leafy vegetables made up the bulk of the farm collections, in Masii and Wamunyu, especially, thus limiting the number of fruit collections that could be made that season (Table 4-8).

4.1.5. Qualitative characteristics of sample materials collected.

The cultivated/semi cultivated fruits were generally fleshy, juicy and not very fibrous. Their edible portions were of various colours, including yellow, the carotene colour. The wild fruits, on the other hand were hard, dry and fibrous. When ripe, their flesh turned brown, with little carotene indication. As for the vegetables, both cultivated and wild species were green and leafy.

4.2. Nutrient Assays

Results of nutrient assays are presented in Tables 4-9 and 4-10. Table 4-9 represents the results for fruits while Table 4-10 represents the results for vegetables.

Table 4-7: Farm/market fruit collections

Season	Iveti	Masii	Wamunyu	Machakos town market
Pre-short rains	Tree tomato	'Mba'	Tamarind	Passion fruit (purple)
	Cape-gooseberry	Custard apple	'Ngomoa'	Passion fruit (yellow)
	Loquat		'Matoo'	Tree tomato
	Guava		'Ndului'	Loquat
	Mulberry		'Maonywe'	Pawpaw
	Wild banana		'Ntheu'	Peach
	'Ngomoa'			Plum
				Custard apple
During short-rains and post short rains	Passion fruit (yellow)		'Matoo'	Passion fruit (purple)
	Mulberry		'Maua'	Passion fruit (yellow)
	Gooseberry			Peach
	Wild fig			Plum
				Mulberry
				Guava
	Passion fruit (purple)		Tamarind	Custard apple

Table 4-8: Farm/market leafy vegetable collections

Season	Iveti	Masii	Wamunyu	Machakos town market
Pre-short rains	Cocoyam	-	-	Cowpea
	Pumpkin			Onion leaves
				Onion stems
				Corriander shoots
During short rains and post rains	Cowpea	Cowpea	Cowpea	Green amaranthus (L.L.)
	Bean	G. gynandra	G. gynandra	Cowpea
	Cocoyam	Green amaranthus (O.L.)	Green amaranthus (L.L.)	Solanum nigrum
	Green amaranthus (L.L.)	Green amaranthus (L.L.)	Green amaranthus (S.L.)	Onion leaves
	S. nigrum	Green amaranthus (S.L.)	S. nigrum	Onion leaves
		'Kikungi'	'Kikungi'	Corriander shoots
		'Kikoowe'	'Kikoowe'	
		'Itula'	'Kamkulutu Kanini'	
	Pumpkin	Pumpkin	Pumpkin	Gynandropsis gynandra

Note: L.L. = Long-leafed; O.L. = Oval-leafed; S.L. = Small-leafed

Although the experiment was designed to investigate locational and seasonal variation (Section 3.2.2.1.) the results obtained did not show significant variations between locations and seasons. The results were thus pooled for each species.

Table 4-9: Composition of some fruits of Machakos in 100 g fresh weight of edible portion

	Fruit	Vitamin C (mg)	β-carotene (μg)	Iron (mg)	Calcium (mg)	Dry matter (g)	Crude fibre (g)	Ash (g)	Crude Protein (g)	Crude Fat (g)
	Cultivated/semi cultivated									
1.	Loquat pc	3±1. (8)	978±281 (5)	1.0±.2 (5)	36±12 (5)	16.0±2 (8)	2.0±.5 (6)	1.1±.5 (4)	0.6±.1 (5)	.16±.04 (5)
2.	Cape goose-berry w	29±2 (5)	1,888±542 (6)	1.3±.2 (5)	10±.3 (3)	17.6±.6 (6)	4.9±.6 (4)	1.3±.1 (4)	2.3±.2 (4)	1.3 ±.3 (3)
3.	Peach pc	4±2 (3)	675 (1)	1.0±.6 (2)	12±3 (2)	15.4±.7 (3)	1.5±.2 (2)	0.7±.03 (2)	0.8±.1 (2)	0.12 (1)
4.	Mulberry w	23±15 (4)	400 (1)	1.8±.4 (3)	36±19 (2)	14.6±1 (4)	2.2±.5 (4)	1.0±.1 (4)	1.6±.2 (4)	0.41±.1 (3)
5.	Custard apple p	19±.4 (2)	trace	0.6±.1 (2)	27±7 (2)	20.6±4 (3)	2.6±1 (2)	1.0±.2 (2)	2.0±.5 (2)	0.31±.1 (2)
6.	Pawpaw p	88 (1)	1,107 (1)	-	-	12.8 (1)	-	-	-	-
7.	Tree tomato w	23±5 (2)	1,613 (1)	-	-	13.5 (1)	-	-	-	-
8.	Passion fruit (purple) p	46±8 (5)	2,146±36 (4)	-	-	16.5±3 (5)	-	-	-	-
9.	Passion fruit (yellow) p	21±9 (3)	trace	-	-	12.6±2 (3)	-	-	-	-
10.	Guava (white flesh) pc	309±135 (2)	"	-	-	20.6±3 (2)	-	-	-	-
11.	Plum pc	-	1,507 (1)	0.3 (1)	9 (1)	12.9± (2)	-	-	-	-
	Semi-wild/wild									
1.	Tamarind p	5±2 (2)	trace	5.7±1 (3)	123±29 (3)	71.3±10 (3)	5.2±.1 (2)	5.7±.6 (3)	3.5±.3 (3)	0.71±.01 (2)
2.	'Matoo' pc	3±1 (2)	308 (1)	5.3±.9 (3)	224±35 (3)	46.1±29 (2)	26.7±17 (2)	3.5±2 (3)	4.9±1 (3)	0.52±.1 (2)
3.	'Ngomoa' pc	5±.6 (2)	60 (1)	1.8±.5 (2)	54±10 (2)	31.5±13 (2)	6.2±2 (2)	1.5±.4 (2)	1.0±.6 (2)	0.23 (1)
4.	Wild fig pc	2 (1)	trace	0.9 (1)	6 (1)	20.0 (1)	5.0 (1)	1.4 (1)	1.1 (1)	1.00 (1)
5.	'Maonywe' pc	1 (1)	212 (1)	1.4 (1)	52 (1)	20.5 (1)	10.0 (1)	0.8 (1)	1.3 (1)	0.48 (1)

Table 4-9: Continued

	Fruit	Vitamin C (mg)		β-carotene (μg)		Iron (mg)		Calcium (mg)		Dry matter (g)		Crude fibre (g)		Ash (g)		Crude Protein (g)		Crude fat (g)	
6.	'Ndului' p	10 or 129?	(2)	312	(1)	5.0±.2	(2)	41	(1)	57.0	(1)	6.5	(1)	3.7±1	(2)	4.9±1	(2)	0.76±.34	(2)
7.	Wild banana p	5	(1)	1,238	(1)	-		-		11.5	(1)	-		-		-		-	
8.	'Mba' pc	16±7	(2)	100	(1)	-		-		14.1±.5	(2)	-		-		-		-	
9.	'Ntheu' w	4	(1)	-		-		-		84.8	(1)	-		-		-		-	
10.	'Maua' pc	256	(1)	trace		-		-		18.75	(1)	-		-		-		-	

Key note: Figures provided are means ± standard deviation; in parentheses is field sample size

- = analysis was not done. (Either sample material was too little or the dry matter content was too low to justify its analysis).

trace = Analysis stopped at acetone extraction step. With 5g sample the extract did not acquire yellow colour.

pc = Edible portion consisted of the pulp and outer fruit covering, seeds excluded.

w = Edible portion consisted of whole fruit, with seeds included.

p = Edible portion consisted of pulp only; seeds and outer rind excluded.

Table 4-10: Composition of leafy vegetables of Machakos in 100g fresh weight of edible portion

Vegetable	Vitamin C (mg)	β-carotene (μg)	Iron (mg)	Calcium (mg)	Total oxalate (mg)	Dry matter (g)	Crude Fibre (g)	Ash (g)	Crude Protein (g)	Crude fat (g)
Cultivated										
1. Cocoyam leaves	146±43 (10)	9,343±1,726 (11)	3.8±1 (9)	208±57 (11)	728±138 (9)	17.2±2 (10)	2.9±2 (9)	2.3±.3 (10)	4.3±.3 (9)	0.97±.31 (9)
2. Bean leaves	167.±9 (2)	13,631±2,554 (2)	17.9 (1)	507±34 (2)	0 (1)	22.4±2 (2)	3.6±.02 (2)	3.3±.2 (2)	6.2±.4 (2)	1.26±.09 (2)
3. Onion leaves	40 ±9 (4)	3,481±169 (4)	2.3±.4 (4)	80±2 (3)	9.2 ±12 (4)	11.6±2 (4)	2.0±.4 (4)	1.5±.3 (3)	2.3±.4 (4)	0.54±.19 (4)
4. Onion stems*	24 ±10 (2)	1,750 (1)	1.8 (1)	55 (1)	2.5 (1)	8.5 (2)	1.6 (1)	.87±.02 (2)	1.2±.04 (2)	0.07 (1)
5. Corriander shoots	68±64 (4)	6,991±1,591 (4)	8.7±6 (3)	180±68 (3)	17 ±8 (4)	16.4± 3 (3)	2.0±.7 (4)	2.3±.9 (4)	4.2±.3 (3)	0.40±.03 (3)
6. Pumpkin leaves	128±30 (7)	9,897±835 (7)	9.3±2 (5)	407±158 (4)	143±62 (7)	20.3± 4 (8)	2.8±.7 (7)	3.7± 1 (8)	5.8±.9 (8)	0.68±.17 (6)
7. Cowpea leaves	78±32 (9)	6,742±1,521 (8)	10.6±5 (7)	287±125 (9)	75±49 (6)	15.8±4 (9)	2.5±.9 (8)	2.4±.6 (9)	4.9±1 (8)	0.53±.24 (8)
Semi-wild/wild										
8. Solanum nigrum Sho	144±51 (6)	10,000±1,177 (4)	11.8±6 (5)	291±82 (5)	58±23 (3)	18.3±2 (6)	1.8±.8 (6)	2.8±.4 (6)	5.8±.7 (6)	0.70±.23 (6)
9. Gynandropsis gynandra Sho	131±41 (7)	8,798±1,115 (5)	10 ±5 (7)	251±70 (6)	27±6 (4)	15.4±4 (7)	1.8±.5 (7)	2.8±.7 (7)	5.4±1 (7)	1.02±.51 (7)
10. Kikoowe Sho	101±30 (5)	6,642±846 (3)	6.7±2 (4)	225±75 (4)	1,030±412 (4)	15.5±4 (5)	2.2±.7 (5)	3.2±.4 (4)	4.3±1 (5)	0.91±.32 (5)
11. Itula Sho	40±1 (2)	5,888±689 (2)	4.1 (1)	153±4 (2)	766±442 (2)	12.5±4 (2)	2.1±.1 (2)	1.0 (1)	2.9±.6 (2)	0.36±.16 (2)
12. Green Sho Amaranthus long-leafed)	123±46 (9)	7,945±2,367 (7)	9.5±5 (7)	480±120 (8)	1,977±507 (9)	13.5±4 (9)	2.3±.5 (9)	4.1±.7 (9)	5.0±1 (9)	0.53±.26 (9)

Table 4-10: Continued

Vegetable	Vitamin C (mg)	β-carotene (µg)	Iron (mg)	Calcium (mg)	Total oxalate (mg)	Dry matter (g)	Crude fibre (g)	Ash (g)	Crude protein (g)	Crude fat (g)
13. Green amaranthus (Small leafed)	131±33 (2)	7,000±177 (7)	10.6±5 (2)	453 (1)	2,286 (1)	14.5±6 (2)	1.6±.5 (2)	3.2±1 (2)	4.4±2 (2)	.82 (1)
14. Green Amaranthus (Oval-leafed) Sho	90±15 (3)	7,546±1,649 (3)	4.5±1 (3)	286±140 (3)	1,163±268 (3)	11.1±2 (3)	1.3±.1 (3)	2.8±.6 (3)	2.7±.4 (3)	.39±.20 (3)
15. Kamkulutu Kanini Sho	39±11 (2)	10,156±4,287 (2)	8.3±1 (2)	618±179 (2)	219±107 (2)	17.6±1 (2)	3.4 (1)	3.2±.2 (2)	5.1±.3 (2)	.58 (1)
16. Kikungi Sho	93±17 (3)	4,000±354 (2)	8.5±3 (2)	337 (1)	92±52 (2)	14.7±4 (3)	2.2 (1)	3.7 (1)	5.0±.1 (2)	.47 (1)

Key note: Figures provided are means ± standard deviation; in parentheses is field sample size.

* = Edible portion consisted of young bulb with the green stem and the immediate leafy part.

Sho (Shoots) = Edible portion consisted of leaves and the tender growing tip.

5. DISCUSSION

5.1. Field Survey

Results of the farm survey were in support of previous findings with regard to the staple foods of the Akamba rural population being maize and beans (8).

It was observed in this study that fruits were not part of the main meals. They were however eaten randomly in between meals by 27.5% of the households (Table 4-1). The conclusion by Bohdal *et al*. (8) that fruits were insignificant in the diet of the rural population might partly be explained by the fact that these researchers based their conclusions on foods taken at main meals only.

However, utilization of fruits by only 27.5% of households was not as high as would be expected of an area with such a wide range of fruits, observed in farms and the large supplies observed in the market and as recorded in the annual report (50). The large supplies of fruits, whose major source was Iveti (Table 4-5) which were relatively lowly priced implies that they were exchanged for cash at a faster rate than they were being consumed. Moreover, though from the farm survey no prejudices or taboos were recorded in connection with fruits, preliminary farm interviews and those of agricultural extension staff did in fact reveal that fruit consumption was not a common practice with adults, especially among adult males.

Although a wide range of vegetables does exist in Machakos (Table 4-4), it was noted during preliminary visits that the wild vegetables were normally eaten in the absence of cultivated types (including imported types like cabbages). The greater preference for cultivated vegetables than wild types was indicated in the results of Table 4-1 (d), in which pumpkin and cowpea leaves appeared at the top of the list for acceptance rating, more frequently than the wild types. The mean percentages of households with among the few best vegetables; pumpkin and cowpea leaves were 90.4% and 74.8% respectively. For 'Kikoowe' and amaranthus these percentages were 68.5 and 66 respectively.

The implication of these results is that in seasons or areas where cabbages were readily available meals would be dominated by these, a fact previously observed by Blankhart (7) and Rodriquez (66); that cabbages and tomatoes have gradually replaced the darker green indigenous vegetables in rural diets. Such a switchover is hardly surprising in view of the fact that research efforts have increasingly concentrated on introduced cash crop species like cabbages, which generally are higher yielding (52). They are however, not necessarily more nutritious. In the rainy season and post-rains, pumpkin and cowpea leaves would appear in the diets (of especially those who cannot afford cabbages) more commonly than wild types. Being seasonal crops (Table 4-11) and since, according to the results of the farm survey, no processing/preservation of vegetable was practiced, in drought seasons the diets would be lacking in vegetables, (except for the sector of the population who might afford to purchase vegetables, mainly cabbage, in markets).

5.2. Nutrient Assays

The results of nutrient assays (Table 4-9 and 4-10) were to a large extent within ranges cited in literature (21,65).

5.2.1. Fruits

Micronutrient levels found in fruits in this study compare well with those cited in Food Composition Tables (21, 65), and by other authors, especially with regard to iron. Iron content of mulberry, custard apple and capegooseberry is cited as 1.5 mg, 0.9 mg and 1.5 mg respectively per 100g fresh weight (21, 65). Calcium content in these fruits is similarly not very different in such literature. Vitamin C content of tamarind viz. 6 mg/100g, reported by Czyhrinciw (15) compares favourably with that observed in this study (Table 2-5 and 4-12). Although the Vitamin C content of purple passion fruit obtained in this study is relatively high compared to that obtained by Gachanja (26), that of guava is within values reported before (Table 2-5).

5.2.2. Vegetables

Micronutrient levels found in vegetables conflicted with some of the previous findings reported. While the observed vitamin C levels were within ranges reported by Gomez (29) and Levy (47) they greatly differed from those reported by Abe et al. (1). The range quoted by the latter, with respect to G. gynandra is supported by Tallantire (71). However, Tallantire had derived his values from Food Composition Table for use in Africa (21) in which the value recorded was based on two observations only. In this study the mean reading recorded was based on seven observations. Levy (47) reported values of vitamin C for pumpkin leaves and cowpea leaves in the range of 70 - 190 mg/100g fresh leaf weight, and 30 - 150 mg/100g for Solanum nigrum, a range which is comparable with the values obtained in this study.

β-carotene values obtained here were within ranges reported by Gomez (28) and Begum (5), especially with respect to amaranthus, G. gynandra and cowpea leaves (Table 2-5 and 4-10).

Iron values observed in this study were rather high compared with those cited in Food Composition (Tables (21). The level of iron in pumpkin leaves is quoted in the latter to be as low as 0.8 mg/100g (fresh edible portion of leaf). Here the value quoted in these tables is also based on two observations only compared with 5 in this study. Iron levels similar to those observed in this study were reported by Levy (47) as, 7 - 14 mg/100g fresh pumpkin leaf.

Crude protein values obtained were within ranges cited by Terra (74), Levy (47) and those cited in Composition Tables (21, 65). With reference to Appendix iii, in which values are expressed on dry matter basis, the vegetables had values within ranges quoted by Imbamba (36) (Table 2-3) and Oyenga (63).

Literature on oxalic acid content of local vegetables is lacking. However, oxalate levels for amaranthus as reported by Stafford *et al*. (68) and Hodkinson, *et al*. (33) in Table 2-4 are comparable with those obtained in this study (Table 4-10).

5.3. Significance of Machakos Fruits and Vegetables in Meeting Micronutrient Recommended Daily Allowances (RDA's)

These results are summarised in Table 5-1 and 5.2.

5.3.1. Vitamin C RDA

Referring to Table 5-1, the recommended daily allowance (RDA or recommended daily intake) for vitamin C would easily be satisfied by consumption of 100g of guava (over and above), pawpaw and purple passion fruit. It would almost be satisfied by

Table 5-1: Significance of Machakos fruits in meeting micronutrient Recommended Daily Allowances* (RDA's) (22).

	Fruit	% of RDA met by consumption of 100g of edible portion			
(a)	Cultivated Semi-cultivated	Vitamin C	Vitamin A	Iron	Calcium
1.	Loquat	9.3	21.7	14.3	8
2.	Gooseberry	95.0	42.0	18.6	2.2
3.	Peach	13.0	15	14.3	2.7
4.	Mulberry	92.2	8.89	25.7	19.1
5.	Custard apple	63.3	0	9.1	5.9
6.	Pawpaw	295	24.6	-	-
7.	Tree tomato	75.7	35.8	-	-
8.	Passion fruit (purple)	154.	47.7	-	-
9.	Passion fruit (yellow)	71.3	0	-	-
10.	Guava (white flesh)	1030	0	-	-
11.	Plum	-	33.5	4.3	-
(b)	Semi-wild/wild				
1.	Tamarinds	15.3	0	81.4	27.3
2.	Matoo	8.3	6.84	75.7	49.7
3.	Ngomoa	17.7	1.33	25	12.0
4.	Wild fig	5.7	0	13	1.3
5.	Maonywe	4.0	4.71	20	11.5
6.	Ndului	33.3 or 430	6.93	70.7	9.0
7.	Wild banana	16	27.5	-	-
8.	Mba	53.3	2.22	-	-
9.	Ntheu	11.7		-	-
10.	Maua	853	0	-	-

Note: 0 = insignificant; - = omitted

* For African active adult male (55 kg).

Table 5-2: Significance of Machakos leafy vegetables in meeting micronutrient Recommended Daily Allowances* (22).

Vegetable	% RDA met by consumption of 100g of edible portion			
	Vitamin C	Vitamin A	Iron	Calcium
Cocoyam	487	208	54	46
Bean	557	303	256	113
Onion (Leaf)	133	77	33	18
Onion (Stem)	80	39	26	12
Corriander	227	155	124	40
Pumpkin	427	220	133	90
Cowpea	260	150	151	64
Solanum nigrum	480	222	169	65
G. gynandra	437	196	143	56
Kikoowe	337	148	96	50
Itula	133	131	59	34
G. Amaranthus (L.L.)	410	177	136	107
G. Amaranthus (S.L.)	437	156	151	101
G. Amaranthus (O.L.)	300	168	64	64
Kamkulutu Kanini	130	226	119	137
Kikungi	310	89	121	75

* Recommended Daily Allowances for African active adult male (55 kg).

consumption of a similar weight of cape gooseberry and mulberry; while over 70% would be met by 100g of tree tomato and yellow passion fruit. Except for 'Maua' the wild fruits do not however, make as significant a contribution.

All the vegetables, except onion stem, which is a spice would easily satisfy vitamin C requirement. The RDA estimations are based on fresh material. Since the studied vegetables are normally cooked before consumption, as was observed in the farm survey (Table 4-1), the actual vitamin C intake would be subject to cooking practices. Investigations by Gomez (29) indicated that due to high initial levels, the residual vitamin C after cooking for 15 - 20 minutes was sufficient to contribute significantly to vitamin C requirement.

5.3.2. Vitamin A RDA

Only about 50% of vitamin A requirement would be satisfied on consumption of the fruit richest in this vitamin. In comparison, well over 100% would be satisfied by a similar intake of most of the vegetables. According to Gomez (28) there is infact an increase in carotene content after cooking; thus the potential of these vegetable in satisfying over and above the requirement for vitamin A cannot be overemphasized.

5.3.3. Iron RDA

Some of the wild fruits would meet over 70% of the iron, in contrast to only about 25% met by the cultivated fruit richest in this mineral. Both wild and cultivated types of vegetables would exceed the requirement for iron; and though the bioavailability of iron from vegetables does not compare favourably with that from other rich sources of iron, like meat for example the high amounts present in these vegetables (Table 4-10 and 5-2) would ensure adequate supply of iron available for absorption.

5.3.4. Calcium RDA

Of the four reportedly limiting micronutrients (vitamins A, C, calcium and iron) calcium appears to be the least satisfactorily supplied by the crops under investigation. With reference to Table 5-1 some of the fruits, the wild types in particular contributed approximately one third of the calcium RDA. The vegetables are better in this respect since the majority contribute more than 50% of the calcium requirement (Table 5-2).

The RDA estimations, however are based on all the calcium present in the vegetables and do not take into account factors like oxalate which might interfere with the availability of the mineral for absorption. Fairbank's findings (20) that 0.29 - 0.69% oxalic acid could impair almost completely the utilization of calcium whose content was as high as 0.86% in the vegetable, could imply that the species which were found to be high in oxalate viz amaranthus sp, and 'Kamkulutu kanini', which coincidentally had high levels of calcium (Table 4-10) might in fact not be suitable sources of calcium. Thus the calcium RDA contributions presented in Table 5-2 might in fact be much lower for species with high oxalate levels.

5.4. Statistical Analysis for Nutrient Superiority of Species

In an attempt to classify the species investigated in the order of overall nutrient superiority a qualitative test procedure was followed.

5.4.1. Ranking of species analysed for micronutrient, oxalate and proximate composition.

Chemical assay results in Tables 4-9, 4-10 and Appendices ii and iii were ranked. In each Table the ranking was done for each nutrient level (column) separately. In each column the lowest nutrient level was assigned rank 1 while the highest level received the maximum rank N, which was equal to the number of species/rows. Other nutrient levels received corresponding ranks between 1 and N. The order of ranking was reversed for the anti-nutrient - oxalate because it is an undesirable factor. The reciprocal of of fibre content was used for the ranking of fruits because some fruits contained very high amount of it (fibre). The fibre content was however, omitted in the case of vegetables.

The ranking results are presented in Tables 5.3, 5-4, 5-5 and 5-6. The sum of ranks for each row (species) was denoted by Rj.

On examining Tables 4-9, 4-10 and Appendices ii and iii some species appear to be consistently high in nutrients e.g. bean leaves, while others are consistently low e.g. Itula, yet others are high in some nutrients but low in others e.g. amaranthus. To test if there was a significant correlation between species (rows) and nutrient levels (columns), i.e. if species displayed a consistent order in nutrient levels a test statistic denoted by Friedman (25) as Xr^2 was computed. The statistic is given by the formula:

$$Xr^2 = \frac{12}{NK\,(N + 1)} \cdot \sum_{j=1}^{N} (Rj)^2 - 3K\,(N + 1)$$

Where * K = No. of columns = No. of nutrient determinations.

N = No. of rows = No. of species

Rj = Sum of ranks in j^{th} row

$\sum_{j=1}^{N}$ Directs one to sum the squares of the sums of ranks over all N conditions.

On computing Xr^2, using the results of Tables 5-3, 5-4, 5-5 and 5-6, the results obtained were found to be highly significant at the highest probability

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Foot note: * In the present case rows and columns were inter-changed because inferences intended would be based on species not nutrients.

Table 5-3: Ranks of vitamin levels in all fruits*

	Fruit	Vitamin C	β-Carotene	Rj. (Row total)
1.	Loquat	4	14	18
2.	Cape gooseberry	15	18	33
3.	Peach	5	13	18
4.	Mulberry	14	12	26
5.	Custard apple	11	6	17
6.	Pawpaw	17	15	32
7.	Tree tomato	13	17	30
8.	Purple passion fruit	16	19	35
9.	Yellow passion fruit	12	6	18
10.	Guava (white flesh)	19	6	25
11.	Tamarind	6	6	12
12.	Matoo	3	10	13
13.	Ngomoa	8	7	15
14.	Wild fig	2	6	8
15.	Maonywe	1	9	10
16.	Ndului	9	11	20
17.	Wild banana	7	16	23
18.	Mba	10	8	18
19.	Maua	18	6	24

* Ntheu and plum excluded. Ranks are on fresh weight basis.

Table 5-4: Ranks of nutrient levels in 11 fruits*

	Fruit	Vitamin C	β-Carotene	Crude fibre	Ash	Crude protein	Crude fat	Iron	Calcium	Micronutrient total	Rj (Row totals)
1.	Loquat	7	10	8	6	2	3	4	8	29	48
2.	Gooseberry	10	11	3	9	11	11	7	2	30	64
3.	Peach	8	9	10	2	4	2	5	4	26	44
4.	Mulberry	11	8	6	7	10	9	11	11	41	73
5.	Custard apple	9	3	7	4	8	7	1	5	18	44
6.	Tamarind	3	3	11	11	3	4	8	7	21	50
7.	Matoo	2	6	1	10	9	5	10	10	28	53
8.	Ngomoa	5	4	5	3	1	1	3	6	18	28
9.	Wild fig	4	3	4	8	5	10	2	1	10	37
10.	Maonywe	1	5	2	1	6	8	6	9	21	38
11.	Ndului	6	7	9	5	7	6	9	3	25	52

* 11 Fruits which were assayed for all the given nutrients. The ranking is on a dry matter basis.

Table 5-5: Ranks of nutrients and oxalate in all vegetables

Vegetable	Vitamin C	β-Carotene	Iron	Calcium	Oxalate	Dry matter	Ash	Crude protein	Crude fat	Micronutrient totals**	Rj (Row totals)
1. Cocoyam leaves	15	12	3	5	6	11	4	6	14	41	76
2. Bean leaves	16	16	16	15	16	16	13	16	16	79	140
3. Onion leaves	3	2	2	2	14	3	3	2	8	23	39
4. Onion stems	1	1	1	1	15	1	1	1	1	19	23
5. Corriander shoots	5	7	9	4	13	10	5	5	4	38	62
6. Pumpkin leaves	11	13	10	12	8	15	15	15	10	54	109
7. Cowpea leaves	6	6	14	9	10	9	6	9	6	45	75
8. S. nigrum shoots	14	14	15	10	11	13	9	14	11	64	111
9. G. gynandra shoots	13	11	12	7	12	7	8	13	15	55	98
10. Kikoowe shoots	9	5	6	6	4	8	11	7	13	30	69
11. Itula shoots	4	4	4	3	5	4	2	4	2	20	32
12. G. amaranthus (L.L.) shoots	10	10	11	14	2	14	16	11	7	47	95
13. G. amaranthus (S.L.) shoots	12	8	13	13	1	5	12	8	12	47	84
14. G. amaranthus (O.L.) shoots	7	9	5	8	3	2	7	3	3	32	47
15. Kikungi shoots	2	15	7	16	7	12	10	12	9	47	90
16. K. Kanini shoots	8	3	8	11	9	6	14	10	5	39	74

Foot note: L.L. = long leafed; S.L. = small leafed; O.L. = oval leafed.

* = On fresh weight basis

** = Micronutrient totals are the sum of vitamin C, β-carotene, calcium, iron and oxalate ranks.

Table 5-6: Ranks of nutrients and oxalate in all vegetables*

	Vegetable	Vitamin C	β-Carotene	Iron	Calcium	Oxalate	Ash	Crude protein	Crude fat	Micronutrient totals**	Rj (Row totals
1.	Cocoyam leaves	14	11	3	4	6	4	5	13	33	60
2.	Bean leaves	11	15	16	11	16	6	9	12	69	96
3.	Onion leaves	4	3	1	2	14	3	2	11	24	40
4.	Onion stems	2	1	2	1	15	2	1	1	21	25
5.	Corriander shoots	5	4	10	3	13	5	6	2	35	48
6.	Pumpkin leaves	7	10	7	10	8	11	10	7	42	70
7.	Cowpea leaves	6	5	14	9	10	7	13	8	44	72
8.	S. nigrum shoots	12	12	12	7	11	8	14	10	54	86
9.	G. gynandra shoots	15	13	13	8	12	10	16	16	61	103
10.	Kikoowe shoots	9	6	6	6	4	12	8	15	31	66
11.	Itula shoots	3	8	4	5	5	1	3	4	25	33
12.	G. amaranthus (L.L.) shoots	10	7	9	14	2	14	7	3	42	65
13.	G. amaranthus (S.L.) shoots	16	9	15	15	1	13	12	14	56	95
14.	G. amaranthus (O.L.) shoots	13	16	5	13	3	15	4	9	50	78
15.	Kikungi shoots	1	14	8	16	7	9	11	6	46	72
16.	Kamkulutu kanini shoots	8	2	11	12	9	16	15	5	42	78

Foot note: Abbreviations same as those in Table 5-5

* On dry matter basis.

** Micronutrient total is the sum of vitamin C, β-Carotene, calcium, iron and oxalate ranks.

level (p = .99). These results imply that there is a correlation between the nutrient levels (columns) and species (rows) i.e. the mean ranks $\frac{(Rj)}{K}$ depend on species.

Thus the species can be ranked in descending order, on basis of all nutrients, as presented in Tables 5-7, 5-8 and 5-9. In these Tables, classification based on overall micronutrient level, in which the antinutrient effect of oxalate is accounted for is also included.

5.4.2. Further analysis for superiority among 8 species of vegetables which were replicated at least twice (spices omitted).

The procedure for ranking as described under Section 5.4.1. was repeated for this limited sample. Results of the ranking, with row totals are presented in Table 5-10.

When Friedman's statistic (25), Xr^2 was computed it was found to be highly significant at the highest probability level(P = .99).

Thus the species display overall nutrient superiority in descending order as presented in Table 5-11.

Friedman's test (25) is only qualitative in so far as the actual nutrient levels do not appear in the comparisons. In some cases the difference between one rank and another might be very insignificant. To

Table 5-7: Ranking order of fruits based on vitamin C and beta carotene composition (on fresh weight basis).

1. Purple passion fruit
2. Cape gooseberry
3. Pawpaw
4. Tree tomato
5. Mulberry
6. Guava
7. 'Maua'
8. Wild banana
9. 'Ndului'
10. Loquat/Peach/Yellow passion fruit/'Mba'
11.
12.
13.
14. Custard apple
15. 'Ngomoa'
16. 'Matoo'
17. Tamarind
18. 'Maonywe'
19. Wild fig

Table 5-8: Overall nutrient ranking order in 11 fruits.

	On basis of all nutrients	On basis of micronutrients
1.	Mulberry	Mulberry
2.	Gooseberry	Gooseberry
3.	Matoo	Loquat
4.	Ndului	Matoo
5.	Tamarind	Peach
6.	Loquat	Ndului
7.	Peach/custard apple	Tamarind/Maonywe
8.		
9.	Maonywe	Ngomoa/Custard apple
10.	Wild fig	
11.	Ngomoa	Wild fig

Table 5-9: Overall nutrient ranking order in vegetables

	On fresh weight basis		On dry matter basis	
	All nutrients	Micronutrients	All nutrients	Micronutrients
1.	Bean leaves	Bean leaves	G. gynandra shoots	Bean leaves
2.	S. nigrum shoots	S. nigrum shoots	Bean leaves	G. gynandra shoots
3.	Pumpkin leaves	G. gynandra shoots	G. amaranthus (S.L.) shoots	G. amaranthus (S.L.) shoots
4.	G. gynandra shoots	Pumpkin leaves	S. nigrum shoots	S. nigrum shoots
5.	G. amaranthus (L.L.) shoots	G. amaranthus (L.L.) shoots/G. amaranthus (S.L.) shoots/Kikungi shoots	G. amaranthus (O.L.) shoots/Kamkulutu kanini shoots	G. amaranthus (O.L.) shoots
6.	Kikungi shoots			Kikungi leaves
7.	G. Amaranthus (S.L.) shoots		Cowpea leaves/Kikungi shoots	Cowpea leaves
8.	Cocoyam leaves	Cowpea leaves		G. amaranthus (L.L.)/ Pumpkin leaves/Kamkulutu kanini shoots
9.	Cowpea leaves	Cocoyam leaves	Pumpkin leaves	
10.	Kamkulutu kanini shoots	Kamkulutu kanini shoots	Kikoowe shoots	
11.	Kikoowe shoots	Corriander shoots	G. amaranthus (L.L.) shoots	Corriander shoots
12.	Corriander shoots	G. amaranthus (O.L.) shoots	Cocoyam leaves	Cocoyam leaves
13.	G. Amaranthus (O.L.) shoots	Kikoowe shoots	Corriander shoots	Kikoowe shoots
14.	Onion leaves	Onion leaves	Onion leaves	Itula shoots
15.	Itula shoots	Itula shoots	Itula shoots	Onion leaves
16.	Onion stems	Onion stems	Onion stems	Onion stems

Foot note: Abbreviations same as those in Table 5-5.

Table 5-10: Ranks of nutrient and oxalate levels in 8 vegetables*

	Vegetable	Vitamin C	β-carotene	Fe	Ca	Ox	A	C.P	C.F	Micro-nutrient totals	Rj (Row totals)
1.	Cocoyam leaves	7	5	1	1	4	1	2	6	18	27
2.	Pumpkin leaves	2	4	4	6	5	5	5	2	21	33
3.	Cowpea leaves	1	1	8	5	6	2	6	3	21	32
4.	S. nigrum shoots	5	6	6	3	7	3	7	5	27	42
5.	G. gynandra shoots	8	7	7	4	8	4	8	8	34	54
6.	Kikoowe shoots	3	2	3	2	3	6	4	7	13	30
7.	G. amaranthus (L.L.) shoots	4	3	5	8	1	7	3	1	21	32
8.	G. amaranthus (O.L.) shoots	6	8	2	7	2	8	1	4	25	38

Foot note: Abbreviations same as those in Table 5-5; In addition Fe = Iron; Ca = Calcium; Ox = Oxalate; A = Ash; CP = Crude protein; CF = Crude fat.

* On dry matter basis.

Table 5-11: Overall nutrient ranking order in 8 vegetables.

	On basis of all nutrients	On basis of micronutrients
1.	Gynandropsis gynandra shoots	G. gynandra shoots
2.	Solanum nigrum shoots	S. nigrum shoots
3.	G. amaranthus (O.L.) shoots	G. amaranthus (O.L.) shoots
4.	Pumpkin leaves	Pumpkin leaves/ cowpea leaves/G. amaranthus (L.L.) shoots
5.	Cowpea leaves/G. amaranthus (L.L.) shoots	
6.		
7.	Kikoowe shoots	Cocoyam leaves
8.	Cocoyam leaves	Kikoowe shoots

test if there was significant species effect on nutrient levels ANOVA (analysis of variance) tables were prepared for the nutrient levels of the 8 species. A Global F test for species effect was then computed. The results of this test are summarised in Table 5-12.

Table 5-12: F. statistic for species effect on nutrient levels*.

Nutrient investigated	(P = .95)	(P = .999)
Vitamin C		Highly significant
β-Carotene		Highly significant
Crude Ash		Very highly significant
Crude Protein		Significant
Crude Oil		Highly significant
Calcium		Highly significant
Oxalate	Not significant	

* Nutrient levels (on dry matter basis) of 8 species replicated at least twice.

The fact that the computed F test for all nutrients was highly significant in almost all comparisons (except for oxalate levels) confirms the fact that species do display nutrient superiority order, with significant differences of nutrient levels from species to species.

6. CONCLUSION

The results of this study lead to the conclusion that, in the locations of Machakos studied there exists a wide range of cultivated, semi-cultivated and wild edible fruits and vegetables which would, if consumed regularly, overcome deficiencies of vitamin A, C, iron and to a lesser extent calcium, micronutrients which are reportedly limiting in the diets of people in these areas (8, 70).

Most of the vegetables, both cultivated, and semi-cultivated/wild types would satisfy requirements for vitamin A, C, iron and to a certain extent calcium (Table 5-2). As for fruits, the cultivated/semi-cultivated types would be good sources of vitamins, especially vitamin C (since fruits are eaten raw they are not subjected to heat losses before consumption). The wild types on the other hand would be good sources of the minerals.

Availability of these crops, however, was found to vary with location and season. While the high potential location did not face a risk of seasonal shortage of supply of micronutrients, the other two drier locations did. In the former location, the supply of micronutrients from the few green vegetables viz. cowpea and cocoyam leaves (Table 4-8) available during drought would easily be supplemented by that from the wide range of cultivated/semi-cultivated fruits found there e.g. loquat, guava (Table 4-7). In addition, commercial type of vegetables available there would contribute further to micronutrient supply.

The situation is different in the other drier locationsof Masii and Wamunyu in which a wide range of leafy vegetables was abundant in the wet season only. In the dry season, shortage of micronutrients would easily be the result. Except from the wide variety of wild fruits (found to have fair amounts of mineral and less of vitamins), there would be hardly any supply from vegetables. Commercial type of vegetables were scarce in these locations. (Fruits like mangoes, which do grow in these locations, were not ready for harvest in the drought season studied, which was the pre-short rains of October - November drought season).

7. RECOMMENDATIONS AND SCOPE FOR FURTHER STUDIES

Some of the recommendations suggested touch on traditional habits and prejudices which might be difficult to change. It is hoped, however, that with the help of extension officers, the home economists in particular, the sectors of population concerned will be made aware of the relevance of the recommended practices, which if adopted would enhance healthier living.

Machakos fruits ought to be consumed more frequently than was observed in this study. In locations where cultivated types are not available, wild species should be consumed, and prejudices done away with. In areas where cultivated ones are in plenty, emphasis should be on consumption, rather than selling of these commodities.

Wherever available, a wider variety of vegetables should be consumed than was observed. Although most vegetables were found to satisfy requirements for vitamins, and iron, many did not meet calcium requirements. Moreover, some species had high levels of oxalic acid which would impair calcium absorption. Consumption of a wide range of vegetables would improve the likelihood of satisfying this nutrient requirement.

Because of the seasonal shortages, and surpluses which characterise the studied crops (e.g. an abundance of cowpea leaves in the wet season but hardly any in the dry one. (Table 4-6 and 4-8) there is need for cheap, rural scale processing/preservation practices, to save surplus fruits and vegetables for times of scarcity. No such practices were observed in this study.

Though mulberry ranked highest among the fruits analysed for micronutrients and proximate composition, cape gooseberry followed closely behind (Table 5-8). On vitamin ranking it was second only to purple passion fruit (Table 5-7). Its oil potential cannot be overlooked (Appendix ii). Its oil content on a dry matter basis was about 10 times as high as in other fruits e.g. loquat.

Of the wild fruits tamarind ranks very favourably (Table 5-8). Although 'matoo' ranks better, its very high fibre content makes it undesirable as a fruit (Table 4-9). The tamarind should be cultivated and the fruit utilised more.

'Maua' has potential for further studies on processing especially into jam/marmalade for the following reasons:

(i) Its moisture content, unlike many of the other wild fruits is high.

(ii) Its very high vitamin C content would ensure a reasonable amount of residual vitamin C after processing.

(iii) Its high acidity.

Of the wild vegetables, Solanum nigrum and G. gynandra are two wild species which feature at the top of nutrient ranking table (Table 5-9). They are on average superior to cultivated types like pumpkin, cowpea and cocoyam leaves (Table 4-10). They ought to be cultivated and thus consumed more frequently. With reference to Table 4-10 their low oxalate levels make them superior to amaranthuses. Although amaranthuses were above average in nutrient ranking (Table 5-9) the high oxalate levels in them limit their nutrient superiority (Table 4-10). However, further research work for varieties low in oxalate should be done and these species of plants elevated to cultivation status.

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Appendix i

QUESTIONNAIRE FOR FARM HOUSEHOLDS

IDRC/VEG/K   DATE: ____________

(A) GENERAL INFORMATION

Province:---------------- District:------------------

Division:---------------- Location:------------------

Sub/Location:------------------

Geography (tick where appropriate).

Mountains ☐   Plains ☐

Semi-arid ☐   Arid ☐

(1) SOCIO-ECONOMIC DATA

(i) Social

(a) Name of family ------------------------------------

(b) Size of family ------------------------------------

(c) No. of children -----------------------------------

(d) No. of pre-school children ---------------------

(e) Occupation of the ~~man~~ husband ----------------------------

(f) Occupation of the wife --------------------------

(g) No. of children working -------------------------

(h) Occupation of each child working ---------------

(i) Household labour employed: No. -----------------

Category --

(ii) <u>Economic</u>

(a) Approximate annual income per family -----------

(b) Farming: (1) Size of farm holding -------------
(hectares)

(2) Owner farmer ☐

Others ☐

(tick appropriately and indicate others) ---------------------------
----

(2) CULTIVATION PATTERNS: (For all crops)

Season	List Mono-crops	Inter cropped	Multi cropped	Quantity harvested	Quantity Sold								Home storage
					At main market		At local market		Exported		Others		
					kg	price	kg	price	kg	price	kg	price	kg
Drought													
Short rains													
Pre-long rains drought													
Long rains													

Notes: Label c for cash crops; s for staple foods

Note storage facilities.

(3) FOOD CONSUMPTION HABITS

(i) No. of meals per day ----- do you take; Breakfast ☐

Lunch ☐ (tick where appropriate)

Supper ☐

(ii) List foods generally taken at:

Breakfast		Lunch		Supper		In-between (Indicate when)		Remarks
Item	Quantity	Item	Quantity	Item	Quantity	Item	Quantity	

(B) SPECIFIC INFORMATION ON INDIGENOUS FRUITS AND VEGETABLES

(1) CULTURAL PRACTICES

Season	List native fruits and vegetables	Cultivated (Indicate other crops)			Semi-cultivated			Wild	
		Mono-cropped	Inter cropped	Multi cropped	Cleared on Weeding	Not cleared			
						Duration left on farm	Approx. quantity	Indicate duration	Approx. quantity
Drought									
Short rains									
Pre-long rains drought									
Long rains									

Other remarks

(2) FOOD UTILIZATION

(i) Fresh Product Consumption

(a) Seasonal variation in supply and cost of the native fruits and vegetables.

Season	Item	Source (tick where appropriate and indicate price where purchased)								
		Home garden	Local farms		Local market		Main market Machakos		Other sources	
			price/kg	quantity	price/kg	quantity	price/kg	quantity	price/kg	quantity/ source
Drought										
Short rains										
Pre-long rains										
Long rains										

Remarks:

(b) Consumption frequency and preparation for consumption

Items	Weekly consumption frequency	Eaten in		Preparation before consumption (tick appropriately and indicate cooking time (T) and, product: water: others; ratio: (P:W:O)												Consumed	
		Main meal	In-between	Boiling		Boiling & decanting		Frying after boiling		Frying after boiling & decanting		Mashing with other foods		Frying only	Others	Day of preparation	After storage
				T	P:W:O	T	P:W:O	T	P:W:O	T	P:W:O	T	P:W:O	T			

Notes: Cooking vessel types; kitchen facilities ________________

____

Any re-preparation before consumption of stored cooked product ________

Note for how long a stored meal lasts.

(ii) Processing and preservation

Season	Item	Source	Mode of processing and preservation					Utilization	Acceptability of product
			Solar drying	Shade drying	Blanching before drying	Salting	Others	Preparation of preserved product	
Drought									
Short rains									
Pre-long rains									
Long rains									

Other remarks: Note storage facilities, containers etc.

Record any pre-processing procedure before cooking, if any.

(3) MISCELLANEOUS

(i) Acceptance rating of indigenous vegetables and fruits.

List vegetables in order of preference	List fruits similarly	Remarks (Special uses e.g. weaning; lactating mother)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

(ii) Acceptability in comparison with some common exotic products (e.g. cabbage, spinach and lettuce; and plums, apples and pears).

Native ones more prefered on the basis of: (tick appropriately) - Indicate F for fruit and V for vegetable	Explanation
(a) Taste Yes ☐ No ☐	
(b) Colour Yes ☐ No ☐	

(c) Texture	Yes ☐	No ☐	
(d) Keeping quality after harvest	Yes ☐	No ☐	
(e) Cooking characteristics	Yes ☐	No ☐	
(f) Pre-cooking characteristics	Yes ☐	No ☐	

(g) Others

e.g. for mashed foods

Yes ☐ No ☐

Yes ☐ No ☐

Yes ☐ No ☐

Yes ☐ No ☐

(iii) Non-food utilization of indigenous fruits and vegetables

Item	use (tick where appropriate and describe application)					
	Medicinal	Insecticidal	As cosmetics	As a spice	Animal feed	Others

(iv) Mention any taboos in connection with fruits and vegetables.

____

(v) Are there any prejudices in connection with these products? ______________________________

____

<u>General remarks:</u>

Appendix ii: Composition in 100g of dry matter* of Machakos fruits

	Fruits	Crude fibre (g)	Ash (g)	Crude protein (g)	Crude fat (g)	Soluble carbohydrates (g)	Iron (mg)	Calcium (mg)	Vitamin C (mg)	β-Carotene (mg)
	Cultivated/semi cultivated									
1.	Loquat	12.5	6.9	3.8	1.0	75.8	6.3	225	18.75	6.11
2.	Gooseberry	27.8	7.4	13.1	7.4	44.3	7.4	57	164.77	10.73
3.	Peach	9.7	4.6	5.2	0.8	79.7	6.5	78	25.97	4.38
4.	Mulberry	15.1	6.9	11.0	2.8	64.2	12.3	589	191.78	2.74
5.	Custard apple	12.6	4.9	9.7	1.5	71.3	2.9	131	92.23	trace
	Wild/semi-wild									
6.	Tamarind	7.3	8.0	4.9	1.0	86.0	8.0	173	7.01	trace
7.	Matoo	57.9	7.6	10.7	1.1	22.7	11.5	486	6.51	0.67
8.	Ngomoa	19.7	4.8	3.2	0.73	71.6	5.7	171	15.87	0.19
9.	Wild fig	25.0	7.0	5.5	5.0	57.5	4.5	30	10.00	trace
10.	Maonywe	48.8	3.9	6.3	2.3	38.7	6.8	254	4.88	1.03
11.	Ndului	11.4	6.5	8.6	1.3	72.2	6.8	72	17.54 or 226.31 ?	0.55

* Mean values calculated from figures in Table 4-9.

Appendix iii: Composition in 100g of dry matter* of Machakos leafy vegetables

	Vegetables	Crude fibre (g)	Ash (g)	Crude protein (g)	Crude fat (g)	Soluble carbohydrate (g)	Iron (mg)	Calcium (mg)	Total oxalate (mg)	Vitamin C (mg)	β-Carotene (mg)
	Cultivated vegetables										
1.	Cocoyam leaves	16.9	13.4	25.0	5.64	39.1	22.1	1209	4233	848.5	54.32
2.	Bean leaves	16.1	14.7	27.7	5.63	35.9	79.9	2263	0	7455.8	60.85
3.	Onion leaves	17.2	12.9	19.8	4.66	45.4	19.8	690	80	344.8	30.01
4.	Onion stems	18.5	10.2	14.1	0.82	56.4	21.2	647	29	282.4	20.59
5.	Corriander shoots	12.2	14.0	25.6	2.44	45.8	53.1	1098	103	414.6	42.63
6.	Pumpkin leaves	13.8	18.2	28.6	3.35	36.1	45.8	2005	704	630.5	48.75
7.	Cowpea leaves	15.8	15.2	31.0	3.37	34.6	67.1	1816	475	493.7	42.67
	Wild/semi-wild vegetables										
8.	Solanum nigrum	9.8	15.3	31.7	3.83	39.4	64.5	1590	317	787.9	54.64
9.	Gynandropsis gynandra	11.7	18.7	35.1	6.62	27.9	64.9	1651	175	850.7	57.13
10.	Kikoowe	14.2	20.7	27.7	5.87	32.5	43.2	1452	6645	651.6	42.85
11.	Itula	16.8	8.0	23.2	2.88	49.1	32.8	1224	6128	320.0	47.10
12.	Green amaranthus (long-leafed)	12.4	22.2	27.0	2.86	35.5	51.4	2595	10687	664.9	42.95
13.	Green amaranthus (small-leafed)	11.0	22.1	30.3	5.67	30.9	73.1	3124	15766	903.5	48.28
14.	Green amaranthus (oval-leafed)	11.7	25.2	24.3	3.51	35.3	40.5	2577	10477	810.8	67.98
15.	Kamkulutu Kanini	19.3	18.2	29.0	3.30	30.2	47.2	3511	1244	221.6	57.70
16.	Kikungi	15.0	25.2	34.0	3.20	23.6	57.8	2293	626	632.7	27.21

* Mean values calculated from figures in Table 4-10.