THE ECONOMICS OF POTATO STORAGE IN KENYA

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

Signed .....
ISAAC I. M. MUGAMBI
(Candidate)

This thesis has been submitted for examination with our approval as University supervisors.

Signed (1) E.W. Schenk
PROF. E.W. SCHENK

(2) .....
G. MATUMO

Dedicated to my mother Mrs. Sarah Marete.

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ABSTRACT

This thesis analyses the economic and technical factors that influence the amount of potato stored and the type of potato storage facilities currently in use at farm-level in Kenya. The thesis is based on survey carried out between February and June, 1977 in Kibirichia location and results of potato storage trials carried out at the same period, in Molo, Ngecha in Kiambu and in Kibirichia in Meru District by German Agricultural Team, International Potato Centre and the author.

Chapter I describes the importance of potatoes in Kenya. Potatoes are compared to maize as staple food stuffs. The calorie production per hectare per year of potatoes is slightly more than that of maize. Since potatoes are highly perishable, they require elaborate storage facilities. Little is known about the storage systems in this country hence the purpose of this study. Chapter II describes the specific objectives of, and the main questions to be answered by the study.

The main hypotheses and the methodology are described in chapter III. A random sample of 71 farmers were interviewed in Kibirichia and potato storage trials set in Molo, Ngecha and Kibirichia.

Results of the research findings are presented in chapters 4 and 5. Potatoes stored for sale accounts for 38.8% of the total potato harvested, compared to 31.8% potato sold immediately after harvest and 30% are consumed. Farmers store potatoes for a maximum period of three months. The main factors that determine the quantity stored is the quantity harvested, and quantity sold directly after harvest; storage capacity given. The quantity harvested explains the variation in quantity stored by 72.9%. This is the major determinant.

Potato acreage in the farms, quantity sold and quantity consumed are inversely related to the quantity stored.

88.7% of the stores in Kibirichia are built separate from other farm buildings (Houselike). Granaries, pits and stores attached to dwelling houses were other types of stores commonly used. More than 65% of the sample stores were built of earth floors, corrugated iron sheets roofs and timber walls, with some form of air ventilation. Other structural designs include, mud and stone walls; concrete and timber raised floors; and

Some of the hypotheses tested were:

(i) The constructional materials of potato stores depend on their sizes;

(ii) The quantity stored is a function of surplus potato production.

(iii) The quantity stored is a function of the expected losses during storage time.

(iv) The losses in potato weight during storage depend on temperatures and relative humidity irrespective of geographical location.

(v) The potato storage temperature range is $5^{o}C$ and the relative humidity range is 20% in Kenya.

(vi) The constructional materials of the established potato stores depend on the local materials available and not on the climatical or technical requirements of the potato storage.

(vii) Destoring period depend on the price movement in the local market.

(viii) That the price during the harvesting period is less than and/or equal to price during the selling period minus the storage cost.

grass thatched roofs; The average investment cost of a store 5.57m long, 3.74m wide and 2.4m in height and of a storage capacity of 37 tons was K.Shs. 2,400.00.

Farmers do not use sprout suppressant chemicals. A few farmers on the lower zone of Kibirichia used tuber moth-killing chemicals. All farmers in Kibirichia store potatoes in bulk with some form of insulation.

The potato storage temperatures in Molo range from 11°C to 15°C, in Kibirichia from 15°C 17°C and in Ngecha from 17°C to 19°C while the relative humidity in Molo range from 72% to 96% in Kibirichia from 65% to 80% and in Ngecha from 40% to 85%.

This shows that potatoes store best in Molo followed by Kibirichia and finally by Ngecha.

In terms of investment strategy, the stores used by the farmers are recommended instead of the improved trial granaries or the forced ventilated store built by Schuelter company.

It is recommended that potato marketing should be carried out co-operatively so that trading margins to the farmers are increased. This would bring about institutional pricing system, which would operate to the benefit of the farmer and the consumer. It is felt that spectral analysis should be carried out to find out whether the factors that influence prices in different markets in Kenya are the same or not.

CHAPTER 1

PROBLEM FORMULATION

1. INTRODUCTION

1.1 The importance of potato in Kenya

1.1.1 per capita consumption

In Kenya the per capita consumption of potatoes is about 15 kgs compared to per capita consumption in Western Europe of 90.8 kgs and Eastern Europe of 182 kgs (24, p.2). However, potatoes are comparable to maize in Kenya as staple food stuffs. Both crops can grow at the same altitude and are rich in carbohydrates. Potatoes have 3½ months growing period while maize has a growing period of between 6-7 months in the highlands (16, p.1). The average production per hectare of potatoes is 8 tons (4) compared to average production of 3.3 tons of maize per hectare (14).

Therefore potatoes productivity in terms of calories per hectare per year is slightly more than that of maize assuming two production seasons per year for potatoes and one season per year for white maize. (see table 1).

TABLE 1:

Potato and maize calorie production per hectare per year *

Food	Average Kgs/ha(1)	K.calories /ha (2)	Total KCl/ha in '000	Total KCla/ha/ in '000
Potatoes	7950	820	6519	13038
Maize(white)	3276	3570	12745.32	12745.32

* Assume two production seasons for potatoes and one season for maize per year.

SOURCE: 1) Duerr, G. Production and marketing of potatoes in Kibirichia interim report I. June 1977.

2) F.A.O. and U.S.U. Department of Health, Education and welfare. Food composition tables for use in Africa. Bethesda, U.S.A. and F.A.O./Rome 1968.

Judged from table 1 potatoes could supplement maize as a staple food in Kenya at a slightly increased level of calorie intake per head per year. Robinson (24) argues that it is possible to plant 2.1 million hectares of potatoes in Kenya without reducing the existing cultivation of other crops. That acreage of potatoes could provide basic food for 150 million people at a per capita consumption of 182 kgs. However Robinson does not indicate whether he considers pasture land as empty.

1.1.2 Export possibilities

H.C.D.A. has been exporting potatoes to Western Europe for the last two years with success*. In addition Robinson asserts that potatoes can be exported to Somalia, Ethiopia, Sudan, Uganda, Tanzania and Persian Gulf, all within a distance of 1600 kms. This would earn Kenya foreign exchange which is needed. However, such export would involve large quantities and would entail elaborate storage and communication facilities both at farm and national levels because potatoes are highly perishable.

1.1.3 Possibilities of industrial processing

Potatoes can be used in industrial production of starch-extraction, alcohol, canned 'new' potatoes, crisps and instant mashed potatoes. There is already a plant extracting starch from cassava in Mombasa - Kenya. An experience that can be extended to potatoes in major producing areas since both their starch contents (about 30 percentage) and their productivity per hectare (25 tons per ha) are the same in some varieties - (12, p. 388, 392). However such plants require skilled manpower, which is to a large extent lacking in Kenya at present. There is also a vegetable dehydration plant at Naivasha where some potatoes are processed in a very small scale.

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* H.C.D.A. records. H.C.D.A. = Horticultural Crops Development Authority.

1.1.2. The present structure of potato production in Kenya.

The estimated area under potatoes in Kenya is 30,700 hectares. Table 2 shows that central province accounts for 44.5%; Eastern province 42.2%; Rift Valley province 13% and the Coast province produces only .3%. Three areas in the three leading producing provinces were selected for study. From table 2 we see that the four leading producing districts are Meru, Nyandarua, Nyeri and Nakuru, with 11,000 ha. 9,000 ha. 2,000 has and 1500 ha. respectively.

1.2. Location of the areas selected for study

1.2.1. Location of Kibirichia in Meru* District

Meru lies on the eastern slopes of Mt. Kenya It is roughly divided into two halves by the Equator as shwn in fig. I. Kibirichia is about 2400m above sea level. It is linked to other parts of the district by a good network of all weather roads. A major tarmac road links the district with Nairobi (16, p.4).

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* Meru is interchanged with Kibirichia in many places throughout the thesis.

TABLE 2: Estimated annual potato hectarage in Kenya 1975

AREA		POTATO HECTARAGE (ha)		
Province	District	Per District	Per Province	%
CENTRAL	Nyandarua Nyeri Kiambu Muranga Kirinyaga	9000 2000 1000 700 1000	13700	44.5
EASTERN	Meru Embu	11000 2000	13000	42.2
RIFT VALLEY	Nakuru Narok Uasin Gishu Nandi Kericho Elgeyo Marak-wet	1500 700 300 300 700 500	4000	13
	Taita	50	50	.3
Total Hectarage for Kenya			30750	100

SOURCE: Ballestrem, C.C., Report on activities and experiences on potato crops in Kenya, Nairobi, July 1975, Page 3.

1.2.2. Location of Ngecha in Kiambu District

Ngecha is about 1800m above sea level and only 30 km from Nairobi. It is linked to Nairobi by tarmac roads and linked to other parts of the district by all weather roads. It is about 1°S latitude and $37\frac{1}{2}^{\circ}$E longitude. See Fig. 1.

1.2.3. Location of Molo in Nakuru District

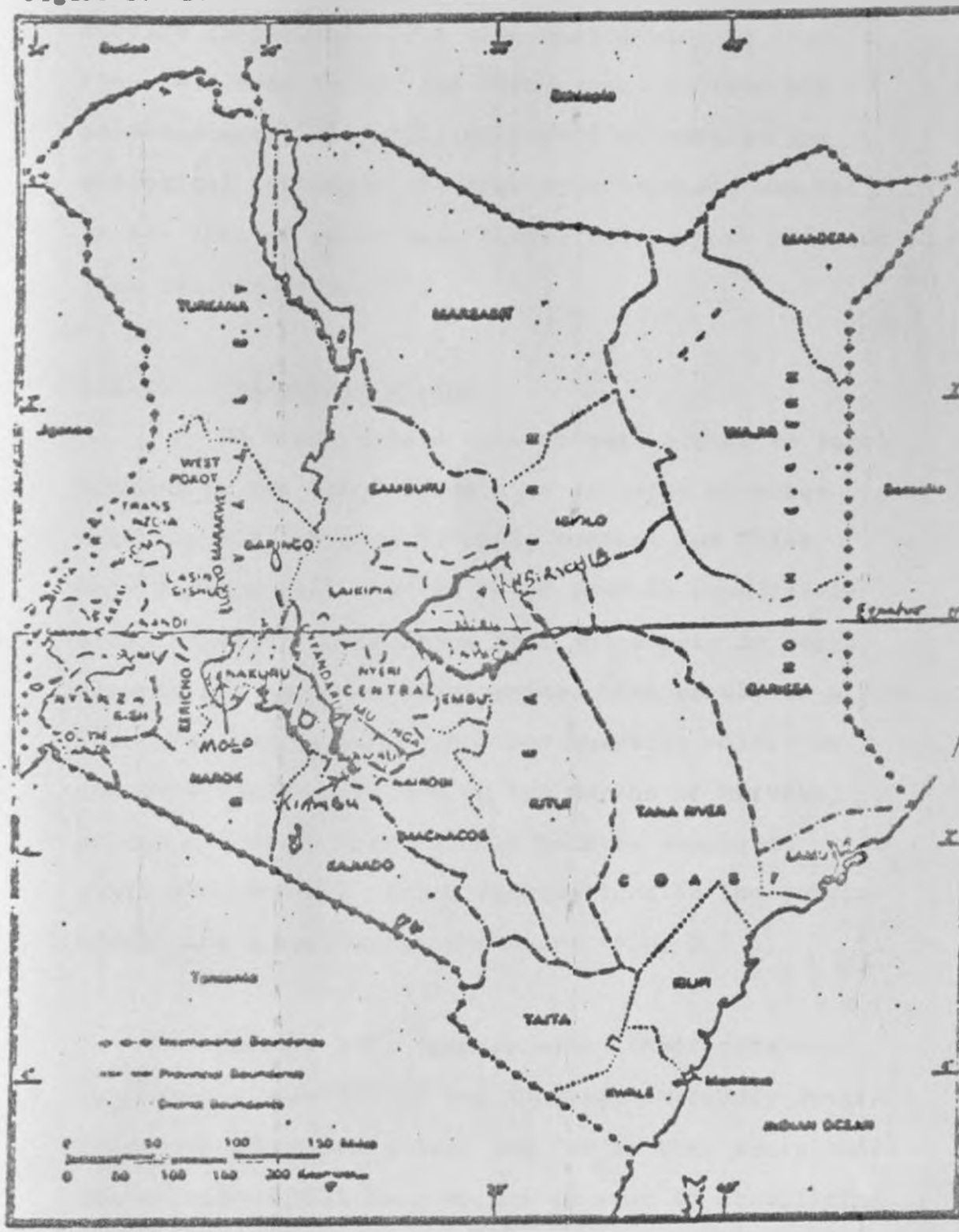
Molo lies on the Mau Escarpment on the Western slopes of the Rift Valley. The co-ordinates are 0.5°S latitude and 35.5°E longitude. It is linked to Nakuru town by rail road and tarmac roads. It is about 60 km. from Nakuru town. (See fig. I).

These three areas were selected for study because they are high potential potato producing areas. Meru is already the leading producing district. (See table 2.) Meru can supply the East and Northern part of the country sufficiently. Molo has an ideal climate for potato production, it can supply the Western and Rift Valley areas if potatoes are grown in the same scale as wheat and barley are grown today.

The Limuru area of Kiambu is a high potential area for potato production. The altitude is ideal for potato production. Potatoes grown here would supply Central province and the city of Nairobi.

Figure 3

Figure 1: Location of Koru, Nakuru & Kiambu Districts



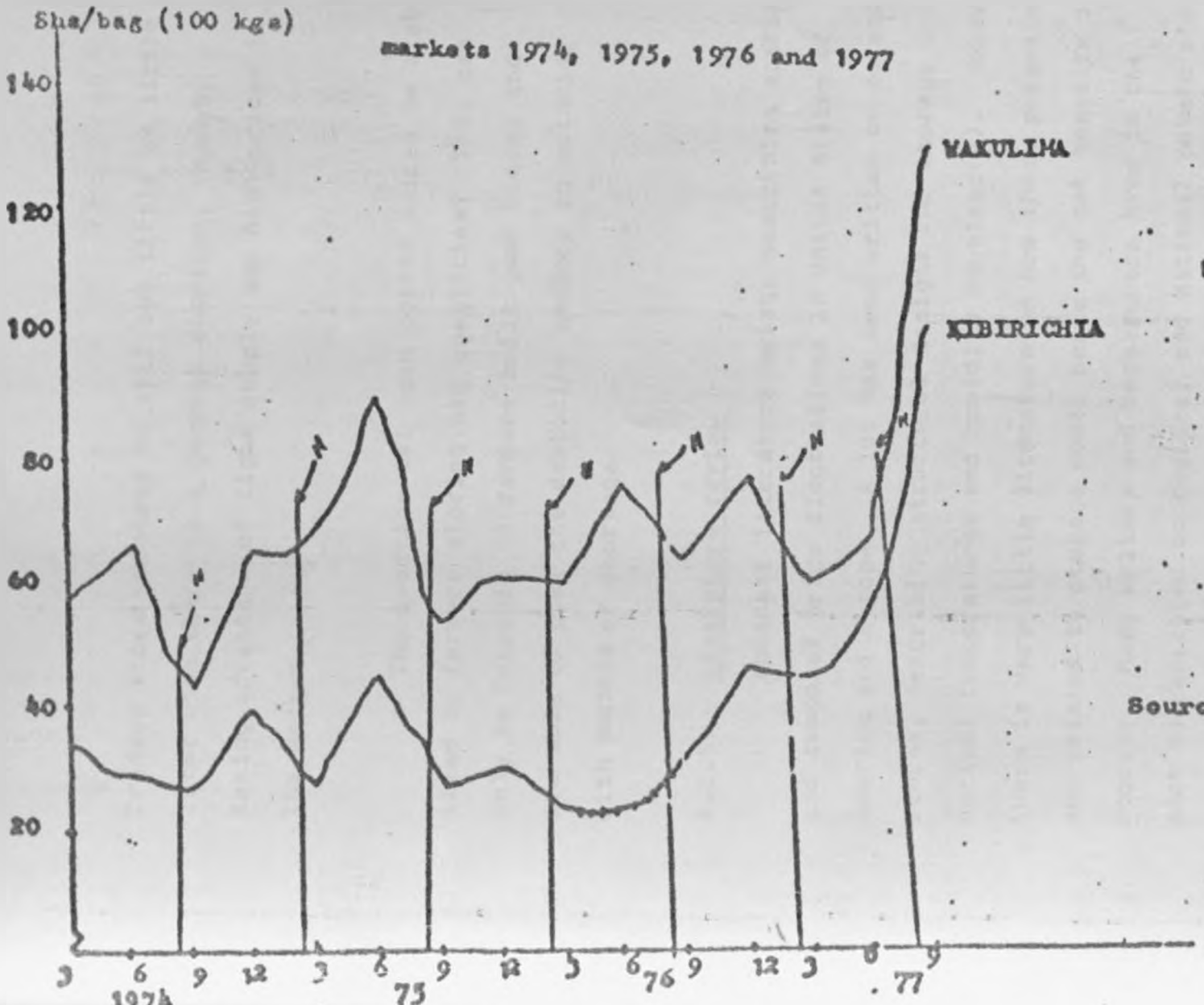
They were also selected for interregional potato storage comparison. The same potato variety (Kerr's Pink) was used in all the three areas to find out potato storability under different climatical and ecological settings. However more emphasis was put in one area of study i.e. Kibirichia in Meru district (See reasons on p. 23).

1.2.4. The potato market

In Kenya potato farmers sell either to local traders in the local markets or directly to urban markets, for instance Nairobi, Mombasa and Thika. Many farmers sell most of their produce immediately after harvest. This means that the supply to local markets has clear seasonal peaks. The result is a low price hence low revenue per quantity sold. On the other hand after one or two months of harvest, prices can go up tremendously because supply is lower than demand. Price fluctuations in the potato market are a well known phenomena (fig. 2.)

However some farmers store their potatoes to reap the benefits of the shortage in supply later. Those who store are either too few or they store small quantities so that they do not go near to stabilizing prices.

Fig 2: Quarterly Average potato prices at Kibirichia and Wakulima markets 1974, 1975, 1976 and 1977



Source: Mbogoh.S.K, potato production and marketing in Kenya, MSC Thesis University of Nairobi 197 and Appendix 9

Traders store potatoes to sell out little by little later when there is a general shortage, thereby taking advantage of tight supply and high prices in the market.

The question is: can potato prices be stabilized by farmers storing big quantities? This can only be feasible if farmers built good stores and are able to plan the destoring periods to coincide with periods of shortage.

1.2.5. Literature review

Abundant literature exists describing spatial and temporal price fluctuations in United States of America and Europe. A lot has been written on potato stores, describing structural designs for storage units, optimal temperatures and humidity required(5). However there is very little literature on how these parameters are related to storage costs hence the net benefits of storage. Many writers and researchers have in the past concentrated on regional and national potato storage aspects as a means of stabilizing prices. These aspects seldom help the farmers, especially those in developing economies with scarce capital resources, to put up these elaborate and expensive storage facilities often recommended.

Nevertheless the following literature directly or indirectly deals with some factors that determine storage costs in relation to farmers' storage facilities and market prices.

Alfred Edgar (5) concluded:-

- that the best storage temperatures for potato storage in U.S.A. are between 13°C and 15°C with a relative humidity of 90 percent (page 346).

- that temperatures and humidity have effect on changes in specific gravity of potato during storage i.e. specific gravity increases with length of time in storage.

Ballestreun, C.C. (2) from the potato research station, Tigoni, Kenya, deals with seed potato and potato for consumption. He argues that ideal controlled temperatures for potato storage for consumption are between 5°C to 10°C, but actual observations made in Molo and Thika revealed a range of + 15°C and + 25°C (2). He contends that earth clamps, crates containing about 50 kgs, maize crib (bin) and maize bags can be used for storing.

Weigard, K.B. (29) observed that in Central Peru potato losses due to spoilage between farm and home could be reduced by 50% through the utilization of adequate storage facilities and that storage could create 'Consumer's Surplus'.

because prices are stabilized below their arithmetic mean. And that estimated costs exceeded measured benefits in every region.

Michael, Q. (18) "production of potatoes in Kenya, results of investigation in 4 districts in 1974", dealt with ideal types of stores organised through government agencies, or co-operatives with artificial temperatures and relative humidity regulators. He states that these stores are expensive at farm level each costing about Shs. 50,000/- and with a capacity of 1000 bags of 84 kgs. each.

Mbogoh, S.G. (16) dealt with storage costs incurred by local traders. He dealt with temporal price fluctuations to a great depth. He found that transportation costs increase at a declining rate as distance increases. He argued that losses in stores are due to sprouting and rotting.

Samuelson, P.A. (25) describes the underlying theory of storage that, where the expected price of a commodity exceeds the harvest price plus storage costs, storage will occur by assuming:-

- monthly demand remains constant
- variable storage cost per month remain constant.
- there is only one instantaneous harvest per year and,

- total monthly sales must equal the fixed quantity harvested.

However, some of the above assumptions are not valid in potato storage because of its perishability. The author deals at length with seasonal adjustments of seasonal crops to reach optimal equilibrium conditions in storage, and prices.

Zettelmeyer (31) in his 1st season 1977 report compares storage profits in an improved granary, forced ventilated store and an ordinary house-store. He took the storage period to be four months. He assumed that all potatoes were sold in Nairobi from Kibirichia in Meru District and that they were transported by a cooperative society, so that the normal traders margin was ploughed back to the farmers. He concluded that improved granary stored better than the house store and the forced ventilated store built by Schuelter company.

Sharma and Bhattacharrya (26) investigated the efficiency of fungicidal treatment to check rottage of the seed potatoes under country storage. They concluded that fungicidal treatment reduced the rate of rottage in seed potatoes. They did not deal with ware potatoes although their findings could be checked within the context of Kenya conditions.

Missener and Shove (20) subjected potatoes harvested in September 1972 to temperature 4.5, 15.6 or 28.3°C and to one of 5 r.h.[1)] levels ranging from 11.9 to 98.4 percentage. Daily tuber weight readings indicated that the rate of moisture loss was a function of vapour pressure difference and time.

Werge (30) found that farmers in Mantaro valley region of Central Peru either sell, process or consume potatoes after harvest. He argues that farmers in developing countries store potatoes to sell later. However they have no idea of stabilising prices and quantity available at any time.

He found that the percentage of potatoes stored by a producer varies inversely with the amount of land planted to potatoes; small farmers store a much larger share of their crop than large farmers, corporations or co-operatives. Three main types of storage units are found in Mantaro region i.e. house storages, out buildings and fixed storages. He found that the farmer's house is the preferred storage.

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1) relative humidity

location because of its convenience, security and design. Out buildings (definition in 30, p.2) are utilized by large growers.

As can be seen from the above literature review there exists a gap in knowledge which needs to be filled by this study i.e. to determine the actual potato storage costs at farm level at present and the climatical factors that influence the stored potatoes so as to determine the benefits or otherwise of storage.

CHAPTER 2

2. OBJECTIVES OF THE STUDY

2.1 Overall objectives of the study

The economic and technical feasibility on the farm potato storage in Kenya was the main objective of the study. The study was carried out to ascertain the costs, both fixed and operational, incurred by farmers in their present storage facilities. These costs were related to prices during storage period and immediately after harvest time. The study will also ascertain the most economic-climatical storage conditions in different storage facilities in different geographical areas in Kenya. The data collected will be useful in planning an equilibrium cost model for potato storage in Kenya which will contribute to planning marketing and production models. Such data will be used to find out whether or not potato storage can be used to stabilize prices and quantities, to the benefit of both the consumer and the producer.

2.2 Specific objectives of the study

Specific objectives were set out in a form of questions that were answered by the study. The questions were divided into two categories, i.e. technical and economical:-

2.2.1 Technical questions

i. What are the alternative methods of potato storage?.

ii. How are the different types of storage facilities in current use related to their climatical and ecological settings?

iii. How does sprouting and the rate of dehydration in different parts of the country compare during potato storage?.

iv. Do temperatures and relative humidity have any serious effects on potato quality and quantity during storage?.

v. Is it technically feasible to have on farm potato storage facilities?.

2.2.2. Economic questions

i. What determines the quantity of potatoes stored?

ii. What are the major determinants of potato losses during storage?

iii. What percentage of potatoes is stored immediately after harvest?

iv. How much do prices fluctuate over time?

v. What is the average investment cost of storage facilities in common use today?

vi. What is the net income per ton of potatoes both before storing and after storing for different periods?

vii. What are major problems in potato storage?

viii. How can storage costs be minimised?

ix. Is it economically feasible to have on farm potato storage?

CHAPTER 3

3. METHODOLOGY

3.1 Hypotheses to be tested and their justifications

Hypotheses were based on the questions to be answered as indicated in chapter 2. The follwing hypotheses were therefore tested.

i. The constructional materials of potato stores depend on their sizes. The assumption is that the bigger the stores the more permanent the structural building elements would be used in the structural design.

ii. The quantity of potato stored is a function of surplus of production. The assumption is that farmers will store surplus after their immediate needs are fulfilled.

iii. The quantity stored is a function of expected quantity losses during storage. This assumption means that farmers will store more in stores where expected loss is small. The assumption is valid because it is, like 3.1.2, based on common sense.

iv. The losses in potato weight during storage depend on temperatures and relative humidity irrespective of geographical areas. Since a potato is about 70-81 percent water (12,p.388)

it can be expected to lose a lot of it to the atmosphere where there are high temperatures and low relative humidity and vice-versa.

v. The potato storage temperature range is 5°C and the relative humidity range is 20 percent in Kenya. It is assumed that climates with higher temperatures ranges will not suit potato storage.

vi. The structural designs of the potato stores depend on the local materials available and not on the climatical and technical requirements in potato storage. The assumption is that a farmer in a developing country like Kenya has no know-how of storage requirements and will use only the materials easily available to build some form of storage facility.

vii. Farmers sell all potatoes immediately after harvest. The assumption is that farmers need cash-money urgently after 3½ to 4 months of waiting for potatoes to mature. Secondly they do not have good storage facilities in which to store other potatoes.

viii. Destoring period depend on the highest prices quoted in the local markets. The assumption is that farmers are price responsive and the

higher the price quoted the more the number of farmers will tend to destore their potatoes to 'catch the market'.

ix. That the price during the harvesting period is less than and/or equal to price during the selling period minus the storage cost. The assumption is that farmers will store only when the expected income is more than and/or equal to income before storage costs. Farmers are also assumed to be economically rational.

3.2 How the hypotheses were tested

To test functional relationships between variables, regression analysis was carried out. The regression coefficients obtained were tested for significance by application of t-statistic values. The conventional levels of significance were used.

However, for those hypotheses which did not require statistical tests inorder to determine their relationships, testing was based on the evidence obtained from questionnaire interviews, results of the storage trials and from discussions with farmers, H.C.D.A. staff and the Ministry of Agriculture staff.

3.3 Organisation of the study

3.3.1 Timing

The study was planned and carried out as follows:-

i) January to March, 1977, search for basic information on potato storage, preparation and questionnaire pretesting, building trial stores and storing potatoes.

ii) April to May, 1977, field data collection took about eight weeks i.e. to interview farmers. Potatoes stored in the trial stores for 2 and 3 months were carried out during the same time.

iii) June to August, 1977, data analysis and their interpretation was carried out.

iv) September to December, 1977, preparation, writing and presentation of the thesis was envisaged.

3.3.2 Data collection

From field observations in all the three areas selected for study it was evident that only farmers in Kibirichia location in Meru District have stores which are basically constructed for potato storage. From table 3 it can be seen that about 17.5 percent of the total crop land in Kiambu District was under potatoes (1st season 1977) compared to 40.5 percent in Kibirichia

(table 4). This means that potatoes in Ngecha location of Kiambu is not a very important crop. Stores in Kiambu are mainly multi-purpose and storage costs incurred in these stores can not be attributed to potato storage alone. However, potato storage trials were built and studied in this area, because it is a high potential area for potato production.

Molo area of Nakuru District is also a high potential area for potato production because climatic conditions for potato production and storage are good. The area was until the last few years dominated by white settlers who were interested in wheat and barley production, which unlike potatoes are not labour intensive crops. Therefore there are few or no potato stores in Molo. The questionnaire, Appendix 1, was therefore used to interview only farmers in Kibirichia, Meru district. With available resources it was planned to interview between 70 and 80 farmers. In addition the Central Bureau of Statistics Kenya, in collaboration with F.A.O. marketing development project attached to the Ministry of Agriculture, was to gather and provide potato prices for the major potato markets in the country. It was not possible for the author to carry out the exercise within the time that was available. The bureau stationed enumerators in the markets to collect weekly price data.

3.3.2.1 Selection of farmers to interview

The selection of the farmers to be interviewed was done on random basis as follows:-

i. By preliminary observation it was found that all the farmers in Kibirichia location had one or other type of potato store. It was therefore found necessary to select the farmers to be interviewed from the list of farmers as per lands and settlement, Meru office. There are 1136 land owners registered with the Ministry of Lands and Settlement in Kibirichia location. Since the number of farmers to be interviewed was pre-determined as between 70 and 80, every 16th farmer in the Registry was selected making the total number of farmers to be interviewed as 71.

ii. It was clear from the land Registry that the land certificate numbers were systematic i.e. they had a clear beginning and a clear end. It was found that farmers could be interviewed according to the title deed numbers selected. However a local man was recruited to identify the actual farms corresponding to the title deed numbers and the names of the farmers.

TABLE 3: LAND USE PATTERN IN KIAMBU DISTRICT

EARLY SEASON 1977

Crop (1)	Frequency of crops on sample farms			Average Acreage under the crop (2) (per year)		
				per grower	per farm	
	No	%		ha	ha	% of total farm size	% of cropped area
	(1)	(2)	(3)	(4)	(5)	(6)
Potatoes	75	97	.23	0.22	13.5	17.5
Maize	75	97	.59	0.5	34.5	44.5
Pyrethrum	8	10	.48	0.05	2.9	3.8
Coffee-tea	19	25	.63	0.16	9.4	12.2
Cabbages	40	52	.23	0.12	7.2	8.2
Beans	40	52	.23	.12	7.2	8.2
Fodder	7	9	.38	.04	2.2	2.8
Total crops	-	-	-	1.28	76.9	97.4
Grazing	42	55	.70	0.38	23.1	2.6
TTotal	77	0	-	1.66	100.0	100.0

SOURCE: George Duerr: Production and marketing of potatoes in Kiambu District. International potato centre.
Interim report, Nairobi, July 1977.

NOTES:
1. No allowance is made for homestead, roads and unusable land.
2. The figures indicate the acreage allocated to a crop for one full year and do not include double cropping.

TABLE: 4 LAND USE PATTERN IN KIBIRICHIA LOCATION EARLY SEASON 1977

Crop (1)	Frequency of crops on sample farm		Average acreage under the crop (2) (per year)		
			per grower		per farm
	No	%	ha	% of total farm size	% of cropped area
	(1)	(2)	(3)	(4)	(5)	(6)
Potatoes	57	98	1.32	1.32	22.4	40.5
Maize	55	95	.94	0.91	15.5	27.9
Wheat	18	31	1.47	0.64	10.9	19.6
Pulses	30	52	0.51	0.77	4.6	8.3
Pyrethrum	19	33	0.28	0.10	1.7	3.1
Cabbages	6	10	0.29	0.03	0.5	0.9
Total crop per land	-	-	-	3.26	55.6	100.3
Grazing	15	88	2.93	2.62	44.6	
Total	58	100	-	5.88[3]	100.2	

SOURCE: George Duerr: Production and marketing of potatoes in Kibirichia location in Meru District. Interim Report I C.I.P. Nairobi June 1977.

NOTES:

1. No allowance is made for homestead, road and unusable land.
2. The figures indicate the acreage allocated to a crop for one full year and do not include double cropping.
3. The total acreage differ from the above mentioned farm size (14.5 acres) due to roundings.

3.3.2.2 Interview procedure

It was possible to interview at least 2 farmers a day and a maximum of 5 farmers a day depending on whether there were rains or not, and/or the willingness of the respondents to answer questions quickly. Interviews were carried out while standing or sitting depending on what the farmer chose. Where a farmer was not present during a visit, his wife was interviewed depending on whether she could answer questions put to her. Many wives answered questions without any problems because they indicated they knew farm problems better than their husbands, who were busy in some other businesses. Where a farmer and/or his wife were not present during a visit some other arrangements were planned to call back again, so that time was not wasted trying to look for them.

3.3.3. Data collected from stores

For each of the three areas selected for study, potato storage trials were set out as follows (29,p.4).

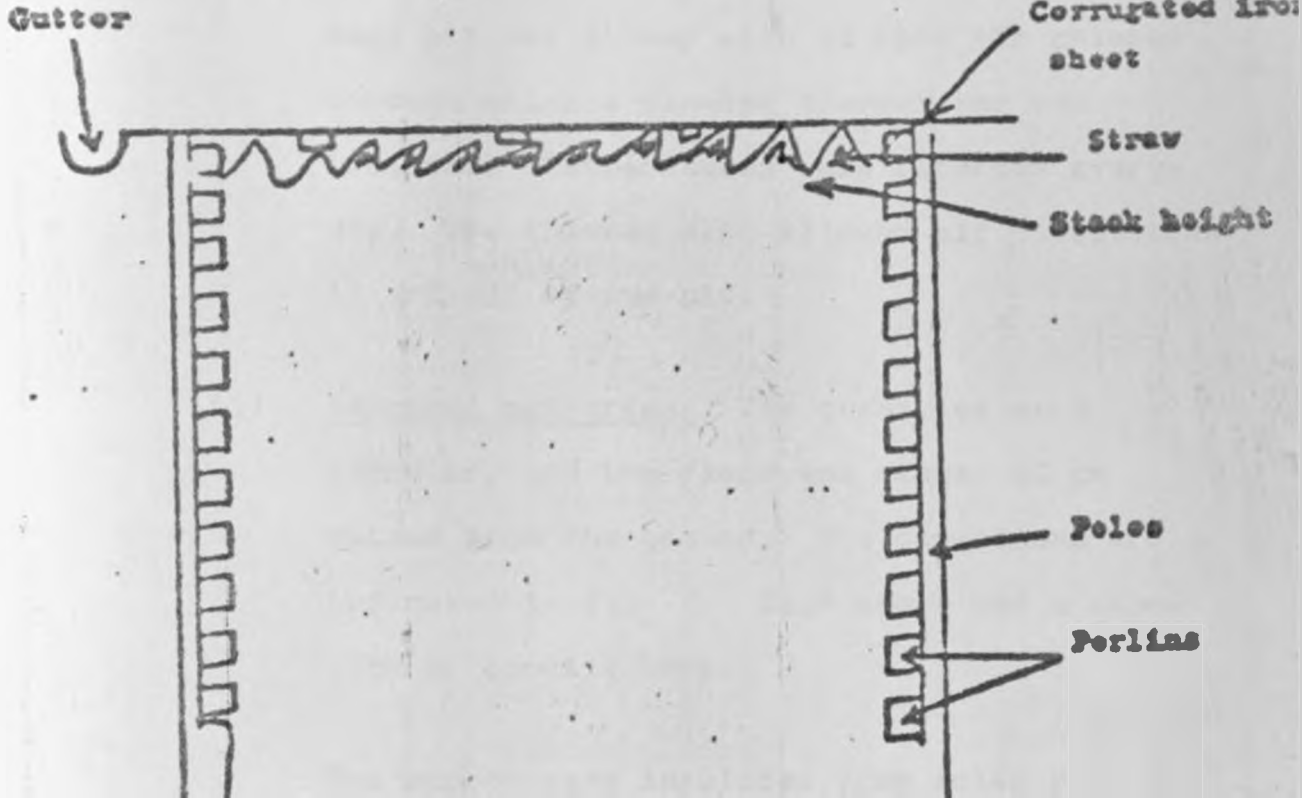
(i) A House-store with three piles of 10 bags (80 kgs) of potatoes each were stored for 2,3 and 4 months respectively.

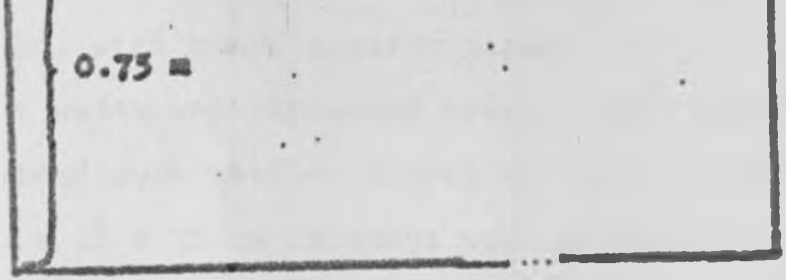
The stack height was the same for all the pits. Thermometres were fixed inside each pit in a way that temperature could be read everyday. The minimum and maximum temperatures and relative humidity of the house were recorded everyday using min-max thermometer for the former and hydrometer for the latter. These instruments were fixed conveniently on the room walls. In each area eight bags (80 kgs) potatoes in three heaps were stored to be destored for one month, two months, 3 months respectively in the same houses as the piles for comparison purposes.

(ii) Pits: Three stacks of ten bags each (80 kgs) of potatoes were stored in pits in each of the three areas selected for 2,3 and 4 months respectively. The stack heights for all the pits were about 1.10m and 1.2m wide and about 1.36m deep (fig. 3(1). The pits were covered with straw at the bottom before storing potatoes and on top after storing potatoes. Some soil was put on top of straw and then a polythene paper was used on top of the soil to protect the pits from rainwater. Some more soil was put on top to prevent the polythene paper from damage (fig. 3.1).

FIG 3[i]

IMPROVED PIT STORE found to be used by some farmers in Kibirichia





NOTES:

Capacity 20 tons

Length = 5 m

Breath = 1.5 m

Height = 1.75 m

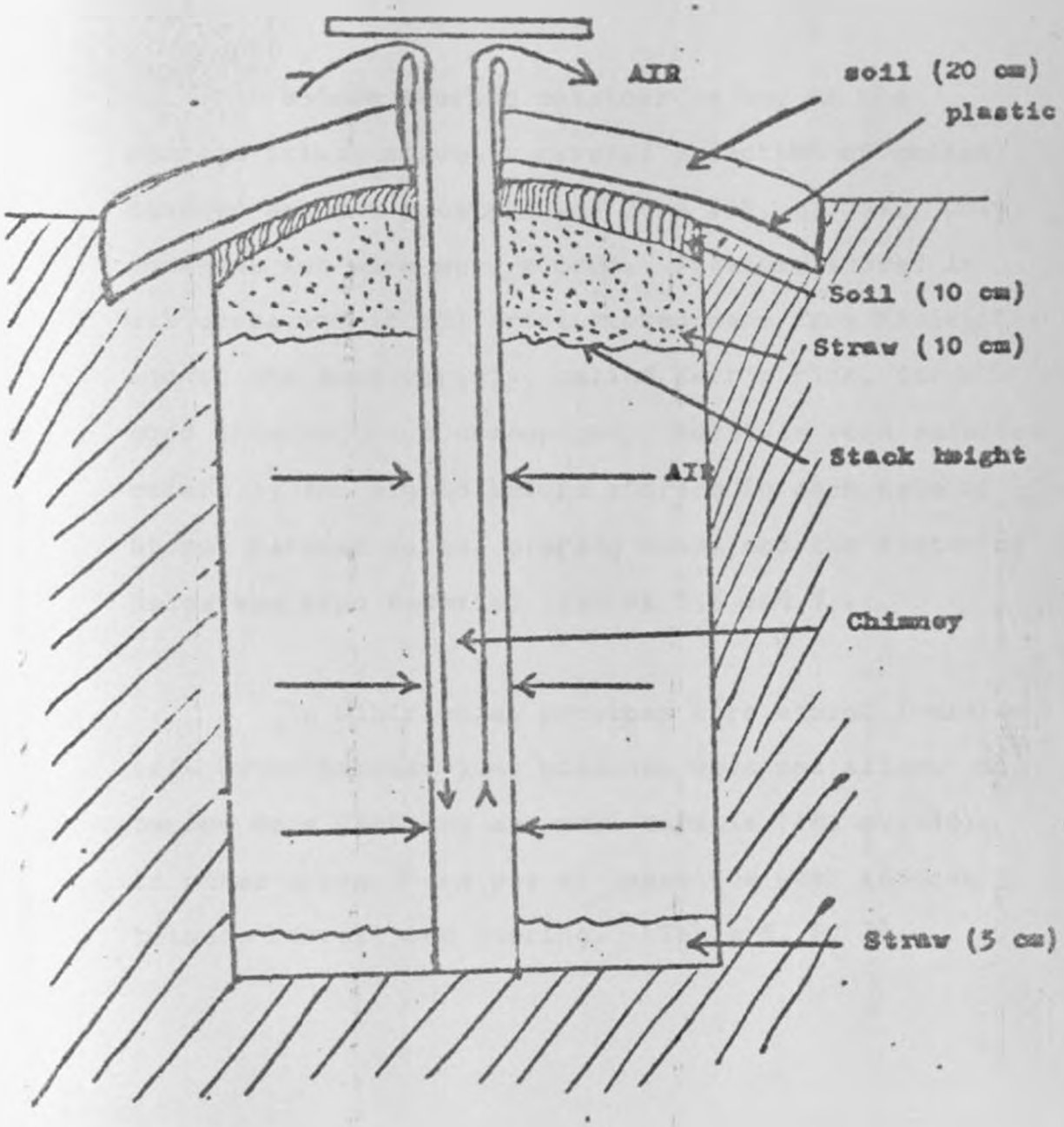
Each pit was fitted with an open air chimney through which a min-max thermometer was inserted. Temperatures were recorded everyday. The chimney also allowed air circulation in and out of the pit.

(iii) Improved granaries: The granaries were circular, and the floor was timber 50 cm raised from the ground. The dimensions are indicated in fig. 4. Each store had a capacity of about 2 tons.

The stores were insulated from solar radiation, with black plastic papers and leafy branches on the walls and straw-mud covers. The roofs were positioned such that no direct sun rays struck the walls. Four 15 x 15 cm chimneys were prepared on the covers of each store to allow air circulation from the slotted floor (fig. 4). Air was allowed to pass to the store from one direction during the night only. The chimneys were openable and were normally opened at night. The idea was that the cool night air should pass through the potatoes and maintain as much of it as possible during the day by closing the flap. (fig. 4).

In each store both inside and outside temperatures and relative humidity were recorded daily.

Fig 3:1) IMPROVED PIT STORE



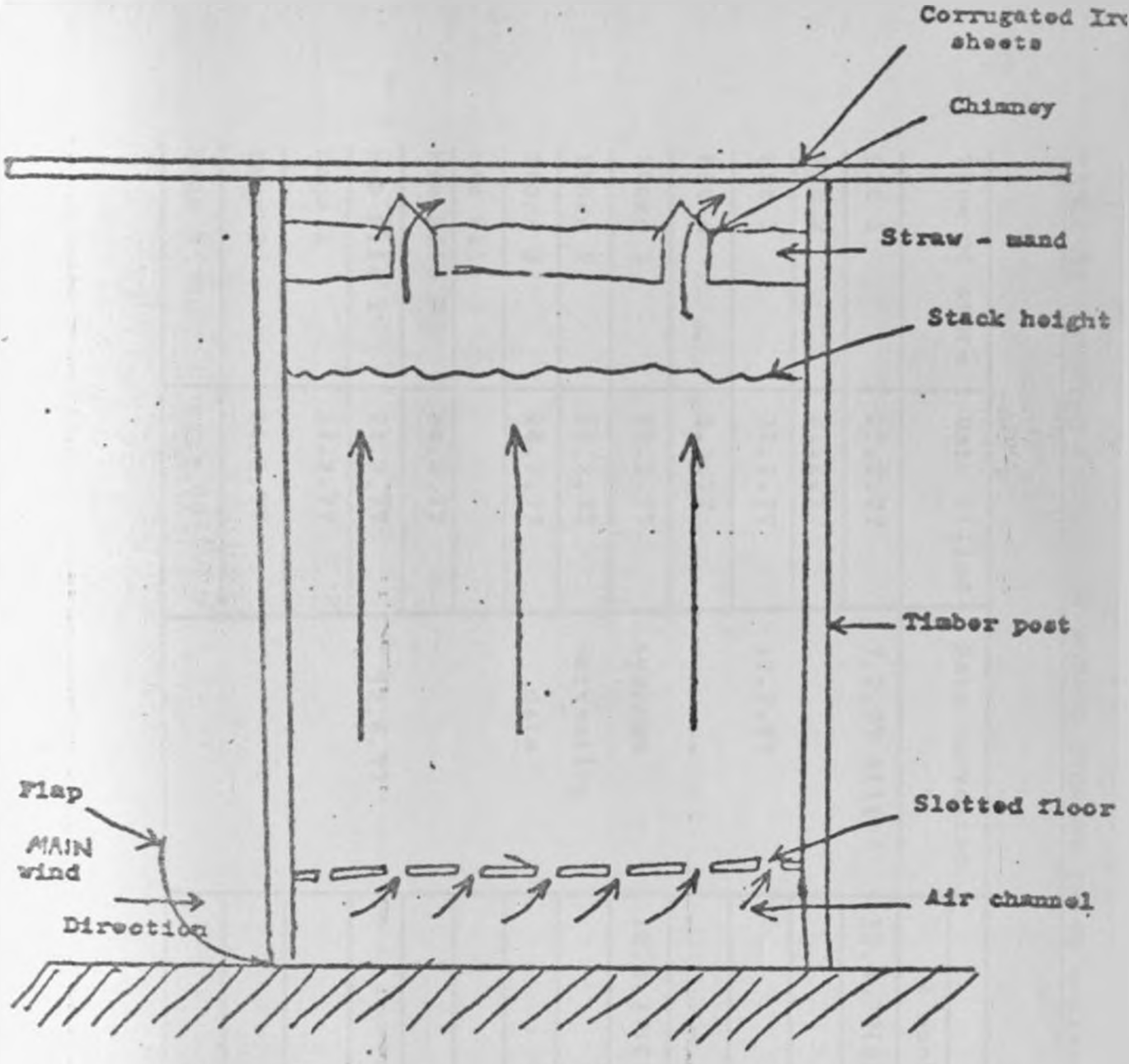
Source: Zettlemeyer W.J. ware potato storage trial. Interim Report, Ministry of Agriculture, Nair August 1977.

Diameter	=	1.20 m (Molo, Ngecha)
		1.40 m (Kibirichia)
Depth	=	1.35 meters.
Capacity	=	± 800 kg (Molo, Ngecha)
		1100 kg (Kibirichia)
Stack height		1.10 meters

Before storing potatoes in any of the storage trials above, a careful selection of rotten damaged and cut potatoes was done (18, p.177). Only potatoes for ware were stored. Potatoes stored in all areas and in all trial stores were from Kibirichia and of the same variety, called Kerr's pink, for a good interregional comparison. Potatoes were selected carefully and wighed before storing in each type of store, harvest dates, storing dates and the destoring dates was also recorded (tables 5,6 and 7).

In Kibirichia, potatoes were stored immediately after harvest i.e. potatoes were not allowed to become more leathery and more durable (18, p. 176). In other areas there was at least one week interval between harvest and storing. (Table 5, 6, 7).

FIG 4. IMPROVED GRANARY



Source: Zettelmeyer, W.J. - Ware potato storag
trial,
Interim Report, Ministr
Agriculture, Nairobi Au
1977.

Capacity = 25 bags of 80 kg.
Stack height 1.45 m
Floor Surface 2.12 m^2
Inner Diameter 1.64 m round
Out Diameter = 1.72 m
Total height = 2.40 m
Ventilation system : Air channel height 50 cm
Floor slots 1 cm wide
Four chimneys 15 x 15 cm.

TABLE 5: WORKING RECORD FOR POTATO STORAGE TRIAL - KIAMBU

Type of store	Date filled	Date harvested	Date of destoring		
			2 months	3 months	4 months
Pit 1	21.2.77	7.2.77 till	12.4.77(61 days)		
Pit 2	21.2.77			11.5.77(90 days)	
Pit 3	21.2.77	12.2.77			13.6.77(123 days
Pit 4	8.3.77				13.6.77(123 days
Store 1	22.2.77	Average	12.4.77(61 days)		
Store 2	23.2.77	Harvesting		11.5.77(90 days)	
Store 3	24.2.77	date			13.6.77(123 days
Hse Pile 1					
Hse Pile 2	24.2.77			11.5.77(90 days)	
Hse Pile 3	24.2.77	12.4.77			13.6.77(123 days
Bags 1	24.2.77				
Bags 2	24.2.77			11.5.77(90 days)	
Bags 3	24.2.77				13.6.77(123 days

Type of store	Date filled	Date harvested	Date of destoring		
			2 months	3 months	4 months
Pit 1	11.2.77	Stored right after 1.3.77	18.4.77(66 days)		
Pit 2	11.2.77			16.5.77(94 days)	
Pit 3	11.2.77				15.6.77(124 days)
Pit 4	12.3.77				
Store 1	17.2.77	Stored right after harvest	18.4.77(60 days)		
Store 2	18.2.77			16.5.77(87 days)	
Store 3	19.2.77				15.6.77(116 days)
House Pile 1	16.2.77		18.4.77(61 days)		
House Pile 2	16.2.77			16.5.77(89 days)	
House Pile 3					
Bags 1	16.2.77		18.4.77(61 days)		
Bags 2	16.2.77			16.5.77(89 days)	
Bags 3	16.2.77				15.6.77(119 days)

Type of Store	Date filled	Date harvested	Date of destoring		
			2 months	3 months	4 months
Pit 1	2.3.77	14.2.77	20.4.77(61 days)		
Pit 2	2.3.77	till		19.5.77(90 days)	
Pit 3	2.3.77	22.2.77			20.6.77(122 days)
Pit 4	2.3.77				20.6.77(122 days)
Store 1	3.3.77		20.4.77(61 days)		
Store 2	4.3.77	Average		19.5.77(90 days)	
Store 3	4.3.77	harvesting			20.6.77(122 days)
Hse Pile 1	5.3.77	18.2.77	20.4.77(61 days)		
Hse Pile 2	5.3.77			19.5.77(90 days)	
Hse Pile 3	5.3.77				20.6.77(122 days)
Hse Pile 4	5.3.77				20.6.77(122 days)
Bags 1	4.3.77		20.4.77(61 days)		
Bags 2	4.3.77			19.5.77(90 days)	
Bags 3	4.3.77				20.6.77(122 days)

CHAPTER 4

4. PRESENTATION OF RESULTS AND HYPOTHESIS TESTING

4.1 On farm potato storage of ware potatoes in Kibirichia location in Meru District Kenya

4.1.1. Types of potato storage facilities in common use

There are several potato storage facilities in common use in Kibirichia location of Meru District, namely pits, granaries, normal house-like type of store, and rooms attached to a dwelling house. Table 8 shows the proportion of the sample farmers that used different facilities between March and May 1977.

TABLE 8: Different sample potato storage facilities used in Kibirichia location 1977

Storage facility	No. of Stores	% of the total sample
House-like type	63	88.7%
Granary	2	2.8%
Pit	1	1.4%
Room attached to dwelling house	5	7.0%

SOURCE:

From survey data

Houselike stores are defined in this thesis as any building apart from a dwelling house where potatoes or other crops are stored (30, p.2). Stores attached are defined as any building attached to either a dwelling house or a kitchen where potatoes are stored. Granary is defined as storage unit with a raised floor.

4.1.2 Structural design of the sample potato storage facilities

4.1.2.1 Houselike

Floor: Table 9, shows that 76.2% of the sample houselike stores had floors made of natural earth and 23.8% of the floors were concrete screed.

Walls: Table 9, indicates that 68.3% of stores were made of timber walls and 31.7% were made of mud plastered walls.

Roofs: 85.7% of the sampled houselike stores had roofs constructed of corrugated iron sheets and only 14.3 of the roofs were grass thatched (table 9.).

4.1.2.2 Stores attached to dwelling houses or kitchens

Floors: From table 9, it is shown that 90% of the floors were made of natural earth and only 20% of the floors were made of concrete.

Walls: 60% of the stores attached to dwelling houses or kitchens were constructed of mud plaster walls while 20% of the stores were made of timber and 20% of the walls were made of stone (table 9).

Roofs: Table 9, shows that 80% of the roofs were made of corrugated iron sheets and only 20% of stores attached to dwelling homes were grass thatched.

4.1.2.3 Granaries

From table 8, we find that there were only 2 granaries out of the sample stores of 71. Both had timbers raised floors but one had mud plastered walls and the other had timber walls. Both roofs were made of corrugated iron sheets table 9.

4.1.2.4 Pits

There was only one pit, i.e. 14% of the sample stores (table 9). The pit had natural earth on

both the floor and walls but was covered with a portable corrugated iron sheet roof. The roof could be removed and replaced during potato storing and destoring. The roof was constructed in such a way that rain water falling on it was collected and diverted away from the pit. (fig. 5).

4.1.2.5 Forced ventilated store

There was only one store which was artificially ventilated to control stack temperatures. The idea was to maintain inside temperatures below 13°C (3). The store had a capacity of 200 tons (3). It was built of earth floor, timber walls and corrugated iron sheets roof. It was not one of the sample stores but it was thought necessary to mention it because it was the only one of its types in the whole district and it was newly introduced in the country by Schlueter Company.

4.1.2.6 Seed storage

From table 11, it was noted that 15.3% of the harvested potatoes in Kibirichia's season 1977 were set aside for seed. Seed potatoes were stored in shallow pits about 0.6m deep, 4m long and 3m wide Potatoes were covered with either a thick layer of straw or small layer of soil (30, p.31). Farmers

TABLE 9: PERCENTAGE STRUCTURAL COMPOSITION OF THE SAMPLE STORAGE FACILITIES IN KIBIRICHIA 1977

Building components	House like stores	Stores attached to dwelling houses	Granaries	Pits
FLOORS	%	%	%	%
Concrete	23.8	20	-	-
Timber raised	-	-	100	-
Earth	76.2	80	-	100
TOTAL	100	100	100	100
WALLS				
Timber	68.3	20	50	-
Stone	-	20	-	-
Mud	31.7	60	50	-
Earth	-	-	-	-
TOTAL	100	100	100	100
ROOFS:				
C.I.S.	85.7	80	100	100
Grass thatched	14.3	20	-	-
TOTAL	100	100	100	100

SOURCE: Own compilation

claim that this method of storage accelerates seed germination (sprouting). The pits were dug near the harvested field to avoid journeying to and from the farmer's house which was often located some distance away (30, p.32). This method was not used for ware potatoes for sale or any other purpose.

Since the study emphasised storage ware potatoes, no further attention was placed to seed storage.

4.1.3 Sample average size of the stores in relation to structural designs

4.1.3.1 House-like

Table 10, shows that 11.3% of the sample stores were house-like built of natural earth floor, mud platered walls and grass thatched roofs. Their average sizes were 4.58m long, 3.9m wide and 2.4m high. 40.8% of similar type of sample stores were constructed of natural earth floors, timber walls and corrugated iron sheet roofs. Their average size were 5.25m long 3.7m wide and 2.4m high. The average sizes of 21% of similar type of stores was 8m long, 4.1m wide and 2.4m high. These were constructed of concrete floors, timber walls and corrugated iron sheet roofs. Finally 15.5% of the house-like sample stores were made of natural earth floor, mud plastered walls and

corrugated iron sheet roofs. These had average dimensions of 4.86m length, 3.42m width and 2.4 height.

4.1.3.2 Stores attached to dwelling houses or kitchen

Table 10, shows only 1.4% of the sample stores were attached to dwelling houses or kitchen, constructed of natural earth floors, mud platered walls and grass thatched roofs. Their average external dimensions were 3m long, 2.4m wide and 2.4m high. 1.4% of similar type of stores were constructed of earth floors, timber walls and corrugated iron sheet roofs. Their average dimensions were 3m long, 2.1m wide and 2.4m high. 2.8% were made of earth floors, mud plastered walls, and corrugated iron sheet roofs, with external dimensions of 3.3m long, 3m wide, and 2.25m high. 1.4% of similar stores were made of concrete floors, stone walls and corrugated iron sheet roofs. These had an average size of 3m long, 3m wide, and 2.7m high.

4.1.3.3 Granaries

Table 10, shows that 1.4% of granaries were made of raised, slotted timber floors, timber walls and corrugated iron sheet roofs. The average dimensions were 3m long, 1.8m wide, and 2.4 high, 1.4% were constructed of timber, slotted raised floor, mud plastered walls and corrugated iron sheets roofs and their average dimensions were 4.5m long, 3.6m wide and 2.1m high.

TABLE 10: AVERAGE SIZES OF THE SAMPLE POTATO STORAGE FACILITIES BY STRUCTURAL DESIGN IN KIBIRICHIA 1977

No. of stores	Floors	Walls	Roofs	House-like stores (metres)				Stores attached to D.House (M)				Granary (metres)				Pits (metres)			
				Length	Width	Height	%	Length	Width	Height	%	Length	Width	Height	%	Length	Width	Height	%
9	Earth	Mud	Grass thatch	4.58	3.9	2.4	11.3	3.0	2.4	2.4	1.4	-	-	-		-	-	-	
30	Earth	Timber	C.I.S	5.25	3.7	3.4	40.8	3.0	2.1	2.4	1.4	-	-	-		-	-	-	
15	Concrete	Timber	C.I.S	8.0	4.1	2.4	21		-							-		-	
1	Ti. Raised	Timber	C.I.S		-		-		-			3.9	1.8	2.4	1.4				
1	Ti. Raised	Mud	C.I.S		-		-		-		-	4.5	3.6	2.1	1.4				
14	Earth	Mud	C.I.S	4.9	3.4	2.4	15.5	3.3	3.0	2.1	2.8								
1	Concrete	Store	C.I.S.		-			3.0	3.0	2.7	1.4								

SOURCE: Own compilation

Note: D = Dwelling

Ti = Timber

C.I.S. = Corrugated Iron Sheets

4.1.3.4 Pits:

Table 10, shows that 1.4% of the pits were made of earth floors, earth sides and corrugated iron sheets roof covers. They had average size of 2.7m long, 1.2m wide and 1.2m high.

From the foregoing analysis the house-like stores were bigger in size compared to all other types of stores. The house-like stores were about 90% of other types combined.

There is enough evidence from the above information to conclude that the structural design of potato storages depend on their sizes.

TABLE 11 Analysis of stored potatoes during the 1st season 1977 in Kibirichia location*

Potato Qt (100 kgs)	Total	Average	%
Stored (bags)	5041	71	38.8
Sold immediately (bags)	4090	57.6	31.4
Consumption (bags)	1396	19.7	10.8
Seed (bags)	1993	28.1	15.3
Other purposes (bags)	482	6.8	3.7
Total harvested	13002	183.2	100

SOURCE: Own compilation (Appendix 1)

*From sample of farmers.

4.2 Analysis of stored potatoes during the 1st season 1977 in Kibirichia location

4.2.1. Purpose of storing

Sale: It can be judged from table 11, that the sample quantity of potato stored was 38.8% compared to 31.4% sold immediately after harvest. Potatoes for consumption and seed were 10.8% and 15.3% respectively. The obvious conclusion was that farmers store quite high percentage of their harvested potatoes and this was a good sign of the need for good storage facilities accompanied by relevant advice.

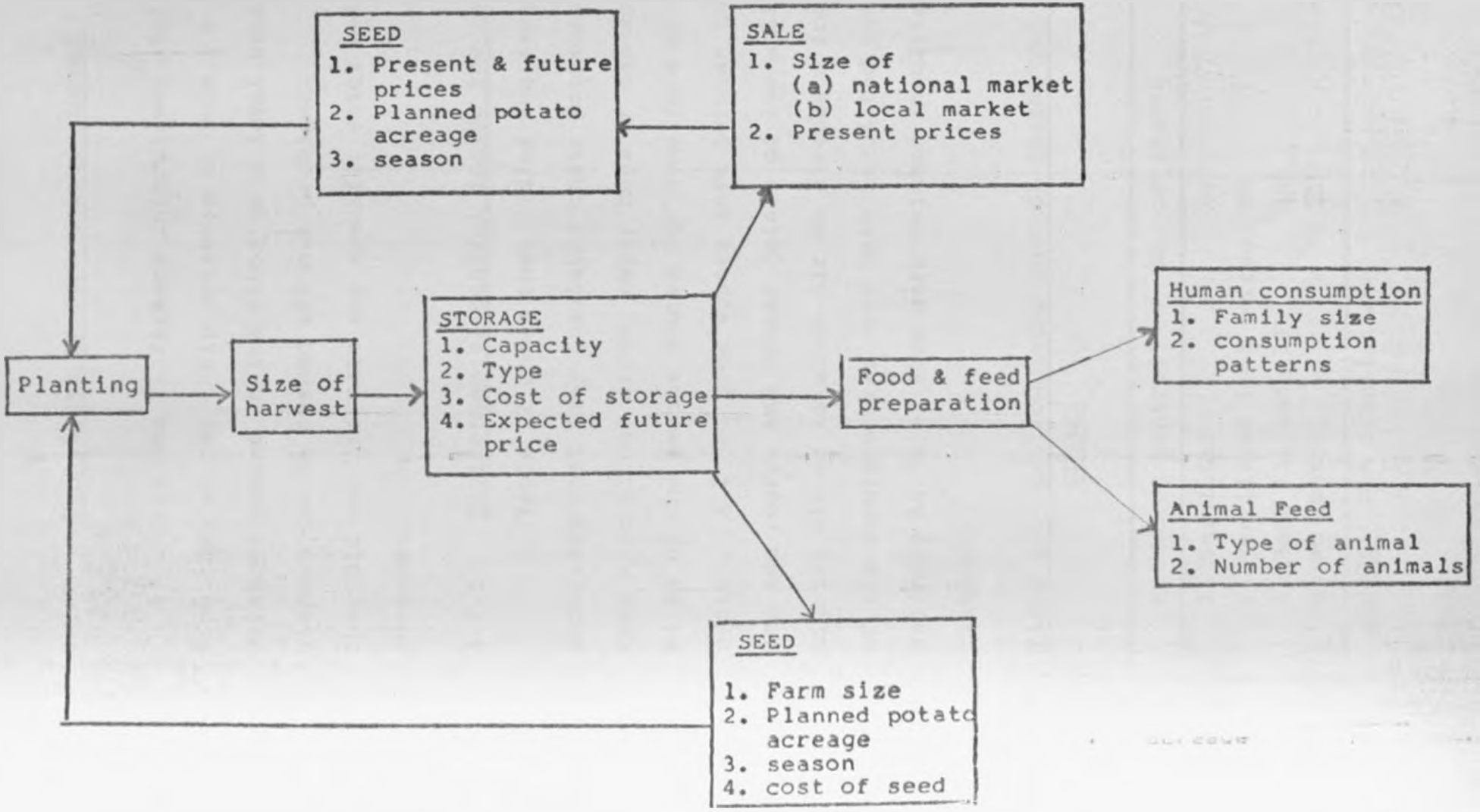
However farmers store potatoes with a speculative motive and not with a motive of stabilizing prices and quantities supplied in the market as a government planner could be tempted to think. Nevertheless storage per se stabilizes prices and quantities to some extent. It is very difficult for either the government or the farmers to try and stabilize prices or quantities of an agricultural products especially for such a perishable crop like potato (10,p.131). The problem of stabilization in agricultural crops is that both demand and supply curves are not always known exactly (10,p.131).

The supply of potatoes can only be controlled using stores for a very limited period of time especially in a developing country like Kenya. Storage trials carried between February-June, 1977 have shown that using ordinary materials for building stores, potatoes can be stored for more than 4 months with little loss (table 30).

Seed: From table 11, 15.3% of the potatoes harvested by the sample farmers were stored for seed. At the time of planting in Kibirichia there is a high demand for seed, owing to under storage, losses and the desire to obtain new stock. Some farmers, therefore, store an amount of seed greater than their own needs in order to sell at a good price to other growers all over the Meru District (30, p.14).

On-farm consumption From table 11, 10.8% of the potatoes were stored for home consumption. This percentage was fair because farmers have to wait for only 3½ months before the next harvest(13). However it was found that farmers with more acreage of land under potatoes sold most of their potatoes immediately after harvest. This is partly because most of the big farmers are farmers-cum-traders and that they sell to invest elsewhere while they wait for the next harvest. And partly because the big farmers lease land and are reluctant to put up big stores in farms they do not own.

Fig. 5 Factors Affecting amount of potatoes stored and alternative decisions open to a farmer



4.2.2 Techniques of farm potato storage

All the 71 farmers interviewed indicated that they stored their potatoes in bulk i.e. potatoes poured on the floor to a level where the windows can be opened without problems.
They did not indicate any specific stack height of the potatoes.

4.2.3 Environmental control inside the sample stores

Table 12 shows that 57% of the sample farmers indicated that they insulated their potatoes by covering them with either straw, empty bags or canvas. In all, 64.8% of the sample stores had some form of ventilation system. All had some spaces left between the walls and the roofs; and timber joints of the walls were not tightly closed to allow air to circulate freely. 42% of the sample stores were both insulated and ventilated and only 15.5% of them were neither insulated nor ventilated.

TABLE 12: ENVIRONMENTAL CONTROL INSIDE THE SAMPLE STORES

Method of Control	No. of stores	%
1. Insulated	40	57
2. Ventilated (not forced)	46	64.8
3. Both (1) and (2)	30	42
4. No control	11	15.5

SOURCE: Own compilation

4.2.4 Use of insecticides and/or disease killing chemicals in sample stores

TABLE 13: PERCENTAGE OF FARMERS THAT USED CHEMICALS IN THEIR STORES IN KIBIRICHIA, 1977

Chemical	No of farmers	%
Chemicals not known	49	69
Chemicals known but not used	13	18.3
Chemicals used	9	12.7
TOTAL	71	100

SOURCE: Own compilation

From table 13, 69% of the sample farmers did not know about any chemical that can be used in stores to prevent any pest and/or disease from attacking the tubers. 18.3% farmers knew about the tuber moth killer chemical but had not used the chemical because tuber moths do not attack tubers stored after the early harvest (January-February). However 12.7% of the sample farmer used tuber moth killer chemical. These farmers had farms on the lower zone of Kibirichia where it is warmer than upper zone (16).

4.2.5 Use of sprout suppressant

Sprout suppressant chemicals are not common in local shops in the country. 84.5% (table 14) of the farmers interviewed indicated that they did not know of any sprout suppressant chemicals. They indicated that such a chemical could prevent the heavy sprouting menace that is common in Kibirichia. 15.5% of the farmers indicated that they had heard about the chemical but they had not seen it. It was being used in the big Methodist Church Store in Kibirichia by the Schuelter Company.

TABLE 14: USE OF SPROUT SUPPRESSANT IN KIBIRICHIA LOCATION, 1977

Use of Sprout suppressant	No. of farmers	% of farme
Used	0	0
Not known	60	84.5
Known but not used	11	15.5
TOTAL	71	100

4.3 Econometric analysis on the potato quantities stored during the early harvest (Jan-Feb. 1977) in Kibirichia - Meru

A regression analysis was used to ascertain the determinants of the potato quantity stored during the early harvest i.e. Jan-Feb. 1977.

Price data was obtained partly from H.C.D.A. files and partly from the survey carried in Kibirichia in April, 1977. H.C.D.A. records weekly minimum and maximum price data at Wakulima Wholesale market every Wednesday (12, p.93). A weekly wholesale price mean was calculated from the price range.

The data on quantities, investment costs, losses, acreage were collected during the April - May 1977 survey carried in Kibirichia. Quantities were measured in terms of bags of 100 kgs.

Limitations of the data:

- prices recorded frequently are weekly averages and not daily averages. (12,p.94)
- the data on quantities, investment costs, and losses incurred during the storage period were given by farmers out of experience i.e. the data were not systematically recorded. The data should therefore be treated with a lot of caution.

- the data were cross sectional and care should be used in converting the time series data to cross sectional data.

4.3.1 Regression analysis

4.3.1.1. Quantity stored - price relationship

Regression analysis was carried out with quantity stored as dependent variable and prices as independent variables. The following models were developed and tested.

(1) $Qs = a + b\ Pt + e$

(2) $Qs = a + b\ P_{t+1} + e$

(3) $Qs = a + b\ P_{t-1} + e$

where a = intercept

Qs = quantity stored

Pt = price prevailing at the market at harvest time (t)

P_{t+1} = expected price after 2 months of storage time (t+1)

P_{t-1} = average price two months before harvest time (t-1)

e = error term

Assumptions in developing the models

In the first model it is assumed that the total quantity stored at any given harvesting period is a function of the price currently ruling during the harvest time. This is a useful assumption because farmers will store potatoes basing their action on the current income and possible future income. If they think prices at harvest time are low they will store lot and vice versa.

The second model assumes that farmers are economically rational. This means that farmers know that supply of potatoes to the market is highest at harvest time hence low prices and when supply decreases with time, prices go up. The collary to this argument is that the economic minded farmers will store a lot to catch the market when there is shortage in future and store small amounts when they expect a contrary situation.

The third model assumes that the quantity stored is a function of the prices that prevailed just before the harvest time. The assumption is valid because farmers will store potatoes with the price trend experienced during the last season.

The prices at the end of the last season will be quite fresh in the minds of the farmers during the harvest time. Farmers will store potatoes with the hope of experiencing similar or otherwise price trend as last season (appendix 9).

Assumptions underlaying the model structure

i. That quantity stored and price relationship exist in a linear manner (12, p.101).

ii. That farmers are exposed to information media (12, p.101).

iii. That alternative methods of disposing the harvested potatoes are known to the farmers.

iv. That there is freedom of exit and entry in the industry (12, p.101).

v. That there are no seasonal carryovers.

The first assumption of linearity of the relationship is necessary in order to carry out the investigation although one cannot be sure whether the relationship is linear or non-linear.

The second assumption that farmers are exposed to information media is valid because about 90% of the sample farmers sell their produce in the local markets and all of them live within a distance of 7 km from the local markets.

The price at the local market is normally determined by the supply and the local and national demand, a demand that is indicated by the trader's demand. However, potato prices may be determined by H.C.D.A. occasionally by using external demand i.e. when potatoes are to be exported outside the country. National prices are always written in 'The Standard' newspaper and the 'Kenya Farmer' newspaper and broadcast over the national radio every friday. Traders are assumed to keep usp with the price information from one media or the other and this information is assumed to pass to farmers. Farmers plan whether to sell or store with sufficient price information hence the validity of the assumption.

The third assumption that farmers have alternative method of disposing the harvested potatoes is valid because without it farmers will have to store anyway. Farmers have only one alternative method of disposing of their produce i.e. selling it if they do not store and besides consumption. (See fig. 5).

The fourth assumption that there is freedom of exit and entry in potato industry is valid because all farmers in Kibirichia are free to grow potatoes, sell and store.

It could be absurd if there were monopolistic tendancies in the industry because prices could not be determined by supply and demand of potatoes. This means that farmers could only store at their risk and the quantity stored could no longer be determined within the model.

Due to the perishability of the potatoes the final assumption of no seasonal carry-overs is valid. No farmer will store until the harvest of next season because the quality of the stored potatoes will be very low compared to the newly harvested potatoes hence low incomes. It could be difficult to determine the quantity stored in one season when there are seasonal carry-overs, hence the validity of the assumption.

Analysis of the Regression Fits

Table 15, shows the coefficients of regressions and the R values. The R values were obtained by the following formula:

$$R^2 = \frac{\sum (y-\bar{y})^2}{\sum (y-\bar{y})^2} = \frac{\text{explained variation of y}}{\text{total variation of y}}$$

From the table the 1st and 2nd equations gave zero values of R^2 where the prices prevailing at the harvest time and prices last season are independent variables. This means that these prices do not explain the variations in the quantity stored at 95% confidence level. The phenomena can be explained by the fact that both prices were taken to be constant for all the quantities sold by sample farmers. Price at harvest time was fixed by H.C.D.A. and last season's price was taken as average of the price of November and December, 1976.

This average was calculated using Wakulima Wholesale Market prices less transportation cost of November and December, 1976.

The third equation shows that the coefficients of regression of prices two months after harvesting period was statistically significant from zero at 95% confidence level (x-5%) and df* = 70. This variable explains 3.9% of the variation in the quantity stored (table 15).

It can be concluded that all prices have little or no effect on the quantity stored under the above assumptions and that other variables excluded in the above regressions explain the variations in quantities stored.

---

*df = Degree of freedom

4.3.1.2 Quantity harvested - quantity stored relationship

Analysis to determine the influence of quantity harvested, quantity sold immediately a harvest, quantity consumed and quantity expected to be lost during the storage period, on the quantity stored were also carried out. The following models were developed and tested, with the same structural assumptions as in section 4.3.1.1.

(4) $Qs = a + bQh + e$

(5) $Qs = a + bQd + e$

(6) $Qs = a + bQc + e$

(7) $Qs = a + bQl + e$

where: Qs = quantity stored

Qh = " harvested

Qd = " sold immediately after harvest

Qc = " expected to be consumed

Ql = " expected to be lost during storage

The first model assumes that the quantity stored is a function of the quantity harvested. Farmers will essentially store the surplus especially where potatoes are the major source of cash incomes.

After 3½ months of growing period farmers are anxious to get some cash and this requirement will determine the amount to be stored.

In second model it is assumed that the quantity stored is a function of the quantity sold immediately after harvest (see 1st assumption).

In the third model, the assumption is that the quantity stored is a function of the quantity expected to be consumed. Again a farmer will only store ware potatoes to sell when his basic requirement for food is satisfied.

The fourth model assumes that the quantity expected to be lost during the storage period determine the quantity stored. Farmers will take risk in storing a certain quantity depending on the expected losses, dictated by the past experience.

A combination of the above factors might determine the quantity stored but it was found necessary to find out the effect of each factor.

Analyses of the Regression Fits

For the first equation the analysis shows that the quantity harvested indicated a coefficient

TABLE 15: REGRESSION ANALYSIS OF QUANTITY STORED WITH RESPECT TO SEVERAL DETERMINANTS IN THE 1ST SEASON 1977 - KIBIRICHIA LOCATION - MERU

MODEL	VALUE		
	a	b	R^2
1. $Qs = a + b_1P_t + e$	1.2 (10.5)•••	-	0.782
2. $Qs = a + b_2P_{t-1} + e$	88.5 (10.5)•••	-	0.782
3. $Qs = a + b_3P_{t+1} + e$	88.5 (10.5)•••	-	0.782
4. $Qs = a + b_4Qc + e$	74.64 (4.12)•••	0.707 (0.87)	0.104
5. $Qs = a + b_5Qh + e$	9.5 (0.9)[1]	0.44 ••• (8.85)	0.729
6. $Qs = a + b_6Qd + e$	73.65 (5.2)•••	0.22 (1.23)	0.155
7. $Qs = a + b_7C + e$	71.4 (5.56)•••	0.047 (1.75)•	0.206
8. $Qs = a + b_8I + e$	66.52 (5.6)•••	0.09 (2.57)••	0.298
9. $Qs = a + b_9Qc + e$	-	3.6 (2.77)•••	0.496

SOURCE: Appendix 3

NOTES: (i) d.f. 69

(ii) The bracketed values are 't' statistics

(iii) ••• Significant at 1%
•• " at 5%
• " at 10%

of regression to be statistically significant from zero, at x - 5%* and at 69 degrees of freedom. The value of R^2 was 0.729, which means that quantity harvested explains the variation in quantity stored by 72.9% (table 15).

In the sixth equation qunatity sold had a coefficient of regression statistically significant from zero at x-5% and df = 69. The value of simple correlation is -0.16. This meant that the quantity sold is inversely related to quantity stored.

The quantity expected to be consumed in the third equation shows a regression coefficient statistically significant from zero at 95% significant level and df = 69. The value of simple correlation is -0.10. This means that the more the quantity expected to be consumed the less the quantity stored for sale and vice versa, table 15.

The above two conclusions, confirm the expected results from the assumptions stated earlier.

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* Probability of having occurred is only 5%

The quantity expected to be lost during storage show the value of R^2 = 0.496. This means that 49.6% of the variation in quantity stored is explained by expected quantity loss during storage. Table 15.

4.3.1.3 Other factors that determines the quantity stored.

In addition to the above, the influence of of the storage capacity and the investment costs of the stores on the quantity stored was investigated by developing and testing the models below:

(8) $Qs = a + bCa + e$

(9) $Qs = a + bIc + e$

where:

Qs = quantity stored

Ca = storage capacity of the stores

Ic = investment cost (present worth)

Assumptions

The first model assumes that the quantity stored is a function of the storage capacity. The assumption is valid because a farmer will store only a quantity that will fit in his existing store.

The second equation indicates that the quantity stored is a function of investment cost i.e. the stores' present worth. The assumption is more psychological, because it is assumed that a farmer will consider using a store effectively after using a certain amount of money in building it It is also assumed that the farmer will only consider the present worth of the store in deciding the amount to store. The present worth was calculated at discount rate of 10% (table 16 Parry's Valuation Tables: p.58-75). 10% is the average rate of interest offered in Kenya's Commercial Banks (28). It was also assumed that the 10% discounting rate will continue throughout the lives of the sample stores for simplicity. It was assumed that the rate of sinking fund was equal to rate of return to investment minus the discounting rate. Therefore no provision for sinking fund was allowed.

Analysis of regression fits

The first equation (table 15(i) shows that the coefficient of regression of storage capacity is statistically significant from zero at x = 5% and df = 69. The value of R^2 is 0.206, meaning that only 20.6% of the variation is explained by storage capacities.

The second equation (table 15) indicates that the value of R^2= .298 at X = 5 and df = 69. This means that 29.8% of the variation in quantity stored is explained by the psychological behaviour of farmers towards the investment costs involved in building stores.

In conclusion the storage capacity and investment costs are directly related to quantity stored.

4.4 Descriptive analysis of the potato Storage costs.

4.4.1 Investment costs

Assumptions and computations

i. The rate of interest was assumed to be 10%, i.e. the commercial average rate of interest offered by commercial banks in Kenya (28). The rate of return to investment above the 10% is equalised by the non-provision of sinking fund.

ii. The present worth = Pw = $\frac{1}{(1+r)^n}$

(Parry's Valuation Tables p.57-75)

TABLE 16: CALCULATION OF INVESTMENT COST OF SAMPLE STORES AS PER 1977 IN KIBIRICHIA

1st Method Type of cost	Total cost	No. of	Average cost per store	Average cost per 100 kgs of potatoes
	Shs		Shs	Shs
Total investment	169,130.00	71	2,382.10	6.44
Annuity	7,067.00	71	100.00	0.37
Monthly	588.92	71	8.30	0.03
2nd Method				
Investment cost	169,130.00	71	2,382.10	6.44
Present worth	100,300.00	71	1,412.70	3.82
Annuity	14,119.58	71	198.87	0.54
Monthly cost	1,176.63	71	16.57	0.04

SOURCE: Own compilation

TABLE 17: AVERAGE LIFE EXPECTANCY OF THE SAMPLE STORES IN KIBIRICHIA AS PER 1977

Life of store	Total No. of years	No. of stores	Average No. of years
Life expectancy	1647	71	23.0
Present age	646	71	9.0
Expected life	1038	71	14.0

SOURCE: Own compilation

iii Amount per year = $(r + s)^n$

where r = rate of interest

n = number of years

s = sinking fund to replace Shs 1 in a n years.

iv. The effect of income tax was ignored.

The above two formulae were used to calculate the present worth and the annual value of the investment in stores in Kibirichia, 1977. In addition a second method of dividing the total average investment cost by average life expectancy of the stores was used to calculate the present worth and annuity of stores respectively (table 16.)

Table 16, shows that the sample average investment cost for the stores was K.Shs. 2382.10 i.e. Shs. 6.44 per 100 kgs of potatoes with average life expectancy of 23.0 years. The average age of the sample stores was 9.0 years and expected life of 14.0 years.

From the discussions held with the farmers, it was found that farmers worry about the present worth of their stores and not about the initial investment cost.

Some sample stores had outlived their usefulness. The average present worth of the sample store was Shs. 1,412.70 (section 4.4.1 (ii) formula was used) and average annuity of Shs. 198.87 using section 4.4.1. (iii) formulae. The average annuity using the second method was Shs. 100.00 which is nearly half the former methods. The difference arises because second method does not allow for both the interest on capital and sinking fund.

4.4.2 Average sample investment cost by structural design of different types of stores in Kibirichia location in 1977

i. House-like stores

It will be recalled in table 8, that the houselike stores accounted for 88.7% of the sample stores. Their average investment costs ranged from Shs. 5080.00 to Shs. 641.00 i.e. from 8.23 to Shs.13.5 per 100 kgs of potatoes. Their average present worth and annuity ranged from Shs. 2867.60 to Shs. 185.00 respectively, depending on whether they were built of concrete or earth floors and/or hand plastered walls and corrugated iron sheet or grass thatch roofs. (Table 18,) their average present age ranged from 6 years to 13.0 years and their expected life ranged from 4 years to 20.0 years (table 18)

40.8% of the sample houselike stores were built of earth floor, timber walls and corrugated iron sheets roof compared to only 11.3% of the same type of stores built of earth floors, mud plastered walls and grass thatched roofs. 21.1% of the sample stores were built of concrete floors (table 18). It can be concluded that farmers are keen to build improved and permanent potato stores.

ii. Stores attached to dwelling houses or kitchen

Table 18, shows that stores attached to dwelling houses accounted for only 7% of sample stores. Their average investment costs ranged from Shs. 1000.00 Shs. 250.00 i.e. from Shs. 17.0 to Shs. 2.94 per 100 kgs. of potatoes. The average present worth and annuity ranged from Shs. 560.00 to Shs. 90.00 i.e. from Shs.9.33 to Shs. 1.40 per 100 kgs and shs. 76.00 to Shs. 52.00 i.e. from Shs. 0.78 to Shs. 2.84 per 100 kgs of potatoes respectively depending on their structural design. Their average present age and expected life ranged from 6 years to 18 years and from 20 years to 2 years. (table 17). These houses are therefore commonly used in Kibirichia. The trend is to build potato stores separate from either dwelling houses or kitchen.

iii. Granaries

There were only two granaries in the sample stores which accounted for 2.8% of the sample stores.

Their average investment costs ranged from Shs.400.00 to Shs. 450.00 i.e. from Shs. 4.00 to Shs. 1.8 per 100 kgs of potatoes depending on their structural design. Their average present worth and annuity ranged from Shs. 140.00 to Shs. 36.00 to Shs. 11.00 respectively. Their average ages ranged between 11 years to 20 years with expected life ranging between 5 years to 10 years (table 18). This leads to concluding that granaries are not in common use in Kibirichia. The traditional granary is not in use in Kibirichia because Kibirichia is a settlement scheme and farmers consider it outdated and too small for potato storage.

iv. Pits

Table 18, shows that pits were only 1.4% of the sample stores. The average investment cost was Shs. 300.00 i.e. Shs. 10.00 per 100 kgs of potatoes. Pits are not in common use for ware potatoes but used for seed potatoes to accelerate sprouting.

TABLE 18: Average sample investment costs by structural design for different types of stores in Kibirichia in 1977

Structural design	No of stores	%	Type of stores	Average Invest cost	Present worth Average	Annuity Average	Age Average	Life Expectancy (Average)
				Shs	Shs			
A_1	29	40.8	Houselike	2560.00	1445.00	196.00	6	24
A_{11}	1	1.4	Attached	1000.00	560.00	76.00	6	26
B	15	21.1	Houselike	5080.00	2868.00	337.00	6	26
C_1	11	15.5	Houselike	936.00	528.00	61.00	6	21
C_{11}	2	2.8	Attached	250.00	96.00	30.00	10	14
D_1	8	11.3	Houselike	641.00	185.00	58.00	13	17
D_{11}	1	1.4	Attached	300.00	72.00	15.00	15	22
E_1	1	1.4	Granary	400.00	140.00	36.00	11	16
E_{11}	1	1.4	Granary	450.00	68.00	11.00	20	30
F	1	1.4	Attached	500.00	90.00	52.00	18	20
G	1	1.4	Pit	300.00	72.00	15.00	15	22
		99.9						

SOURCE: Own compilation

TABLE 18: Continued

Where: A = Store with earth floor, Timber walls and C.I.S. roof
B = " " concrete floor, Timber walls and C.I.S. roof
C = " " earth floor, mud walls and C.I.S. roof
D = " " " " " " and grass thatch roof
E = " " Timber raised floor, timber walls and C.I.S. roof
F = " " concrete floor, stone walls and C.I.S. roof
G = Pit store a C.I.S. cover and timbered sides

4.4.3 Percentage losses incurred in sample stores according to structural design in different storage periods in Kibirichia 1st season 1977

Houselike stores

Table 19, shows that stores with concrete floors, timber walls and corrugated iron sheet roofs and highest losses (8%) for the three storage periods while stores built of earth floor, mud walls and corrugated iron sheet roofs and the least losses (2.3%). However both display the same trend of losses i.e. losses increased sharply for the first two months and then decrease gradually during the third month. Losses in stores (structural design A and D) generally increase with increased storage period.

Other types of potato stores

Farmers with stores attached to dwelling houses and the pits did not store potatoes in the early harvest 1977. This can be explained by the fact that the price offered by H.C.D.A. of 55/= per bag (100 kgs) was so attractive that, these farmers with small stores found no reason to store (table 19).

Another possible explanation is that they do not grow potatoes in large scale, and therefore whatever they produced satisfied their immediate cash requirement only. They had no surplus to store. However only one interviewed farmer used a store attached to dwelling (structural design D) for two months and losses were 10%. This was the highest loss compared to all other types of stores. The reason is that the dwelling house was used as a kitchen as well and due to high temperatures, high physiological losses occurred.

Losses in granaries were almost constant for the three storage periods in the two structural designs. The range was 0.8%.

TABLE 19: PERCENTAGE LOSSES INCURRED IN SAMPLE STORES ACCORDING TO STRUCTURAL DESIGN OF THE STORES IN DIFFERENT STORAGE PERIODS IN KIBIRICHIA 1ST SEASON 1977

Structural design	No. of stores	Type	% losses for 1m	2m	3m
Ai	29	Houselike	1.5	2.9	6.9
Aii	1	Attached	-	-	-
B	15	Houselike	1.3	9.9	9.7
Ci	11	Houselike	2.3	2.5	2.1
Cii	2	Attached	-	-	-
Di	8	Houselike	3.8	2.9	6.3
Dii	1	Attached	-	10.0	-
Ei	1	Granary	2.9	3.7	-
Eii	1	Granary	-	3.3	-
F	1	Attached	-	3.1	-
G	1	Pit	-	-	-
TOTAL			11.8	32.2	26.0

SOURCE : Own compilation
m - month

4.4.4 Sample average losses due to price movement involved in potato storage by farmers in Kibirichia 1st season 1977

Price during the early harvest in Kibirichia were unusually high due to export demand. H.C.D.A. was buying potatoes for a European market. The price was fixed at Shs. 55 per bag of 100 kgs. Many farmers sold their potatoes to H.C.D.A. although some quantities were stored by farmers who expected prices to shoot up because of the apparent shortage envisaged. The worst came when the H.C.D.A. did not sell the so bought potatoes to the European market because of some inanticipated failure in shipment. H.C.D.A. released the bought quantity two months after harvest flooding the local and national markets hence pushing prices down by almost 1/3. This over supply continued until middle of May, the third month after harvest. Many farmers who had stored, had already sold their potatoes by mid-May.

Sample farmers incurred heavy losses for the first three months of storage i.e. average loss of Shs. 19.00 per bag of 100 kgs (table 20). By June the same year prices doubled (appendix iv) contrary to what farmers expected. Prices continued to go up in July, August and September.

Price continued to go up because there was a very poor late harvest of potatoes all over the country, apparently, caused by too much rainfall in March-May. If farmers stored for more than three months they could have benefited a lot from storage (table 20).

It should be noted that past price figures for say five years or so are not available hence the problem of any meaningful comparison.

TABLE 20: SAMPLE AVERAGE LOSSES DUE TO PRICE•[1] MOVEMENTS INVOLVED IN POTATO STORAGE BY FARMERS IN KIBIRICHIA 1ST SEASON, 1977

I T E M		Stored for months 1	2	3	4•[2]
1. Quantity stored	bags	25.90	34.36	6.7	22.32
2. Harvest price	Shs/bag	55.00	55.00	55.00	55.00
3. Value of stock	Shs	1424.50	1889.80	368.50	1227.60
4. Rate of interest on (3)C at 10%	Shs	11.90	31.50	9.20	40.90
5. Total amount	Shs	1436.40	1921.30	377.70	1268.50
6. •Quantity destored	bags	25.90	34.36	6.7	22.32
7. Price at destoring period	Shs/bag	38.50	38.80	36.70	81.90
8. Total amount	Shs	919.45	1333.20	245.90	1828.00
9. Total loss after destoring	Shs	- 516.95	- 588.10	- 131.80	+ 559.50
10. Average storage profit/loss per bag	Shs	-20.00	- 17.10	- 20.00	25.10

SOURCE: Own compilation

1• Assuming no loss through storage

2• There was another harvest at the end of the 4th month

Notes:

Line 3 = $l_1 \times l_2$

Line 4 = A line 3 = $\frac{(10 \times m)}{(100 \times 12)}$ - 10% assumed rate of interest.
- m number of months

Line 5 = $l_4 + l_3$

Line 8 = $l_6 \times l_7$

Line 9 = $l_8 - l_5$

Assumption:

i. 4th month quantity is taken as average of 1, 2 and 3 months and average June price Wakulima market, Nairobi.
Less Shs. 10/= transportation cost.

ii. Assumed rate of return to stock is 10%

iii. No transportation cost, interest on investment and working capital i.e. no handling cost were considered.

Summary:

From table 20, it will be noted that the sample farmers who stored for one and three months incurred average losses to the tune of Shs. 20.00 per bag of 100 kgs.

Those who stored for 2 months incurred average losses of Shs. 17.10 per bag of 100 kgs. Had the farmers stored for 4 months they would have had average storage profit of Shs. 25.10 per bag of 100 kgs. This means that farmers were not able to forecast price movement because of the unexpected poor late harvest and the inability of H.C.D.A. to sell the potatoes it had bought for the European market.

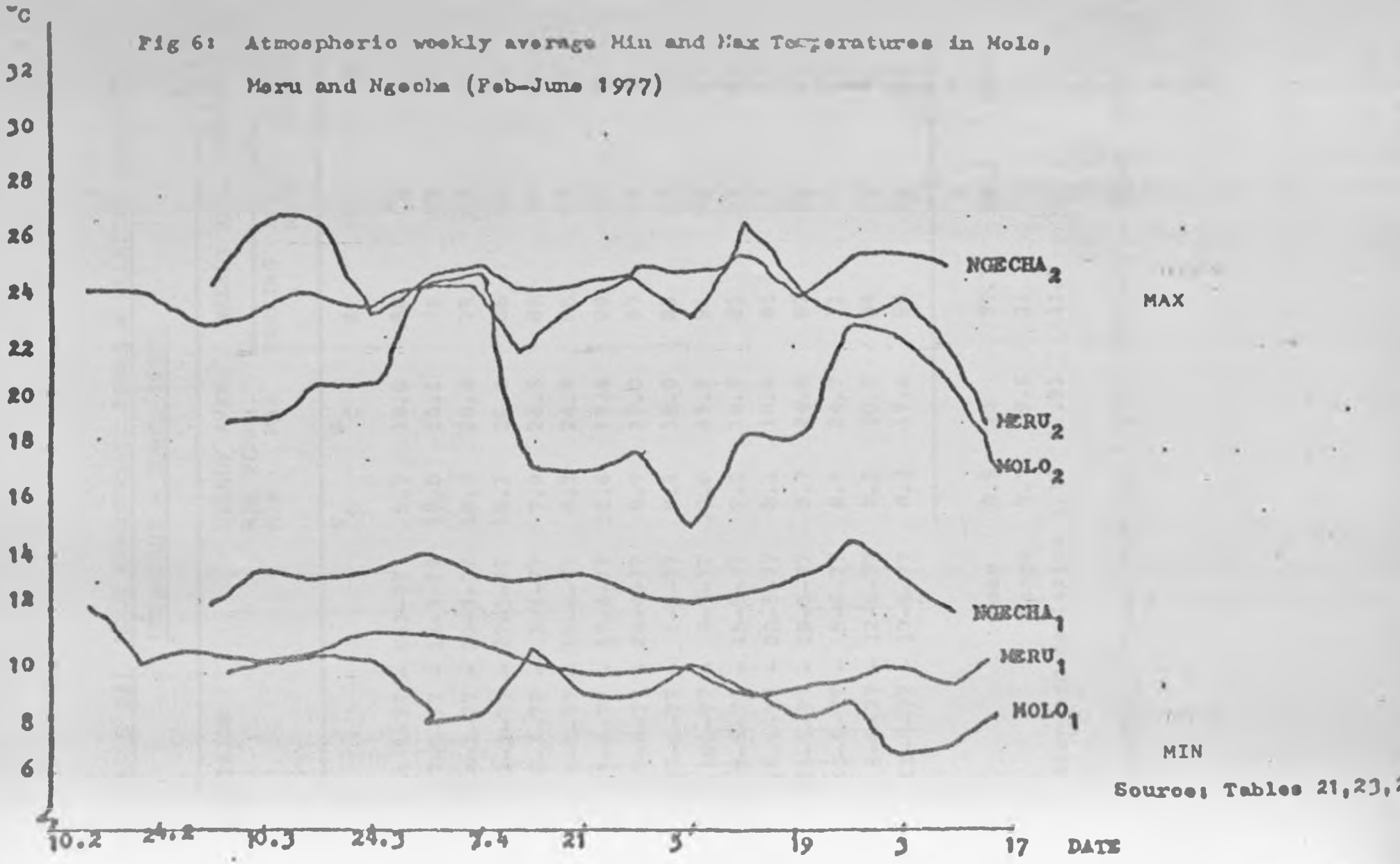
4.5 Interregional comparison of climatical factors that affect potato storeability

4.5.1 Temperatures

Outside Temperatures

It is clear from tables 21, 22, 23 and graph (6) that the outside temperatures minimum and maximum of Ngecha in Kiambu were highest between March and June 1977. Kibirichia's and Molo's outside average maximum and minimum temperatures were second and third highest respectively. The average maximum temperatures for Molo was 20°C, for Kibirichia 23.6°C and for Ngecha 24.4°C and average minimum temperature was 8.9°C, for Molo, Kibirichia 10.3°C while for Ngecha it was 13.2°C. However both average weekly maximum and minimum temperatures for Molo fluctuated most compared to Kibirichia and Ngecha.

Fig 6: Atmospheric weekly average Min and Max Temperatures in Molo, Meru and Ngecha (Feb–June 1977)



Source: Tables 21,23,

TABLE 21: MOLO ATMOSPHERIC TEMPS & RELATIVE HUMIDITY (FEBRUARY - JUNE, 1977)

PERIOD	WEEKLY AVERAGE TEMPS.		WEEKLY REL. HUMIDITY		
	MIN	MAX	MORNING	AFTER-NOON	DAILY AVERAGE
	°C	°C	%	%	%
4-3-77 - 6-3-77	9.7	19.0	80	63	72
7-3-77 - 13-3-77	10.0	10.1	76	97	78
14-3-77 - 20-3-77	10.3	20.4	79	64	72
21-3-77 - 27-3-77	10.1	20.4	86	61	74
28-3-77 - 3-4-77	7.9	24.5	89	72	81
4-4-77 - 10-4-77	8.3	24.9	98	90	94
11-4-77 - 17-4-77	10.6	17.4	90	90	90
18-4-77 - 24-4-77	8.9	17.0	97	82	96
25-4-77 - 1-5-77	9.1	18.0	83	94	89
2-5-77 - 8-5-77	10.0	15.3	91	95	93
9-5-77 - 15-5-77	9.2	18.7	81	81	81
16-5-77 - 22-5-77	8.1	18.6	81	83	83
23-5-77 - 29-5-77	8.7	24.8	67	68	68
30-5-77 - 5-6-77	6.9	24.3	71	71	71
6-6-77 - 12-6-77	7.1	20.7	84	82	83
13-6-77 - 17-6-77	8.2	17.4	90	92	91
Mean	8.9	20	77.7	80.3	82.3
Range	3.7	9.6	31	34	28
Standard deviation	1.16	2.91	11.7	12.3	9.15

SOURCE: Potato storage trials February - June, 1977

TABLE 22: NGECHA ATMOSPHERIC TEMPS & RELATIVE HUMIDITY (FEBRUARY - JUNE 1977

PERIOD	WEEKLY AVERAGE TEMPS.		WEEKLY REL. HUMIDITY		
	MIN	MAX	MORNING	AFTER-NOON	DAILY AVERAGE
	°C	°C	%	%	%
• 25-2-77 - 27-2-77	20.0	22.0	78	66	72
28-2-77 - 6-3-77	12.3	24.0	98	41	70
7-3-77 - 13-3-77	13.6	26.7	89	40	65
14-3-77 - 20-3-77	13.2	26.6	91	41	66
21-3-77 - 27-3-77	13.6	23.0	95	58	77
28-3-77 - 3-4-77	14.1	24.1	95.	67	81
4-4-77 - 10-4-77	13.3	24.0	95	90	93
11-4-77 - 17-4-77	13.3	24.0	91	93	92
18-4-77 - 24-4-77	13.5	24.4	94	83	91
25-4-77 - 1-5-77	12.7	25.0	95	67	81
2-5-77 - 8-5-77	12.5	24.8	89	81	85
9-5-77 - 15-5-77	12.8	25.3	86	77	82
16-5-77 - 22-5-77	13.4	23.9	88	79	84
23-5-77 - 29-5-77	14.8	25.4	91	85	88
30-5-77 - 12-6-77	13.5	25.7	83	78	81
6-6-77 - 12-6-77	12.1	25.1	90	85	88
Mean	13.2	24.4	90.5	70.7	81
Range	7.9	4.7	20	53	28
Standard deviation	0.7	1.2	4.2	18	9

SOURCE: Potato storage trials February - June 1977

• Average for only two days - ignored in the calculation of sd

TABLE 23: MERU ATMOSPHERIC TEMPS & RELATIVE HUMIDITY (FEBRUARY - JUNE 1977)

PERIOD	WEEKLY AVERAGE TEMPS.		WEEKLY REL. HUMIDITY		
	MIN	MAX	MORNING	AFTER-NOON	DAILY AVERAGE
	°C	°C	%	%	%
12-2-77 - 18-2-77	12.1	23.8	70	54	62
19-2-77 - 25-2-77	10.1	23.7	72	57	65
26-2-77 - 4-3-77	10.6	22.6	77	60	69
5-3-77 - 11-3-77	10.0	22.9	78	70	74
12-3-77 - 19-3-77	10.3	23.8	75	74	75
20-3-77 - 26-3-77	11.3	23.3	73	56	65
26-3-77 - 2-4-77	11.3	24.1	73	59	66
3-4-77 - 9-4-77	11.0	24.1	78	72	75
10-4-77 - 16-4-77	10.1	21.9	79	73	76
17-4-77 - 24-4-77	9.8	25.4	77	62	70
25-4-77 - 1-5-77	9.9	24.7	80	75	78
2-5-77 - 8-5-77	10.0	23.0	79	72	76
9-5-77 - 15-5-77	9.0	26.6	74	58	66
16-5-77 - 22-5-77	10.3	24.3	81	68	75
23-5-77 - 29-5-77	9.7	23.0	70	63	67
30-5-77 - 5-6-77	10.0	23.9	63	66	65
6-6-77 - 12-6-77	9.6	21.9	75	59	67
13-6-77 - 15-6-77	10.3	21.7	86	77	82
Mean	10.3	23.6	75.6	65.3	70.1
Range	3.1	4.9	23	23	20
Standard deviation	0.75	1.25	5.25	7.55	5.82

SOURCE: Potato storage trials (February - June, 1977)

Kibirichia temperatures fluctuated more than Ngecha temperatures. Potatoes also received different post harvest treatments and were from different farms with different production treatments. For instance potatoes stored in both Molo and Ngecha were shipped from Kibirichia. (see other possible reasons in the text later).

It would appear, therefore, that potatoes can store better in Molo than in Kibirichia and Ngecha although more trials should be set out to explain further the apparent contradiction of the logic and the results (see table 31).

Temperatures inside houses with stores

Room temperatures

From tables 28, 29, 30 and graph 7 it can be judged that Ngecha had highest house average minimum temperatures i.e. 14.7°C and average maximum temperatures was 24.4°C. The room was built of earth floor, mud plastered walls and grass thatched roof. One part of the house was used as a dwelling house without a kitchen.

The average minimum temperatures for Kibirichia was 10.3°C while the average maximum temperatures was 30.4°C. The average maximum temperatures was the highest. This may be explained by the fact that one

room in the house was being used as kitchen during the day and that unlike in Molo and Ngecha, the Kibirichia house was built of earth floor, timber wall and corrugated iron sheets roof. The roof conducted solar radiation directly to the room because there was no insulation provided by the ceiling and the timber walls.

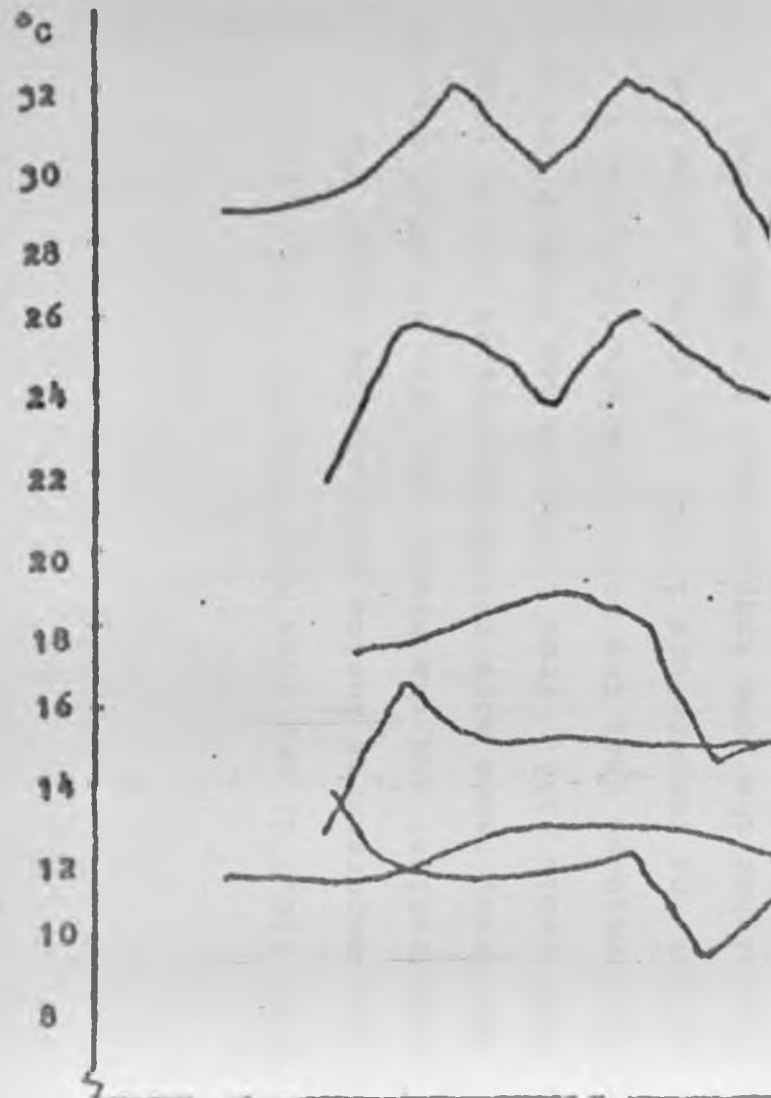
The average minimum and maximum temperatures for Molo were computed to be 11.6°C and 16.7°C respectively (table 28). The house was built of earth floor, mud plastered walls and grass thatched roof. The house was not used as a kitchen or a dwelling house. The average weekly maximum and minimum temperatures range were 4.7°C and 3.9°C respectively.

Judging from the micro-climatical conditions in the houses it would be difficult to conclude which areas could store potatoes best. However, potatoes could be expected to dehydrate most in the house with highest average maximum temperatures, for instance in Kibirichia.

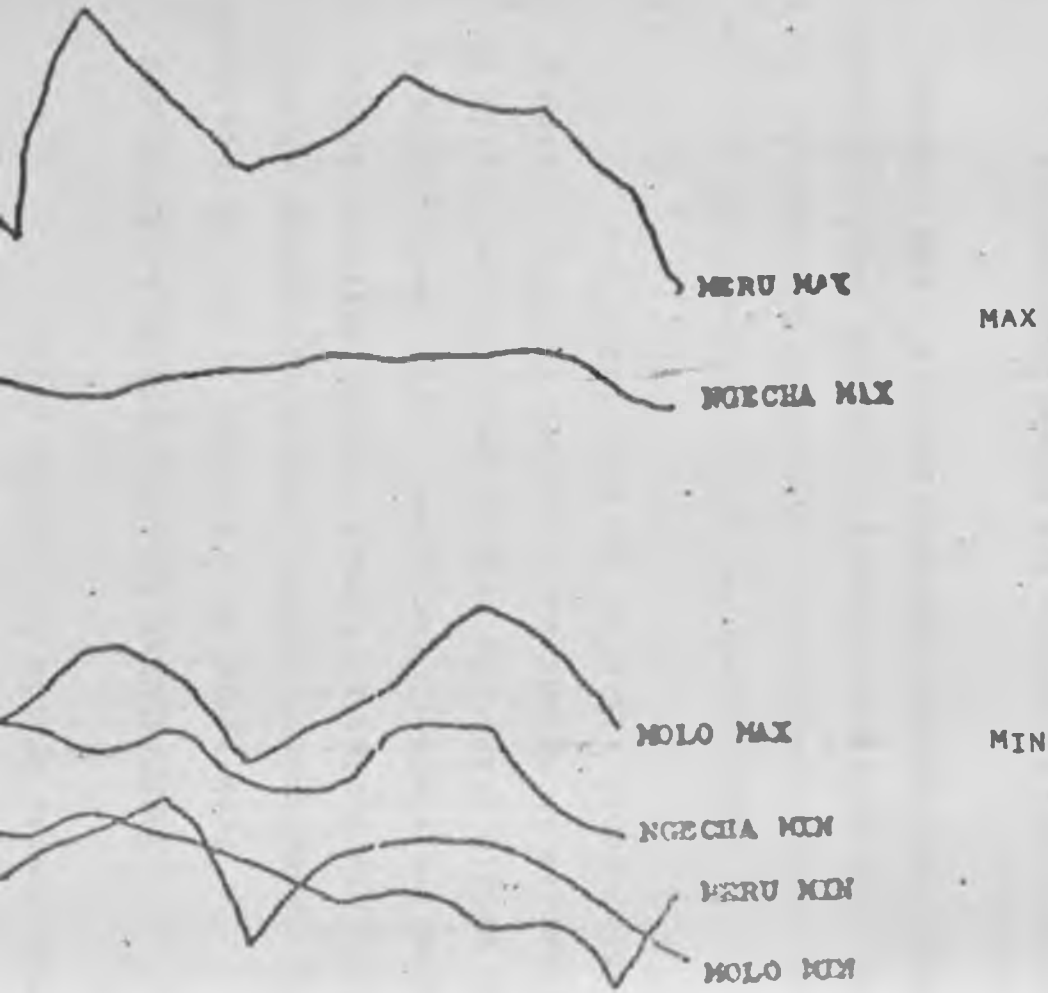
Temperatures inside potato piles in house

It can be noted from table 24 and graph 8 that average absolute temperatures inside the potato piles for Ngecha were highest (17.6 C) followed by

Fig 7.1 House Average



Max and Min. Temperatures



Source: Potato storage tr
(Feb-June 1977)

Meru (16.3°C) and then Molo (14.2°C). The higher the temperatures inside potatoes the higher the dehydration* and the higher the rate at which disease can grow, hence more potato rotting as can be noted from table (31). From (table 24 and graph 8) it can be concluded that the room temperatures (graph 7) affect the temperature inside the potato piles i.e. the higher the room temperatures the higher the temperatures inside the potato piles.

Temperatures inside potatoes in granaries

From table 26 and graph 10 the average absolute temperatures inside potatoes in wooden stores, with raised slotted timber floors, differed in the three areas under discussion. Like temperatures in the potato piles the average temperatures inside the granaries in Ngecha were highest (17.9°C) followed by Kibirichia (16.6°C) and Molo (12.4°C).

Again it can be concluded that Molo has the best potato storability followed by Kibirichia. Moreover, the difference between average absolute temperatures, for Ngecha and Molo was 5.5°C and between

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*dehydration = include any weight loss due to physiological changes in potatoes.

TABLE 24: House pile weekly temp. in Molo, Kibirichia and Ngecha (Fevruary - June, 1977)

DATE	MOLO	DATE	KIBIRI-CHIA	DATE	NGECHA
5-3-77	°C		°C		°C
5-3-77	14.3	15-2-77	16.4	28-2-77	18.3
10-3-77	14.4	22-2-77	16.0	3-3-77	17.5
17-3-77	13.4	1-3-77	16.1	10-3-77	17.6
24-3-77	14.0	8-3-77	16.3	17-3-77	17.4
31-3-77	14.2	15-3-77	16.4	24-3-77	16.8
7-4-77	14.3	23-3-77	16.9	31-3-77	17.7
14-7-77	13.6	30-3-77	17.0	7-4-77	17.9
21-4-77	13.7	6-4-77	17.2	14-4-77	17.9
28-4-77	14.1	13-4-77	16.5	21-4-77	18.0
5-5-77	14.0	20-4-77	17.0	28-4-77	17.6
12-5-77	13.8	28-4-77	16.9	5-5-77	17.7
19-5-77	14.4	5-5-77	15.2	12-5-77	18.0
26-5-77	14.4	12-5-77	16.3	19-5-77	17.8
2-6-77	14.4	19-5-77	16.2	26-5-77	17.2
9-6-77	14.6	26-5-77	16.0	2-6-77	17.0
15-6-77	16.3	2-6-77	15.1	9-6-77	17.8
		9-6-77	16.2		
		14-6-77	16.0		
Average	14.2		16.3		17.6
Range	1.2		2.1		1.5

SOURCE: Potato storage trials (Feb - June, 1977)

TABLE 25: Weekly average temp. in potato pits in Ngecha, Molo and Kibirichia (Feb-June 1977)

DATE	MOLO	DATE	KIBIRI-CHIA	DATE	NGECHA
	°C		°C		°C
31-3-77	19.9	26-3-77	25.6	7-4-77	27.1
7-4-77	20.3	30-3-77	27.4	14-4-77	27.1
14-4-77	20.4	6-4-77	29.2	21-4-77	25.8
21-4-77	21.1	13-4-77	26.9	28-4-77	25.2
28-4-77	21.4	20-4-77	24.6	5-5-77	22.6
5-5-77	21.9	27-4-77	23.6	12-5-77	23.7
12-5-77	22.6	4-5-77	24.5	19-5-77	23.2
19-5-77	23.9	12-5-77	26.8	26-5-77	23.5
26-5-77	28.1			2-6-77	23.7
2-6-77	26.1			9-6-77	22.4
Average	22.6		26.1		24.4

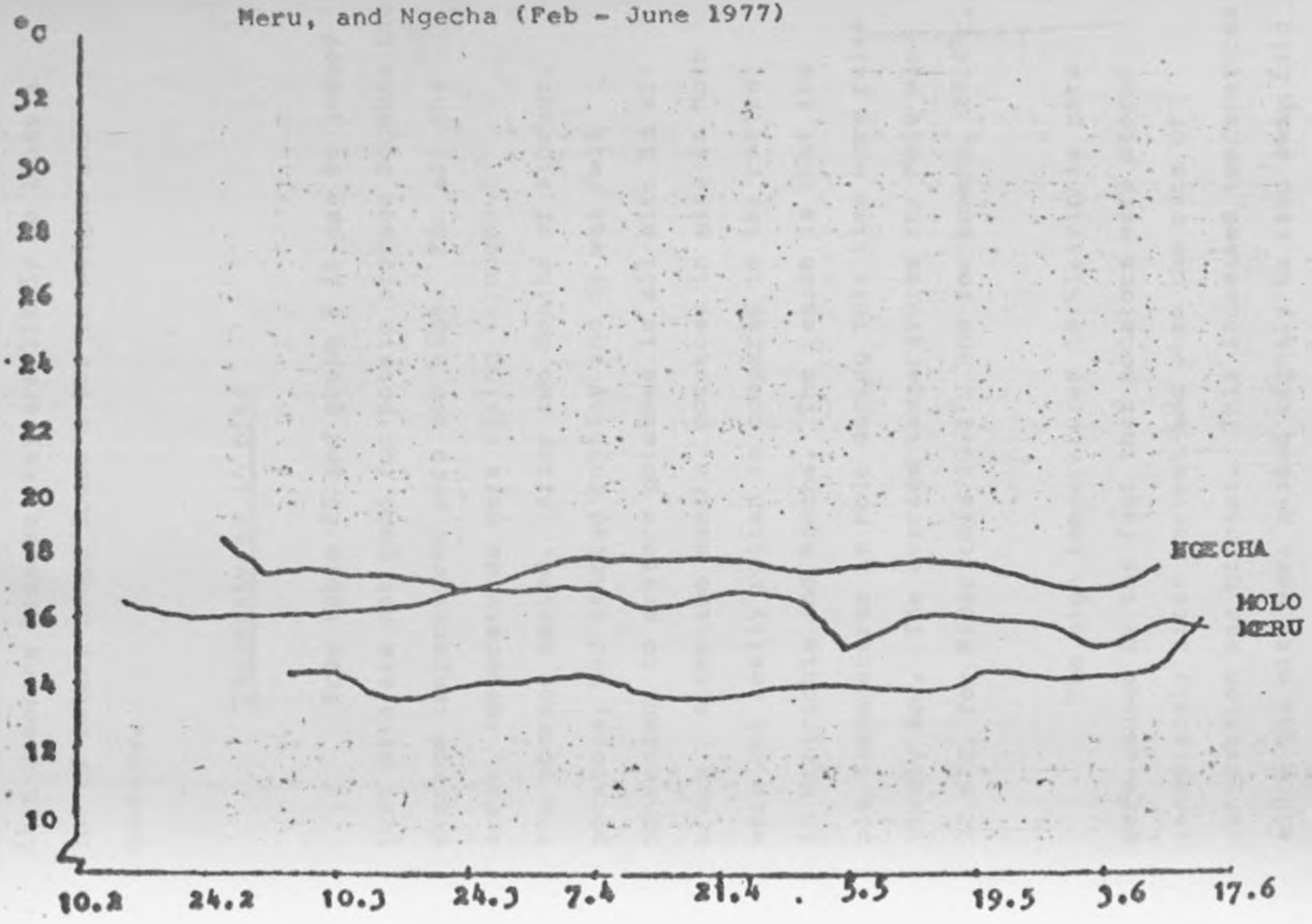
SOURCE: Potato storage trials (Feb - June, 1977)

TABLE 26: Weekly average temp. inside potatoes in granaries in Molo, Kibirichia and Ngecha (February - June, 1977)

DATE	MOLO	DATE	KIBIRI-BHIA	DATE	NGECHA
	°C		°C		°C
5-3-77	13.7	22-2-77	17.2	26-2-77	18.4
10-3-77	11.9	1-3-77	16.2	3-3-77	17.9
17-3-77	11.9	8-3-77	15.9	10-3-77	17.6
24-3-77	12.0	15-3-77	16.7	17-3-77	17.7
31-3-77	12.5	23-3-77	16.3	24-3-77	17.7
7-4-77	12.4	30-3-77	17.0	31-3-77	18.0
14-4-77	12.2	6-4-77	17.3	7-4-77	18.2
21-4-77	12.3	13-4-77	17.3	14-4-77	18.2
28-4-77	12.6	20-4-77	17.2	21-4-77	18.0
5-5-77	12.0	28-4-77	16.9	28-4-77	18.1
12-5-77	13.1	5-5-77	16.6	5-5-77	18.2
19-5-77	12.8	12-5-77	16.6	12-5-77	18.3
26-5-77	13.1	19-5-77	16.5	19-5-77	18.0
2-6-77	12.3	26-5-77	16.2	26-5-77	17.4
9-6-77	11.6	2-6-77	15.5	2-6-77	17.1
15-6-77	11.4	9-6-77	16.1	9-6-77	17.5
		14-6-77	16.0		
Average	12.4		16.6		17.9
Range	2.3		1.8		1.3

SOURCE: Potato storage trials (Feb - June, 1977)

Fig. 8: Weekly average House Pile temperatures in Molo, Meru, and Ngecha (Feb - June 1977)



Source: Table 24

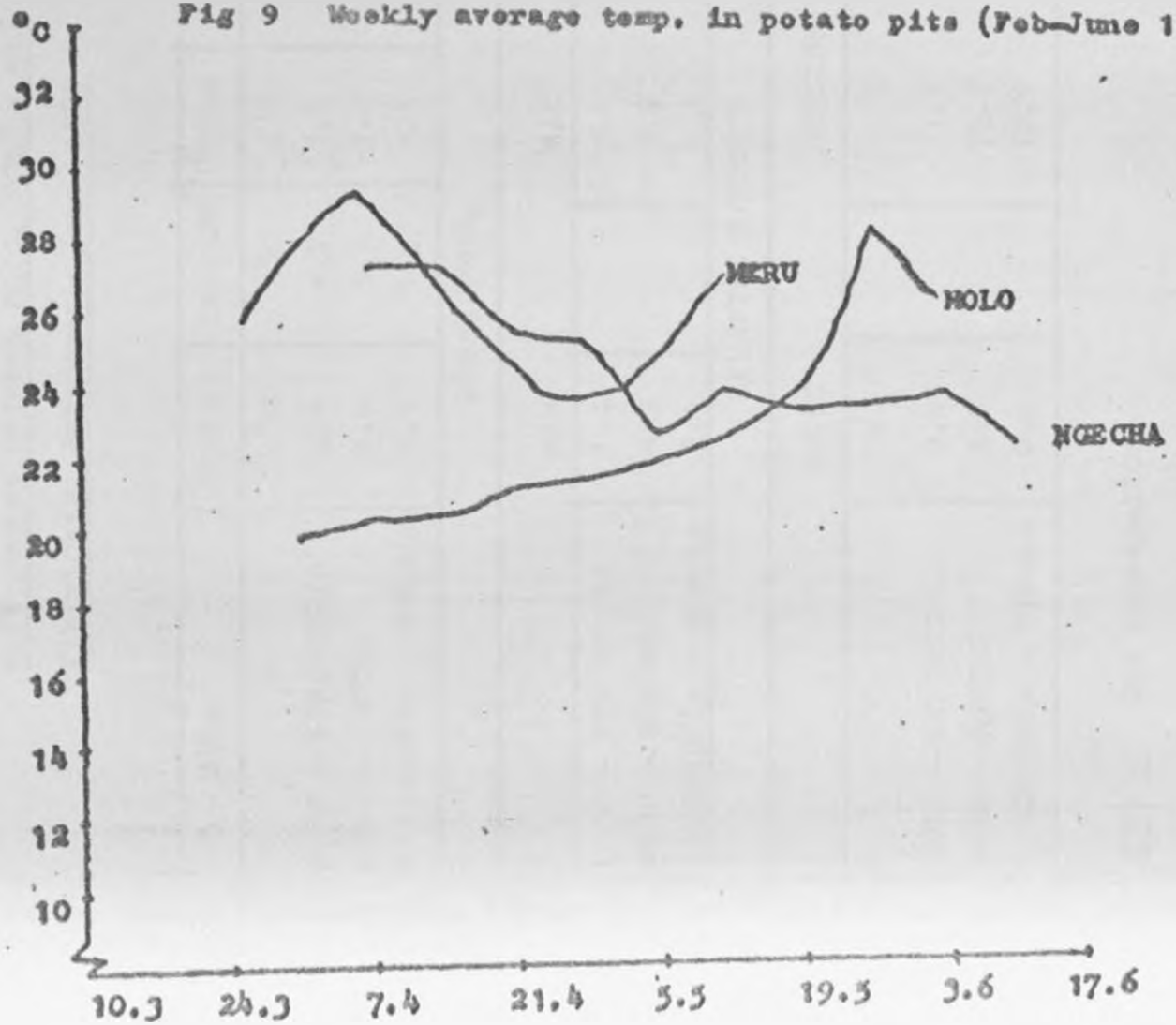
Ngecha and Kibirichia was 4.2°C. This means that potatoes should not be stored in Ngecha for more than 2 months because they are likely to loose a lot of water, hence loose a lot in weight and quality.

Temperatures in pits

From table 25 and graph 9 it can be judged that pits are not good for potato storage because the average temperatures were too high. For all the areas, temperatures were rising throughout the storage period. After two months of storage, potatoes, had started rotting and it was felt convenient to destore potatoes in all pits in all areas. After two months, potatoes in pits in Molo were not really rotten as compared to the rotting in Kibirichia and Ngecha. The reason is that the pit temperatures in Molo during this time were relatively low. The average temperatures for Molo was 22.6°C, for Kibirichia 26.1°C and for Ngecha, 24.4°C.

The high temperatures in Kibirichia pits were caused by the fact that potatoes were stored immediately after harvest and when the rate of dehydration was highest. This increased temperatures since the pits were closed tightly to keep away rain water. As a result, by the end of two months of storage all potatoes were rotten (7, p.176, 177).

Fig 9 Weekly average temp. in potato pits (Feb–June 1977)



Source: Table 25

TABLE 27: 4 months temperature and relative humidity differences between Molo, Ngecha and Kibirichia, February - June, 1977

AREA	OUTSIDE	GRANARY	PILE	PIT
	$A^{o}C$	$A^{o}C$	$A^{o}C$	$A^{o}C$
MOLO - KIBIRICHIA	2.5	4.2	2.1	4.5
MOLO - NGECHA	4.6	5.5	3.4	1.8
KIBIRICHIA - NGECHA	2.1	1.3	1.3	1.7

HOUSE TEMP.

	MIN		MAX
MOLO - KIBIRICHIA	1.4		3.6
MOLO - NGECHA	4.3		4.9
KIBIRICHIA - NGECHA	2.9		1.3

RELATIVE HUMIDITY

	HOUSE		OUTSIDE
	%		%
MOLO - KIBIRICHIA	9.4		1.3
MOLO - NGECHA	8.8		12.2
KIBIRICHIA - NGECHA	0.6		10.9

SOURCE: Own compilation

Note: $A^{o}C$ = Absolute average temperature

The rate of potatoes rotting in other areas was much slower because potatoes had to be moved from harvesting place and the initial perspiration which is normally highest immediately after harvest, had taken place during the movement.

From both average outside outside and room temperatures it can be concluded that potato storage is better in Molo than in Meru and in Ngecha.

4.5.2 Relative Humidity

Outside relative humidity

Relative humidity is the measure of the amount of water in a given atmosphere normally expressed as a percentage.

From tables 21, 22, 23 and graph 11 the average relative humidity during the storage period was highest in Molo (82.3%); followed by Ngecha (81%) and then Kibirichia (70.1%). The weekly average of relative humidity range were as follows:

Molo 25%, Ngecha 28% and Kibirichia 20%

The above amounts to saying that the rate of dehydration in Kibirichia was highest followed by Ngecha and then Molo. It can also be noted that, Ngecha had the highest weekly variation in relative humidity followed by Molo and then Kibirichia. This means that the total amount of dehydration cannot be judged by the average relative humidity of four months storage period only. (see table 31).

House relative humidity

From tables 28, 29, 30 and graph 12 it will be noted that the house average relative humidity for Molo was highest, (81.6%), followed by Ngecha, (81%) and Kibirichia, (72.2%). The lower average relative humidity for Kibirichia can be attributed to the fact that one room in the house was used as a kitchen.

The weekly range of relative humidity at Ngecha was highest, (28%) followed by Molo, (25%) and then Kibirichia (16%). The weekly relative humidity for Kibirichia was most stable compared to Molo and Ngecha.

TABLE 28: Molo House Weekly (Feb- June, 1977)

PERIOD	AVERAGE TEMP. MIN °C	AVERAGE TEMP. MAX °C	AVE. REL. HUMIDITY %
4-3-77- 3-3-77	13.3	17.4	85
7-3-77-13-3-77	11.8	17.6	81
14-3-77-20-3-77	11.6	18.2	69
21-3-77-27-3-77	11.9	18.9	69
28-3-77-33-4-77	12.3	18.4	72
4-4-77-10-4-77	9.7	14.7	84
11-4-77-17-4-77	11.5	15.6	87
18-4-77-24-4-77	12.3	17.1	66
25-4-77- 1-5-77	13.2	16.7	89
2-5-77- 8-5-77	9.4	14.1	91
9-5-77-15-5-77	11.6	15.3	86
16-5-77-22-5-77	12.1	16.5	87
23-5-77-29-5-77	12.1	18.1	88
30-5-77- 5-6-77	11.6	17.3	73
6-6-77-12-6-77	10.0	15.1	89
13-6-77-17-6-77	11.1	15.4	90
Average	11.6	16.7	81.6

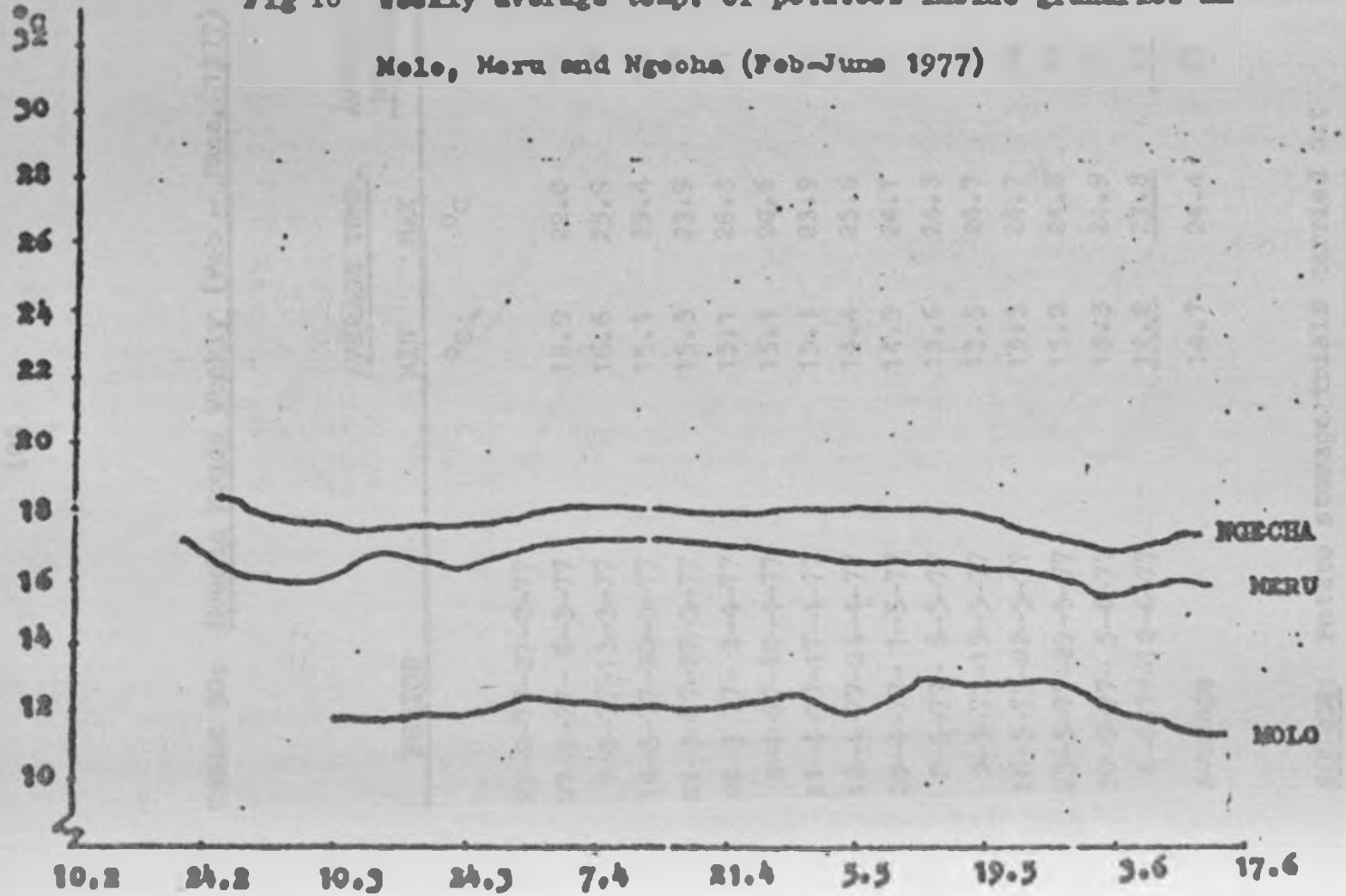
SOURCE: Potato storage trials carried out between February - June, 1977

TABLE 29: Meru House Weekly (Feb - June, 1977)

PERIOD	AVERAGE TEMP. MIN °C	AVERAGE TEMP. MAX °C	AVERAGE REL. HUMIDITY %
12-2-77-18-2-77	17.0	30.0	75
18-2-77-25-2-77	11.6	28.9	71
26-2-77- 4-3-77	11.6	29.1	69
5-3-77-11-3-77	11.5	30.5	65
12-3-77-19-3-77	12.5	32.1	65
20-3-77-26-3-77	13.0	30.6	69
27-3-77- 2-4-77	13.0	32.4	72
3-4-77- 9-4-77	12.7	31.5	72
10-4-77-16-4-77	12.1	26.0	81
17-4-77-24-4-77	12.8	33.8	77
25-4-77- 1-5-77	12.1	28.0	75
2-5-77- 8-5-77	11.4	29.7	77
9-5-77-15-5-77	10.5	30.4	73
16-5-77-22-5-77	10.9	32.1	74
23-5-77-29-5-77	9.9	30.3	73
30-5-77- 5-6-77	10.0	30.3	67
6-6-77-12-6-77	8.4	29.4	68
13-6-77-15-6-77	10.7	26.7	76
Average	11.8	30.4	72.2

SOURCE: Potato storage trials carried out between February - June, 1977

Fig 10 Weekly average temp. of potatoes inside granaries in Molo, Meru and Ngecha (Feb-June 1977)



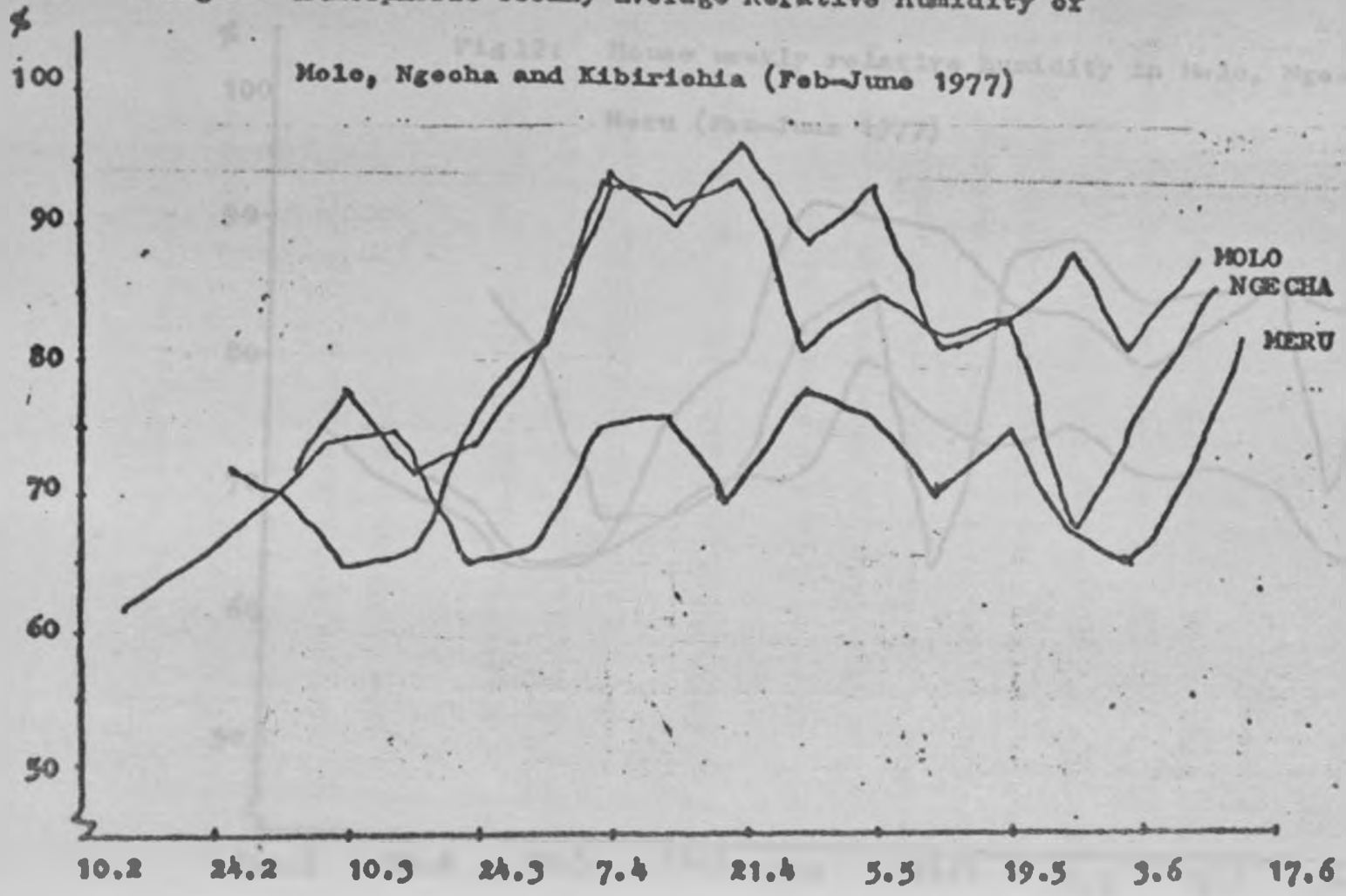
SOURCE: Table 26

TABLE 30: Ngecha House Weekly (Feb - June, 1977)

PERIOD	AVERAGE TEMP. MIN °C	AVERAGE TEMP. MAX °C	AVERAGE REL. HUMIDITY %
25-2-77-27-2-77			
27-2-77- 6-3-77	12.9	22.0	70
7-3-77-13-3-77	16.6	25.9	65
14-3-77-20-3-77	15.1	25.4	66
21-3-77-27-3-77	15.3	23.9	77
28-3-77- 3-4-77	15.1	26.3	81
4-4-77-10-4-77	15.1	24.6	93
11-4-77-17-4-77	15.1	23.9	92
18-4-77-24-4-77	14.4	23.6	91
25-4-77- 1-5-77	14.9	24.1	81
2-5-77- 8-5-77	13.6	24.3	85
9-5-77-15-5-77	13.5	24.7	82
16-5-77-22-5-77	15.3	24.7	84
23-5-77-29-5-77	15.2	24.8	88
30-5-77- 5-6-77	13.3	24.9	81
6-6-77-12-6-77	12.2	23.8	88
Average	14.7	24.4	81

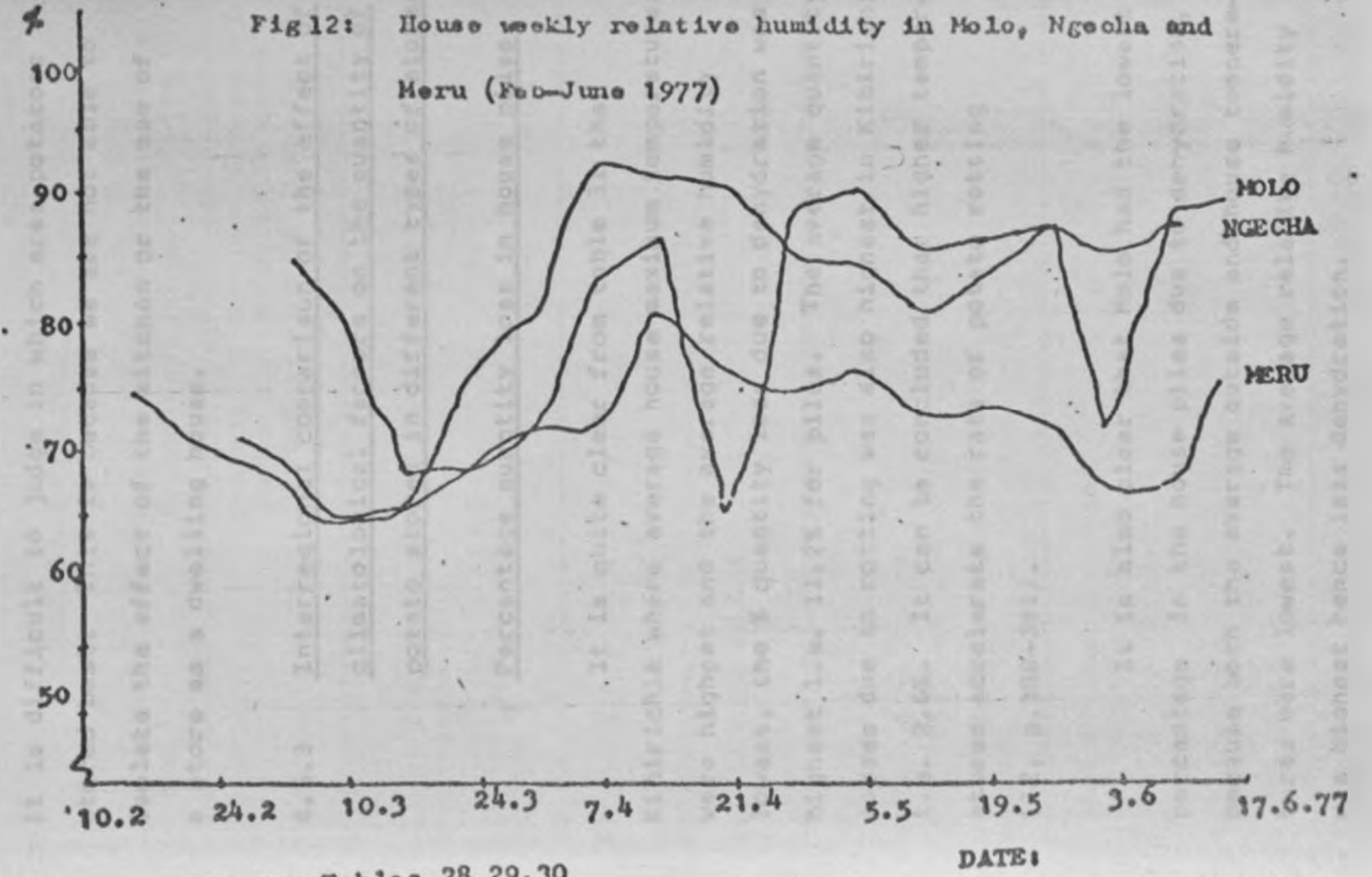
SOURCE: Potato storage trials carried out between February - June, 1977

Fig 11: Atmospheric Weekly average Relative Humidity of Molo, Ngecha and Kibiriehia (Feb–June 1977)



SOURCE: Potato storage trials carried between Feb–June 1977.

Fig 12: House weekly relative humidity in Molo, Ngecha and Meru (Feb–June 1977)



Source: Tables 28,29,30

Looking at house relative humidity alone it is difficult to judge in which area potatoes stored best. This is because we are not able to isolate the effect of the kitchen or the use of a store as a dwelling house.

4.5.3 Interregional comparison of the effect of climatological factors on the quantity of potato stored in different types of stores

Percentage quantity loss in house piles

It is quite clear from table 31 that Kibirichia where average house maximum temperatures were highest and the average relative humidity lowest, the % quantity loss due to dehydration was highest i.e. 11.2% for piles. The average quantity losses due to rotting was also highest in Kibirichia i.e. 2.6%. It can be concluded that higher temperatures accelerate the rate of potato rotting (12, p.388-391).

It is also clear that Molo had the lowest percentage in the house piles due to dehydration, because both the average outside and house temperatures were lowest. The average relative humidity was highest hence less dehydration.

TABLE 31: PERCENTAGE LOSSES DUE TO CLIMATICAL FACTORS IN TRIAL STORES IN NGECHA, MOLO, AND KIBIRI- FEBRUARY - JUNE 1977

AREA	Granaries	House Piles	Pits	
	Average % losses per (4 months)	Average % losses per (4 months)	Average % losses per (4 months)	Total average % losses
MOLO				
Weight loss due to dehydration	5.0	6.8	1.0	4.26
Weight loss due to rotting	0.1.	0.2	68	22.7
KIBIRICHIA				
Weight loss due to dehydration	3.1	11.2	0	4.7
Weight loss due to rotting	0.6	2.6	100	34.4
NGECHA				
Weight loss due to dehydration	8.9	9.1	0	6.0
Weight loss due to rotting	1.3	2.0	83.2	28.8
Total Average % weight loss due to dehydration in all areas.	5.7	9.0	0.33	5.1
Total Average % weight loss due to rotting in all areas	0.67	1.6	83.7	28.0

SOURCE: Potato storage trails carried out between February - June 1977

Ngecha had the second highest average percentage loss due to dehydration because the outside average temperatures were highest but the house temperatures were not as high as Kibirichia house temperatures. The house average relative humidity was comparable to that of Molo. The latter had 81.6% average relative humidity and the former had 81%.

It can be concluded, therefore, that a house in Molo stored best bacause both average relative humidity and temperatures were lowest. To a large extent a kitchen in the same building with the potato store will accerlerate the rate of dehydration by increasing the house temperature and lowering relative humidtity. The same argument can be used to conclude that a dwelling house should not be used as a potato store.

ii. Percentage potato losses in granaries

From table 31, it can be concluded that the average percentage loss due to dehydration in Ngecha was highest i.e. 8.9% during the four months storage period. Average relative humidity and average outside maximum and minimum temperatures were

highest in Ngecha; see table 21.

The average percentage weight loss in Molo due to dehydration was higher (5%) than in Meru (3.1%). The following factors explained this unexpected phenomena. Firstly the average weekly temperature range in Molo (6.6°C), with average standard deviation of 2.03, was higher than the average weekly temperature range of 4°C and average standard deviation of 1.0 in Meru. This means that the average weekly amount of sunshine was higher in Molo than in Meru. This made the weather in Molo more drier and humid - (higher relative humidity) than in Meru. Secondly, casual observation indicated that it was more windy in Molo than in Meru. Thirdly, it was wetter and less windy in Meru than in Molo. Normally this period (February to June) is the long rains in Meru hence less dehydration. The fourth factor is that potatoes received different post storage treatments, e.g. potatoes stored in Molo were shipped from Meru and this may have affected the potato texture to accelerate the rate of dehydration.

However, it should be noted that the average percentage weight losses due to dehydration, and rotting in granaries, in house piles and in pits in total were least in Molo than either in Meru and Ngecha,(see table 31)

iii. Percentage losses in Pits (improved)

After the first two months of potatoes in the pits it was noted that all potatoes got rotten (table 31). The potatoes in Kibirichia got rotten even before the two months were over. The average absolute temperature was 26.1°C with 5°C average range (table 24). The average temperatures in Molo and Ngecha pits were 22.6°C and 24°C respectively. Table 30 shows that therrate at which potatoes rotted matched the rate at which temperatures were rising. The explanation for too high average temperatures for Meru pits was that some ground water seeped into the pits thus accelerating the rotting rate of the potatoes.

4.6 Sample potato storage profit at average prices (March-May, 1977 in Kibirichia Location)

4.6.1 Computation of storage costs and prices

Investment cost

An average investment cost was calculated for all types of stores belonging to the 71 farmers interviewed between March and May 1977. This average was Shs. 2,400.00 or Shs. 6.50 per bag of 100 kgs (Appendix 4).

Life Expectancy

This refers to average life expectancy of all types of stores belonging to the 71 farmers interviewed. The average life expectancy was 23 years (table 16).

Capacity of the store

The capacity of the stores was calculated by averaging the capacities of the stores of 71 farmers interviewed. This was approximately 370 bags of 100 kgs. (table 16).

Storage period

During the survey it was found out that most of the farmers stored their potatoes for only one to three months.

Interest on Investment

The rate of interest was taken to be 10% the bank rate. No allowance was given to sinking fund while the interest on the working capital was assumed to be 12%.

Price at harvest

This was fixed by H.C.D.A. as Shs. 55/= per bag of 100 kgs.

Price at time of sale

These were the average prices at which all the farmers interviewed indicated had sold their stored potatoes and the average prices were Shs. 38.50 after the 1st month, Shs. 38.80 after 2 months and Shs. 36.70 after 3 months (table 32). The price went down immediately after harvest because the H.C.D.A. released the potatoes bought earlier because they were unable to sell them to Britain as anticipated. There was over-supply both at local level and at national level.

Handling cost

These included loading at Shs. 1/= and unloading at Shs. 1/= per bag.

Percentage loss

The average percentage losses for one month, two months and three months were calculated to be 15.2%, 24.62% and 5.7% respectively. They were computed from the losses the farmers incurred during the early harvest 1977. (Appendix 3).

It can be seen that the percentage loss during the 3rd month was least. Probably monthly changes in temperatures and relative humidity affected the potatoes stored adversely (see tables 21,22, & 23). In Meru district potatoes are normally harvested in February of every year. Long rains start in mid-March and continue up to early May (16). Temperatures and relative humidity were highest in March and April, the first two months of potato storage hence higher potato losses due to both rotting and dehydration were recorded especially so for the month of April. Temperatures and relative humidity are relatively lower in May, the 3rd month of potato storage. Quantity losses in the 3rd month were therefore lowest. However it should be noted that farmers selected the rotten potatoes after every destoring period so that there were no carryovers of rotten potatoes. Normally after two months of potato storage, potatoes which are likely to get rotten within the first three months of storage show up and are removed. This implies that the rate of potato rotting during the third month is lower because only the best potatoes are left in the store for the third storage month. In addition farmers' records were not very accurate and the figures above should be treated with caution otherwise it is recommended that further

research on the same subject be done.

Production costs

Taken from Duerr (4, p.13) Kibirichia Survey 1977, Shs. 33.95/84 kg bag converted to Shs. 40.42/100 kg bag.

Transfer costs

Average transfer cost was calculated to be Shs. 2.22 per bag for all the storage periods.

4.6.2 Basic Equation used in table 32 (29, p19)

Total storage cost = cost of operation + losses.

$$\text{Depreciation/bag/month (13)} = \frac{\text{Investment cost}}{\text{life expectancy} + \text{capacity} \times \text{storage months/year}}$$

$$\text{Interest on investment/bag/month (14)} = \frac{\text{Investment} \times \text{interest rate}}{\text{capacity} \times \text{storage months/year}}$$

Interest on working/bag/month (15)

= Price at harvest + handling C/bag $\times$ Interest rate

Handling cost/bag/month(16) = $\frac{\text{Total cost per store}}{\text{capacity storage month}}$

Losses/bag/month(19) = Release price x losses per store mx100 / Quantity stored/month mx100

Net storage profit/bag/month(29)

= Profit release - profit at harvest (interest on cap. included as cost.

Note that calculation for both profits at release and at harvest are included in the table.

4.6.3 Summary of sample storage profit/loss for the first three months of potato storage in Kibirichia March - May, 1977.

Table 32 shows that the sample farmers made losses during the 1st three months of potato storage in Kibirichia. The net average losses were Shs. 26.24 per bag of 200 kgs for the first month, Shs. 30.22 for the second month and Shs.25.44 for the third month. The losses in the third month were less than the losses in second month because (i) the average release prices during the third month was less than release price during the second month and (ii) the losses in the third month were

less than losses during the second month (section 4.6.1).

Zettelmeyer (30) calculated the net storage profits for different seasons 1974 - 1977 comparing different types of storage facilities. He found that (30, p.11,12, 13) an improved granary stored better than house-like store used by farmers in Kibirichia and the forced ventilated store built by Schuelter company He found that the average storage profits were Shs. 3.99 per bag of 100 kgs, Shs. 7.16 for improved granary and Shs. 6.72 for forced ventilated store (table 33). However, Zettelmeyer assumed zero investment cost for the house-pile, and that potatoes were transported and sold in Nairobi by a co-operative organization, so that he assumed zero trader's profit margin.

Zettelmeyer's finding forms a good basis for further research using the storage facilities and co-operative marketing (30, p.32).

TABLE 32: Potato storage profits/losses at average prices in Kibirichia incurred by farmers March - May, 1977

	Primary data		Months		
			1	2	3 3
1.	Investment cost	Shs/	2400	2400	2400
2.	Life expectancy:	Years	'23	23	· 23
3.	Capacity of store	Bags	370	370	370
4.	Storage period	Months	1	2	3
5.	Interest on Investment	%/year	10	10	10
6.	Interest on working capital	%/year	12	12	12
7.	Price at harvest	Shs/bag	55	55	55
8.	Price at release	Shs/bag	38.50	38.80	36.70
9.	Handling cost	Shs/bag	3.00	3.00	3.00
10.	Quantity loss	Kg/bag	15.2	24.62	5.7
11.	Production costs	Shs/bag	40.42	40.42	40.42
12.	Transfer costs	Shs/bag	2.22	2.22	2.22
	Operating costs/ bag/month				
13.	Depreciation	Shs/bag	0.14	0.07	0.05
14.	+ Interest on Investment	Shs/bag	0.14	0.08	0.05
15.	+ Interest on working C.	Shs/bag	0.58	0.58	0.58
16.	+ Handling cost	Shs/bag	3.00	1.50	1.00
17.	= Total Op. costs/bag/month	Shs/bag	3.88	2.23	1.68

TABLE 32: Continued

	Primary data		Months		
	Storage cost period				
18.	Operating costs	Shs/bag	3.88	4.46	5.04
19.	+ Weight loss	Shs/bag	5.85	9.55	2.09
20.	Storage cost + Price/harvest	Shs/bag	64.74	69.02	62.14
21.	Total storage costs	Shs/bag	9.74	14.02	7.14
	Profit at release				
22.	Fresh produce P/ release	Shs/bag	38.50	38.80	36.70
23.	- Production cost	"	40.42	40.42	40.42
24.	- Transfer cost	"	2.22	2.22	2.22
25.	- Total storage cost	"	9.74	14.02	7.14
26.	- Loss/profit at release	"	13.88	17.86	13.08
	Profit at harvest				
27.	Produce price at harvest	"	55.00	55.00	55.00
28.	Produce + Transfer cost	"	42.64	42.64	42.64
29.	Profit at harvest	"	12.36	12.36	12.36
30.	Net storage profit/loss	"	-26.24	-30.22	-25.44

SOURCE: Own compilation

TABLE 33: THE AVERAGE PROFITS AND RETURNS TO INVESTMENT

Season	House pile	Granary or wooden store	Forced Vent-store
First season			
Sh/bag	5.36	7.17	6.84
% year	70.9	33.6	23.5
Second season			
Sh/bag	3.99	7.16	6.72
% year	48.4	32.2	22.8

SOURCE: Zettelmeyer, W.J. Ware potato storage Trial Physical Results and Economic Evaluation, Interim Report on the 1st storage season Feb-June 1977. Nairobei, 20/8/77

4.6.4. Investment decision

The major question that a planner would as is: what type of potato store should be recommended to the farmer? Answer to this question will be based on three alternative types of stores currently used in potato producing areas. These are (i) houselike stores, (ii) improved granary used in the potato storage trial fig. 4 and (iii)forced ventilated store built by Schuelter company.

Assumptions

1. Potatoes stored in each store will be sold at the same market and at the same price.
2. All losses are assumed to have occured in the 1st season of 1977.
3. Interest on capital and sinking fund are accumulating at the same rate for all stores.
4. The life expectancy for all stores is assumed to be 23 years (table 17).

TABLE 34: COST OF STORING ONE TON OF POTATOES FOR 4 MONTHS

Item		Type of store: House like	Granary	Forced Vent.
Investment	Shs	2400	1000	100,000
Capacity	tons	37	2.5	200
Life expectancy	years	23	23	23
Price at harvest	Shs/ton	550	550	550
Weight loss during storing	%	14.6	6.7	5.3
Handling & treatment	Shs/ton	30.0	30.0	36.7
Storing period	months	4	4	4
Investment cost per ton	Shs/ton	0.94	5.80	7.25
Losses after storing		79.60	36.9	29.0
Total cost of storing 1 ton 4 months	Shs/ton	110.54	72.70	72.95

Source: Own compilation

Notes and computations

Computations of investment cost, capacity of the stores, and handling and treatment cost are shown in table 32.

Weight loss

The weight lost by potato piles in the trial house was 13.75% (30, p.20) and that of sample average was 15.2% see table 32. Potato weight loss in granary was the same as in wooden store, i.e. 6.7% and that in forced ventilated store was 5.3%.

$$\text{Investment cost per ton per } 4m^{1} = \frac{\text{Investment cost} \times 4m}{\text{capacity} \times 12m \times \text{life expectancy}}$$

Losses after 4m of storing = Price at harvest x capacity x % losses

Total cost of storing 1 ton for 4m = Investment/ton plus losses after 4 months of storing.

Table 34, shows that investment cost per ton for storing potatoes for 4 months in houselike stores was least, Shs. 0.94, followed by granary Shs. 5.80, and finally the forced ventilated store Shs.725.

[1] M = Month

It is clear that the houselike stores used by farmers are very cheap in terms of capital outlay compared to either improved granary or the forced ventilated store.

However losses incurred in the houselike stores are more than double the losses incurred in the other two types of stores (table 34). The total cost of storing one ton of potatoes in houselike store was Shs. 110.4, while in granary was Shs. 72.70 and in forced ventilated store was Shs. 72.95 table 34.

It will also be noted that the cost of storing one ton of potato in forced ventilated store is slightly higher than the cost of storing one ton in improved granary. This means that farmers put up stores according to the amount of money they have at hand and not according to expected losses during storage. The explanation is that farmers store surplus and the question of how much would be lost during storage is a secondary one.

TABLE 35: POSSIBILITIES OF MARKETING POTATOES IN VARIOUS MARKETING SYSTEMS IN KIBIRICHIA LOCATION

Marketing system	No. of farmers	%
1. Co-operative	40	56.3
2. Traders (Small)	21	29.6
3. Companies	7	9.9
4. Any of the above	3	4.2
	71	100

SOURCE: Own compilation

4.7 Possibilities of marketing potatoes in various marketing systems in Kibirichia Location

From table 35, it will be noted that 56.3% of the sample farmers indicated that they would prefer potatoes to be marketed co-operatively. Farmers felt that since other crops like wheat, pyrethrum etc. in the area are co-operatively marketed potatoes can be marketed in the same way with proper management. They also indicated that trading margins could be reduced because a co-operative society could have more bargaining power and the profits realised by the traders (middle men) would be farmers' profits.

However 39.5% of the sample farmers indicated that they prefer either the present system where farmers sell directly to traders or a limited company. Many farmers felt that, soon after harvesting, they would like to realise cash from the harvest in order to pay for their immediate needs. Other farmers expressed their concern over lack of proper storage facilities and they felt that co-operative marketing could be quite difficult due to the perishability of potatoes. In addition they said that there is no ready potato market like many other cash crops which are co-operatively marketed. This means that management for such a society could be problematic.

They indicated that since there is no industrial potato processing in Kenya, the value added after sale is too small to warrant the waiting period that could be experienced. They argued that this is contrary to other cash crops which are co-operatively marketed.

Other farmers argued that co-operative society could not work while the local traders operated at the same time, because there could be cut-throat competition from them.

If and when the above setbacks to co-operative potato marketing are overcome, the concept of co-operative marketing is ideal as expressed by some farmers.

CHAPTER 5

HYPOTHESES TESTING

In this chapter emphasis will be placed on hypotheses testing and answering of the questions raised in chapter 2 as follows:-

(i) The constructional materials of potato stores depend on their sizes.

This hypothesis states that the bigger the size of the stores the better their structural designs and vice versa. The analysis of the sample stores reveals that 21% of the stores were constructed of concrete floors, timber walls and corrugated iron sheet roofs and their average sizes were 8m long, 4.1m wide and 2.4m high. 40.8% of the stores were built of earth floors, timber walls and corrugated iron sheet roofs with average dimensions as follows:

length 5.25m, breadth 3.7m and height 2.4m, 15.5% of the stores were built of mud walls, earth floors and corrugated iron sheet roofs and their average dimensions were 4.9m long, 3.4m wide and 2.4m high.

stores built of mud walls, earth floors and grass thatched roofs formed only 11.3% and their size were 4.58m long, 3.9m wide and 2.4m high. From the above information the hypothesis is accepted. The sizes of the stores were taken during the interview and therefore the information may be taken as having no drawbacks.

(ii) The second hypothesis stated that the quantity stored is a function of potato production surplus.

Table 15 shows that value to R^2 in quantity harvested is .729 which means that this variable explains the 72.9% of the variation in quantity stored, at 95% level of confidence. Regression coefficient is statistically different from zero. The value of partial correlation of quantity sold is - 0.16. This means that the quantity sold is inversely related to quantity stored (table 15). Quantity expected to be consumed show a value of simple correlation of .10.

Again this means that as the quantity stored increases the quantity consumed decreases and vice versa. It can be noted that each

variable does influence, to some extent, the quantity stored. The hypothesis is therefore accepted.

(iii) The third hypothesis stated that the quantity stored is a function of the expected quantity losses during storage period.

Table 15 shows that the coefficient of regression is statistically different from zero. The variable explains 49.6% variation in the quantity stored. This means that expected quantity loss is a function of the quantity stored. The hypothesis is therefore accepted. However the amount of losses should be treated with caution because farmers were not completely sure of the losses they incurred during storage because few of them kept records.

(iv) The fourth hypothesis stated that losses in potato weight during storage depend on temperatures and relative humidity irrespective of the geographical location. Table 31 shows that the average percentage losses due to dehydration in granaries in each study area were lower than losses in potato piles in houses. The average losses in piles was 9% compared to 5.7% in

granaries in three months period. The average relative humidity and average temperature in piles were 74.5% and 16°C respectively compared to 74.6% and 15.6°C in granaries (table 26 and graph 6).

After two months of storage in the pits whose average temperature was, 24.6°C, the loss was 100% (table 25).

The hypothesis is therefore accepted although further research by the Ministry of Agriculture is still going on now and in future to prove the hypothesis further.

(v) The fifth hypothesis stated that potato storage temperature range is 5°C and average relative humidity range is 20% in Kenya. Tables 24, 25, 26 show that the average temperatures range in potato piles in houses at Ngecha, Molo and Kibirichia was 1.6°C, in granaries it was 1.8°C and in the pits the average temperature range was 6.2°C.

The average house relative humidity range was 23% (graph 12) and outside relative

humidity average range was 24% (graph 6). The average temperature range in all the trial areas was 3.2°C. The analysis indicates that the range in temperature is less than 5°C but the range in the house is higher.

The sixth hypothesis stated that the constructional materials of the potato stores depend on the local material available and not on the climatical and technical requirements of the potato storage.

Table 9 shows that 97.1% of the sample potato storage facilities in Kibirichia were in one way or another built of wood either in walls or roofs. For example, all types of sample stores were built of timber supporting roofs (table 9). There is a forest within a distance of 3 km to Kibirichia, hence the availability of timber and poles. The local towns are within a distance of 30 km and corrugated iron sheets are within reach.

These two constructional materials are easily available and therefore many farmers use them.

Table 12 shows that 57% of sample farmers tried to insulate and 64.8% tried to ventilate their stores, which means that they did not incorporate these environmental control aspects during the construction of the stores. Hence the acceptability of the hypothesis.

(vii) The seventh hypothesis stated that farmers sell all their potatoes immediately after harvest.

Table 11 shows that 31.4% of the potatoes were sold, 38.8% were stored for sale, 15.3% were kept for seed and 10.8% were set aside for consumption by sample farmers in Kibirichia in the 1st season 1977. This means that the hypothesis is rejected because it is clear that farmers do not sell all their potatoes immediately after harvesting.

(viii) The eighth hypothesis stated that destoring periods depend on the highest prices quoted in the local market.

Table 32 shows that the average price per bag of 100 kgs after one month's storage

was Shs. 38.50, Shs. 38.80 after two months and Shs. 36.70 after three months. The price at harvest time was Shs. 55.00 per bag of 100 kgs. This means that farmers expected prices to go up throughout the destoring period as was the case in 1975 and 1976 (fig. 2). The H.C.D.A. had fixed price at harvest time because there was an external demand. However, H.C.D.A. was unable to sell to the external market and decided to sell to the local market after one month of storage, thus over supplying both the local and national markets.

The hypothesis cannot be rejected only on the basis of the early harvest season 1977 because the previous years' experience indicated that prices were rising constantly after harvest.

(ix) The ninth hypothesis stated that the price during the harvesting period is less than and/or equal to price during the selling period minus the storage cost.

Table 32 shows that there was a net storage loss of Shs. 26.24 per bag of 100 kgs after

one month's storage, Shs. 30.22 after 2 months storage and Shs. 25.44 after 3 months. Profit at harvest was Shs. 12.36. This means that prices at release were less than harvest price by Shs. 13.88 after one month storage, Shs. 17.86 after two months storage Shs. 13.08 after three months storage. Farmers did not seem to be cost conscious and therefore the hypothesis was rejected. However it should be noted that the dumping of potatoes by H.C.D.A. caught the farmers unaware.

CHAPTER 6

CONCLUSION AND DISCUSSION

In this chapter emphasis will be placed on the discussing the conclusions on the results presented in chapter 4.

(i) Farmers in Kibirichia are willing to store potatoes after harvest in hope of fetching high prices later. This conclusion is revealed in table 11 where 38.8% of the potatoes harvested in 1st season 1977 were stored immediately after harvest. However the period of storage varies from a few weeks to three months. They seldom store for more than three months, because next crop is often harvested after 3½ months (16). There is therefore inherent fear that the stored potatoes will be of lower grade than the harvested potatoes, hence lower income.

Table 8 shows that over 90% of the sample farmers had stores separate from other farm buildings for potato storage only. Again this demonstrates that farmers are keen in storing potatoes after harvest.

(ii) It can be concluded that farmers use locally available materials for building potato stores. Table 9 shows that over 95% of the farmers used some local materials. Nevertheless farmers do not in-corporate environmental requirements in constructing stores because they are normally ignorant of their necessity at the time of building. Their worry at that time is usually a store of some form or another. However some farmers realise the need for insulating and ventilating the tubers and they result in using temporary measures, like covering potatoes with canvas and empty bags during potato storage. 57% of the farmers tried to insulate and 64.8% of the sample farmers tried to ventilate their potatoes (table 12).

(iii) Thirdly it can be concluded that, technically potato storage is feasible because with fairly mechanical methods, temperatures in stores can be modified (fig. 4), so that losses due to dehydration are reduced.

Table 31 shows that losses were 5.7% in the improved granary and in house piles and

pits, losses were 9.0% and 83.7% respectively under the average temperature and average relative humidity indicated in appendix 6.

(iv) The average investment cost of a store in Kibirichia is Shs. 2,400.00, with an average capacity of 37 tons (Table 16). Table 10 shows that the average dimensions are 5.5m lenth, 3.7m width and 2.4m height. The annuity was found to be about Shs. 198.87 @ 10% rate of return, allowing for no sinking fund. The investment cost per bag per year is Shs. 0.27 with a life expectancy of 23 years (table 17). This amounts to concluding that in terms of investment costs it is not expensive to store potatoes in the type of stores found in Kibirichia at present.

(v) Since 38.8% of the potatoes harvested was stored during early harvest 1977, and 26.1% of potatoes store were for seed and home consumption (see table 11) about 12.7% of the stored potatoes were stored for sale for consumption within and without the production area.

However most of the bigger potato farmers sold most of their potatoes immediately after harvest because they invest elsewhere while they wait for the next harvest. These farmers are traders-cum-farmers and in many cases they leased land away from their farms and were reluctant to build stores in farms they did not own hence the apparent economic contradition.

(vi) It was very uneconomical to store potatoes in Kibirichia in the 1st season 1977 for less than 3 months*. Table 3 shows that the average storage losses were Shs. 27.30 for the first 3 months of potato storage where farmers sold their potatoes in the local markets. However Zettelmeyer (table 33) indicates that farmers could get average net storage profit of Shs. 3.99 within the first seasons, 1974-1977, if farmers stored in house piles, marketed co-operatively in Nairobi and assuming zero investment costs for their stores.

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*H.C.D.A. - Dumped potatoes in the local market after three months of storage at much lower prices than farmers expecte

CHAPTER 7

RECOMMENDATIONS

The following recommendations and proposals are found to be relevant to potato storage in Kenya, based on the conclusions in chapter 5:

(i) Potato storage methods and techniques should be improved in the following ways:-

1. An improved granary (fig. 4) with bigger capacity should be encouraged to farmers because the building materials for such a store are relatively cheap and locally available. However the granary flap should be openable to the direction of wind during the night rather than the present position where it is openable to the direction of wind during the day. This is because the flap is usually opened during the night to allow cold air in and closed during the day to retain the cold air inside and prevent hot air in. It is recommended that slots should be about 30m wide to allow more air in the store. To reduce costs further a thatched roof instead of G.I. sheets can be used.

2. To avoid heavy investment losses for those farmers with good house-like stores, it is recommended that these houses should be improved to allow more ventilation by building a timber-raised slotted false floor and a timber ceiling covered with a straw inside the existing stores.

3. From the study in February-June 1977 it was found that no cold storage existed in the country for potato storage and it is recommended that traders, companies and other institutions should be encouraged to construct cold storages. Electricity is now available in local towns in Kenya and such cold potato stores are possible to prevent heavy dehydration in potatoes during storage, that is normally experienced.

4. The economic feasibility of the few forced ventilation stores being put up in the country by Schuelter company (3) should be investigated. This is despite Zettelmeyer's findings (table 32) that

an improved granary stored better than the forced ventilation stores. Zettelmeyer had so many assumptions, that the validity of his conclusion should be treated with caution.

(ii) It is recommended that the marketing system should be improved so that:

1. Co-operative marketing of potatoes becomes the main channel of distributing potatoes to consumers. This is to avoid the big trading margins being enjoyed by traders (Appendix 10) today to the disadvantage of both the consumer and the producer. It is felt that a co-operative society could be able to build cold stores recommended in (i).

2. None potato producing areas in the country can be supplied with potatoes; Such areas like Machakos, Kitui, and to a large extent Coast Province. It is felt that instead of exporting potatoes to other countries the local demand should be catered for sufficiently. Co-operative marketing and/or marketing

organised by corporation are recommended for organising transportation of potatoes to these deficit areas.

(iii) It is recommended that a price spectral analysis should be carried out to find out whether the factors that cause price changes in local markets and national markets are the same or not, so that planning can be carried out with a clear vision of casual factors.

REFERENCES

1. ACLAND, J.D. East African Crops. FAO., and Longman Group Ltd, London, 1971.

2. BALLESTREM, C.C. Report on activities and experiences of Agriculture, Potato Research Station, Tigoni, July 1975.

3. BOOCOCK, J. Report on performance of the forced ventilation potato store. Kaaga Rural Training Centre, Meru, Kenya, June 1977.

4. DUERR, G. Interim Reports on production and marketing of potatoes in Kenya. International potato Centre, Nairobi June - September 1977.

5. EDGAR, A.D. "Storage of potatoes" in Ora Smith: Potatoes: production, storing and processing. Westport Connecticut, U.S.A., 1968.

6. GRANGER, C.W.J. and HATANAKA, M. Spectral analysis of Economic Time Series. Princeton University press, Princeton, N.J. 1964.

7. GRIFFITH, G.R. "Across spectral approach to measuring pricing efficiency in the New Wales pigment market." Review of marketing and Agricultural Economics: Vol. 43, No.4 Dec. 1975 (p.163-183)

8. F.A.O and U.S.A. Department of Health, Education and welfare. Food Composition Tables for use in Africa. Bethesda, U.S.A. and F.A.O/Rome 1968.

F.A.O & U.S. Dept. of Health, Ed & W. U.S.A. HEW, Beth U.S.A. & FAO, Rome.

9. HEINZ, P.H. ET AL Storage and Transportantion of potatoes. Potato handbook, Vol. XI, New Brunswick, N.J. 1966.

10. IKERD, J.E. "Spatial price difference during market trade transistions." " Southern Journal of Agric. Economic Vol. 5. No. 2, May 1973 (p.51-55).

11. MINISTRY OF AGRICULTURE KENYA Horticultural handbook Nairobi, 1966.

12. JANICK, J. ET AL Plant Science. An Introduction to world crops. W.H. Freeman and Co. San Francisco, 1969.

13. LIPSEY, R.G. An introduction to positive Economics English language Book Society and Weidenfeld and Nicolson. Third Edition, U.K. 1971.

14. MAIZE AND PRODUCE BOARD Discussion held in Meru branch of M.P.B. office August, 1977.

15. MARITIM, H. Analysis of produce flows to Wakulima Wholesale Market Nairobi, Unpublished, Dept. of Agricultural Economics, M.Sc. Thesis University of Nairobi, 1976.

16. MBOGOH, S.G. Marketing and production of potatoes in Kenya. Unpublished M.Sc thesis, University of Nairobi, 1976.

17. MEIJERS, C.P. Potato storage in warm countries. Dutch information centre for potatoes The Hague, Holland (no date given).

18. MICHAEL, Q. Production of potatoes in Kenya Results of investigation in 4 districts in 1974. A pilot study Nairobi, Mimeograph Ministry of Agriculture, 1971-1975.

19. MINISTRY OF AGRICULTURE Department of Technical services. Limuru (Kenya) Potato Research Station, (no date given).

20. MISSENER, G.C. any SHOVE Moisture loss from Kanaebac potato storage period. Research Station Agric. Canada, Fredericton 1976.

21. MICHIGAN STATE UNIVERSITY Potato storage: design and operation extension Bulletin 585. East Lansing, 1967

22. BALLESTREM, C.G. AND HOLLER, H.S. Potato Atlas of Kenya. Frankfurt, West Germany, 1974.

23. RINDLEY, S.C. and HOGAN, J.M. "Effect of storage temperature and tuber composition, intrusion force and Brabender Viscosity". River Falls, U.S.A. 1976.

24. ROBINSON, R.A. Potato development. Report of the Government of Kenya. F.A.O., Rome 1973.

25. SAMUELSON, P.A. Intertemporal price equilibrium: A prologue to the theory of speculation. Reprinted in the collected scientific papers of Paul Samuelson, Cambridge, the M.I.I. press, 1966.

26. SHARMA, V.C. and BHATTACHARRYA, S.K. "Efficiency of fungicidal treatment to check rottage of the seed potatoes under country storage". Journal of the Indian Potato Association, 1976 3(En. 4 ref) Central potato Res. Inst. Simla H.P. India.

27. SOLIZ, R. Analysis of potato storage in Peru (Unpublished) Quito INIAP, 1970.

28. STANDARD BANK: Discussion with the Manager of Meru Standard Bank Branch, June 1977.

29. WEIGARD, K.B. The economic feasibility of stabilizing the price and supply of potatoes in Ecuado. M.Sc thesis University of Florida, 1975.

30. WERGE, W.R. Potato storage systems in the Mantaro Valley region of Peru.

International potato centre centre Apartado 5969 Lima - Peru Social-economic Unit, 1977.

31. ZETTELMEYER, W.J. Ware potato storage trial physical results and economic evaluation. Ministry of Agriculture - Kenya. Interim Report I. Nairobi, August, 1977.

APPENDIX I

ON FARM POTATO STORAGE QUESTIONNAIRE:

DATE.....

INTERVIEW NO. .....

NAME OF FARMER .....

PLACE..... DISTRICT.....

LOCATION ..... VILLAGE.....

TIME THE INTERVIEW START .....

FINISH (time) .....

---

1. Did you grow potatoes last season? Yes/No
2. How big is your farm? ..... Acre/Hectares.
3. Which other crops did you grow last season
   (Names) (1) ..... (2) .....
   (3) ..... (4) .....
4. How many Acres/Hectares of potatoes did you plant last season? .....Acres/Hectares.
5. In which months and week did you harvest?
   .....
6. Could you please name the used varieties?
   (a) ..... (b)..... (c).....

6. How many acres/hectares of potatoes do you expect to plant next season? .....
hectares/acres.....

B. If the acreage is more or less. Why?
.....

7. How many bags of potatoes did you harvest last season? ..... Bags.

8. What did you do with the potatoes immediately after you harvested?

STORED FOR SALE	SOLD	FOR OWN SEED	FOR CONSUMPTION	FOR OTHER PURPOSES
.....bags	...bags	...bags	....bags	...bags

9. Where do you store your potatoes?
i) In the house (ii) In a pit (iii) In granary
iv) Open air covered with straw (v) Any other.

10. When did you construct your storage facility?
Year .....

11. What is the capacity when completely full?
..... bags.

12. What are the dimensions (i) Lenth.....ft/m
(ii) Breadth ..... ft/m
(iii) Height .....ft/m (ceiling level).

13. In the floor/foundation (i) Earth

(ii) Concrete (iii) Timber slabs

(iv) Any other .....(tick)

i) Is the floor raised or not? .....(tick)

ii) If concrete, how much did it cost you to buy (Transportation cost included)?

A.	Cement and Wire	Shs .....
B.	Gravel/sand	Shs .....
C.	Hardcore	Shs .....
D.	Stores	Shs .....
E.	Labour	Shs .....
	Total	Shs .....

iii) If Timber/slabs, how much did it cost you buy? (Transportation cost included)?

A.	Timber/slabs	Shs .....
B.	Poles	Shs .....
C.	Nails	Shs .....
D.	Other (labour etc)	Shs .....
	Total	Shs .....

iv) If earth - how much did it cost Shs.....

14. The walls are

i) Earth/mud plastered Shs .....

ii) Stone/bricks (Transport cost included) Shs.....

iii) Timber/slabs Shs .....

iv) Any other (sand, nail etc) Shs .....

Total Shs .....

15. The roof is (i) Grass thatched Shs .....
(transportation cost included)

ii) Timber/shingles Shs .....
(Transportation cost included)

iii) Tile/C.I.S. Shs .....
(Transportation cost included)

iv) Rafters/Partins Shs .....
(Transportation cost included)

v) Others (nails etc) Shs .....
(Transportation cost included)

Total Shs .....

16. How much did it cost you to install the fittings?

i) Doors Shs .....

ii) Windows Shs .....

iii) Vents Shs .....

iv) Rain water pipes Shs .....

v) Ventilation system (if any) Shs .....

vi) Others Shs .....

Total .....

17. How much did you pay for Preservatives (if used)? Shs.....

18. If the storage facility was built by a contractor, how much did you pay the contractor?

Shs .....

19. Describe the insulation system used in the storage facility .....

.....

.....

20. Describe the ventilation system used in the storage facility .....
.....
.. ..

21. How much does it cost you to repair and maintain the store per year Shs .....

22. How long do yoy expect the store to last?
years .....

23. Do yoy store your potatoes in (A) bulk
(B) in bags?
(tick)

24. How much does it cost to ensure security?

25. What quantities and how long did you store the potatoes last season?

MONTHS			
1 month ....bags	2 months .....bags	3 months .....bags	4 months ....bags

26. How much did your lose per selling period? through either insect, pest attack, disease attack, bad conditions or given to neighbours after storing for

	MONTHS			
CAUSE	1	2	3	4
SPOILT	...bags	...bags	..bags	...bags
Given to neighbours	..bags	...bags	..bags	..bags

27. How many bags seeds included did you sell after storing for

i) 1 month ..... bags Shs.....

ii) 2 months ..... bags Shs.....

iii) 3 months ..... bags Shs.....

iv) 4 months ..... bags Shs.....

Total bags Shs.....

28. At what market did you sell?

A) To traders coming to your farm

B) To traders in local markets

C) To traders in National markets

D) To neighbours for home consumption

E) To others .....

29. Why did you sell to any of the above?

.....

.....

.....(Reasons)

30. In each case what was the transportation cost Shs ...../bag to .....(place) (km .....)

31. Describe any problems encountered during storage period and during selling time .....

.....

.....

.....

32. Do you think your store could be improved to minimise current loses? Yes/No

ii) If yes in what ways could it be improved?

.....

.....

33. Do you use sprout suppresant? Yes/No.....

ii) If No, why not? .....

iii) Do you treat your potatoes with any other disease killing chemicals .....

.....

Name .....

34. What do you think could improve the potato culture more?

A) Better potatoe seed

B) Better husbandry (weeding, spraying etc)

C) Better storage facilities

D) Better marketing systems

35. What is your opinion about a potato Co-operative to do the storage, marketing and to provide transport? .....

.....

ii) Do you think it could pay? Comment ...

.....

.....

.....

Appendix 2: Analysis of sample potatoes immediately after harvest (early harvest 1977)

Farm No	Q. harvested	Stored	Sold	Seed	Consumed	Other purposes
	Bags 100 kgs					
1.	134	37	30	27	25	15
2.	42	-	15	13	12	2
3.	210	132	38	20	10	10
4.	20	65	80	45	10	5
5.	25	-	-	14	11	-
6.	130	10	60	30	30	-
7.	58	6	17	10	20	5
8.	30	-	-	4	26	-
9.	100	0	56	26	18	-
10.	100	16	47	20	10	-
11.	320	140	100	40	40	-
12.	258	60	80	48	20	50
13.	290	200	-	50	20	20
14.	120	62	6	32	20	-
15.	500	200	100	70	30	100
16.	70	20	20	10	20	-
17.	240	160	-	40	30	10
18.	260	140	60	30	20	10
19.	430	240	100	60	30	10
20.	130	50	50	10	10	-
21.	430	300	79	32	15	4
22.	40	5	20	10	5	-
23.	73	50	6	10	6	1
24.	250	-	200	30	20	-
25.	389	100	209	50	20	10

Appendix 2: Cont.

Farm NO.	Q. harvested	Stored	Sold	Seed	Consumed	Other Purposes
			Bags 100 kgs			
26.	100	30	20	30	20	-
27.	150	-	100	30	20	-
28.	105	-	75	16	13	1
29.	180	105	30	25	10	10
30.	160	40	20	40	60	-
31.	195	50	100	30	10	5
32.	200	15	140	35	10	-
33.	450	250	100	30	30	40
34.	135	-	80	30	20	5
35.	250	60	100	40	30	20
36.	170	9	101	30	30	-
37.	200	10	130	30	20	10
38.	75	-	38	12	10	5
39.	92	-	65	12	10	5
40.	276	115	100	24	30	7
41.	400	270	100	50	20	10
42.	250	153	52	30	15	-
43.	100	80	5	10	5	-
44.	35	12	7	10	6	-
45.	85	5	20	50	10	-
46.	165	10	85	40	30	-
47,	193	135	20	18	20	-
48.	30	5	15	5	5	-
49.	72	35	-	20	15	2
50.	90	32	12	16	30	-
51.	261	30	140	50	16	25
55.	261	58	146	32	20	5

Appendix 2: Cont.

Farm NO.	Q. harvested	Stored	Sold	Seed	Consumed	Other purposes
	Bags 100 kgs					
53.	275	-	150	70	40	15
54.	40	8	20	5	7	-
55.	60	-	20	20	20	-
56.	320	200	20	70	20	10
57.	310	200	60	25	25	-
58.	43	-	-	8	35	-
59.	97	60	-	24	13	-
60.	120	66	20	14	20	-
61.	100	40	40	12	8	-
62.	300	202	40	30	20	8
63.	.83	8	-	9	15	-5
64.	140	70	30	30	10	-
65.	32	8	-	9	15	-
66.	200	99	56	25	20	-
67.	300	250	-	40	10	-
68.	360	200	100	30	30	0
69.	220	40	60	20	25	15
70.	100	50	-	20	30	-
71.	400	40	260	30	50	20
	13002	5043	4090	1993	1396	483

Source: Survey carried in Feb. - June 1977

APPENDIX 3

Sample analysis of potatoes after storage in Kibirichia location 1st season 1977

	MONTHS													
	Q. stored for			Q. spoilt in			Q. sold after			Income per bag			Transportation Cost Distance	
	1	2	3	1	2	3	1	2	3	1	2	3		
Farmer No.	Bag/100 kgs.			Bags/100 kgs.			Bags/100 kgs.			Shs/bag			Shs/bag	km.
1.	30	7	-	1	1/2	-	29	6.5	-	30	30	-	2.00	1
2.	-	5	-	-	-	-	-	C	-	-	C	-	2.00	.5
3.	110	20	-	2	-	-	109	20	-	30	40	-	2.50	3.5
4.	-	48	-	-	2	-	-	46	16	-	35	40	2.50	4.5
5.	-	8	-	-	-	1/4	-	C	-	-	C	-	-	-
6.	-	11	-	-	2	-	-	10	-	-	45	-	2.00	1
7.	-	6	-	-	-	-	-	6	-	-	40	-	3.00	4
8.	-	20	-	-	-	-	-	C	-	-	C	-	-	-
9.	-	7	-	-	-	-	-	C	-	-	C	-	-	-
10.	-	16	-	-	-	-	-	16	-	-	35	-	2.00	2
11.	-	103	22	-	3	1 1/2	-	100	20	40	40	-	3.00	4
12.	-	40	20	-	-	-	-	40	20	-	40	45	3.00	2
13.	-	200	-	-	5	-	-	195	-	-	40	-	-	-
14.	35	27	-	1	1	[illegible]	[illegible]	26	-	35	40	-	3.00	4
15.	100	100	-	20	4	-	80	96	-	44	30	-	1.00	.5

Appendix: 3 cont.

16.	–	–	20	–	–	1	–
17.	64	36	–	15		–	49
18.	–	–	140	–		15	–
19.	80	–	–	5		–	75
20.	25	15	–	–	$1\frac{1}{2}$	–	25
21.	200	100	–	8	3	–	192
22.	–	5	–	–	$\frac{1}{2}$	–	–
23.	30	20	–	2	2	–	28
24.	–	–	–	–	–	–	–
25.	60	40	–	–	1	–	60
26.	–	30	–	–	2	–	–
27.	–	–	–	–	–	–	–
28.	–	–	–	–	–	–	–
29.	10	105	–	–	1	–	–
30.	40	–	–	–	–	–	40
31.	35	15	–	–	–	–	35
32.	–	15	–	–	1	–	–
33.	150	90	–	–	–	–	150
34.	–	–	–	–	–	–	–
35.	–	–	–	–	–	–	–
36.	–	–	–	–	–	–	–
37.	–	5	5	–	–	–	–
38.	–	10	–	1	–	–	–

-	19	-	-	30	3.00	4
36	-	34	55	-	10.00	30
-	125	-	-	30	3.00	1.5
-	-	35	-	-	3.00	2.25
13	-	30	40	-	2.00	1
97	-	30	33	-	3.00	1.5
C	-	-	C	-	2.00	2
18	-	80	60	-	15.00	2.40
-	-	-	-	-	-	-
39	-	44	50	-	3.00	4
28	-	-	40	-	2.00	.5
-	-	-	-	-	3.00	3
-	-	-	-	-	-	-
104	-	-	40	-	1.50	1
-	-	40	-	-	1.50	.5
15	-	30	40	-	2.00	1
14	-	-	40	-	2.00	.5
90	-	30	40	-	1.50	1
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
5	5	-	35	30	2.50	3
9	-	-	32	-	2.50	2

Appendix 3: Continued

39.	-	-	-	-	-	-	-
40.	40	160	16	3	5	1	37
41.	30	20	-	1	1	-	-
42.	40	100	-	2	5	-	48
43.	-	80	-	-	3	-	-
44.	-	5	-	-	-	-	-
45.	-	3	-	-	-	-	-
46.	5	5	-	-	-	-	-
47.	80	10	15	-	1	1	80
48.	-	-	-	-	-	-	-
49.	36	-	-	1	-	-	35
50.	-	32	-	-	1	-	-
51.	7	23	-	-	-	-	7
52.	-	150	-	-	1	-	-
53.	-	150	-	-	5	-	-
54.	-	7	-	-	-	-	-
55.	-	-	-	-	-	-	-
56.	130	70	-	-	-	-	130
57.	100	80	-	-	20	-	100
58.	-	10	-	-	-	-	-
59.	60	-	-	-	-	-	60
60.	6	30	30	-	-	-	6

–	–	–	–	–	–	–
155	15	44	45	50	3.00	3
29	19	40	40	–	3.00	6
95	–	30	30	–	2.00	1
77	–	–	40	–	1.00	1
5	–	–	30	–	3.00	2
C	–	–	–	–	–	–
–	–	30	32	–	2.00	2
9	14	40	39	39	3.00	4
C	–	–	–	–	–	–
–	–	30	–	–	3.00	3.5
31	–	–	40	–	2.00	3.5
23	–	30	40	–	2.00	2
57	–	–	32	–	4.00	6
145	–	–	40	–	2.00	.5
C	–	–	C	–	–	–
–	–	–	–	–	–	–
70	–	30	40	–	3.00	5
60	–	40	35	–	3.00	4
C	–	–	–	–	–	–
–	–	30	–	–	1.50	1
30	30	30	45	50	1.00	.5

Appendix 3: Continued

61.	24	16	-	-	-	-	24	16
62.	130	72	-	-	2	-	130	70
63.	-	5	-	-	-	-	-	C
64.	40	30	-	-	-	-	40	30
65.	-	-	8	-	-	-	-	-
66.	-	99	-	-	33	-	-	96
67.	150	60	-	10	9	-	140	51
68.	-	-	200	-	-	15	-	-
69.	-	80	-	-	2	-	-	78
70.	-	60	-	-	4	-	-	56
71.	-	36	-	-	1	-	-	35

SOURCE: Survey carried in March - June, 1977

Notes: C = potatoes for consumption
Q = Quantity.

-	30	40	-	3.00	2
-	30	40	-	2.50	1.5
-	-	C	-	C	-
-	40	37	-	3.50	3
8	-	-	40	3.00	3
-	-	35	-	4.00	5
-	45	38	-	1.00	..5
185	-	-	40	3.00	2.5
-	-	40	-	4.00	5
-	-	35	-	3.00	2.5
-	-	40	-	3.00	2.5

Appendix 4: Sample investment costs and life expectancies of the storage facilities in Kibirichia as per 1977

Type of store	Investment cost Shs.	Present worthy @10% Shs.	Annuity @10% Shs.	Annual cost Direct method Shs.	Present Age years	Life Expect.	Capacity Bags (100kg
1. House like	2500.00	1875	220.30	109	3	23	200
2. "	11000	6820	751.60	367	5	30	100
3. "	1500	450	73.22	65	13	23	30
4. "	2000	640	75.20	62	12	32	50
5. "	5000	1600	188.00	156	12	32	100
6. "	2000	520	61.10	59	14	34	60
7. "	2000	1120	645.34	250	6	8	20
8. "	2000	1240	163.06	100	5	20	10
9. "	2600	2366	278.00	124	1	21	20
10. "	300	153	17.98	11	7	27	10
11. "	700	140	36.93	32	14	22	50
12. "	1500	630	166.20	105	9	14	30
13. "	600	156	25.38	25	14	24	40
14. Granary	400	140	36.93	25	14	19	10
15. House like	9000	6120	674.42	310	4	29	80
16. "	1500	585	154.32	100	10	15	20
17. "	3000	66	10.74	188	16	26	100
18. "	12000	10920	1203.38	462	1	26	120
19. "	7000	5250	578.55	250	3	28	60
20. "	800	376	44.18	29	8	28	30

Appendix 4: Continued

Type of store	Investment cost Shs,	Present worthy @10% Shs.	Annuity @10% Shs.	Annual cost Direct method Shs.	Present Age years	Life Expect.	Capacity Bags (100k
21. House-like	1000	620	163.56	100	5	10	400
22. Attached to D. House	300	93	24.53	18	12	17	100
23. House-like	5000	1550	203.83	185	12	27	800
24. "	600	186	49.07	35	12	17	140
25. "	550	500	53.05	18	1	32	200
26. "	4000	1680	185.14	118	9	34	400
27. "	3000	2720	299.74	103	4	29	200
28. "	2000	1120	131.60	77	6	26	150
29. "	2500	2075	272.86	147	2	17	500
30. "	200	28	7.39	8	21	26	600
31. "	1500	1020	119.85	63	4	24	120
32. "	200	40	10.55	9	17	22	250
33. "	5000	1100	178.97	192	16	26	80
34. "	500	255	41.49	29	7	17	100
35. "	250	77	30.96	18	12	14	300
36. "	200	52	29.96	12	14	17	1200
37. "	2500	650	85.48	86	14	29	1000
38. "	2000	1870	198.41	65	1	31	100
39. "	1600	496	130.84	94	12	17	100
40. "	1700	1275	207.44	131	3	13	200

Appendix 4: Continued

Type of store	Investment cost Shs.	Present @10% Shs.	Annuity @10% Shs.	Annual cost Direct method Shs.	Present Age - years	Life Expect	Capacity Bags (100kg)
41. House-like	200	28	7.39	8	21	26	300
42. "	1500	240	20.05	52	19	29	300
43. "	1050	273	44.42	54	14	24	300
44. "	2000	840	98.70	69	9	29	200
45. Attached to D. House	300	117	19.04	15	10	20	100
46. "	1000	420	53.23	42	9	24	150
47. "	4700	1410	371.96	261	13	18	250
48. Pit	300	153	20.12	14	7	22	30
49. House-like	2000	840	110.46	91	9	24	200
50. Attached to D. House	300	84	48.40	15	18	20	100
51. House-like	300	78	14.38	14	14	22	200
52. "	1600	672	88.37	67	9	24	250
53. Granary	450	68	11.06	15	20	30	250
54. House-like	2000	1820	200.56	77	1	26	200
55. Attached to D. House	1000	560	65.80	39	6	26	60
56. House-like	5000	2800	329.00	192	6	26	300
57. "	13000	10790	1144.82	406	2	32	1000

Appendix 4: Continued

Type of store	Investment cost Shs.	Present @10% Shs.	Annuity @10% Shs.	Annual cost Direct method Shs.	Present Age years	Life Expect	Capacity Bags (100kg
58. House-like	3500	1960	207.97	97	6	36	100
59. "	2000	1500	159.15	61	3	33	100
60. "	300	126	72.60	27	9	11	100
61. "	500	155	40.89	29	12	17	250
62. "	1000	620	68.32	33	5	30	500
63. "	200	60	152.83	11	13	18	1000
64. Attached to D. House	200	92	53.00	20	8	10	70
65. House-like	3500	2391	385.70	121	4	29	300
66. "	1500	1025	396.70	167	4	9	200
67. "	5000	2823	587.50	192	6	26	1100
68. "	3200	2912	376.00	152	1	21	200
69. "	2500	2066	275,50	92	2	27	180
70. "	4530	3744	480.63	146	1	31	500
71. "	2500	1060	513.50	156	9	16	480
TOTAL	169130	1100300	14119.58	7067	546	1646	
AVERAGE	2400		198.87	100	9.1	23	

Source: Survey carried in Feb-June, 1977

Note: D = Dwelling

APPENDIX 5

Dimensions and Structure of the sample on Farm storage facilities (1977)

Farmer Interviewed	Type of storage facility	FLOORS			WALLS			ROOF		DIMENSIONS		
		Co	TR	Ear	Ti	Sto	Mud	C.I.SS	G.TT	L. M	B. M	H. M
1.	Houselike			X	X			X		4.2	4.2	2.4
2.	"			X	X			X		9.0	4.5	2.4
3.	"	X		X				X		5.4	4.2	2.7
4.	"			X	X			X		5.4	4.2	2.4
5.	"	X		X				X		9.0	4.2	2.4
6.	"			X	X			X		6.0	4.8	2.4
7.	"			X			X		X	4.2	4.2	2.1
8.	"			X	X			X		3.6	3.0	2.4
9.	"			X	X			X		4.2	3.6	2.4
10.	"			X			X	X		9.0	.4	2.4
11.	"			X			X	X		7.5	3.0	2.4
12.	"			X			X	X		4.8	3.6	2.4
13.	"			X	X			X		6.0	3.0	2.4
14.	Granary		X	X				X		3.0	1.8	2.4
15.	Houselike	X		X				X		12	4.2	2.4
16.	"			X	X			X		5.4	4.2	2.4
17.	"	X		X				X		12	4.2	2.4

Appendix 5: Continued

Farmer Interviewed	Type of storage facility	FLOORS			WALLS			ROOF		DIMENSION		
		Co	TR	Ear	Ti	Sto	Mud	C.I.S.	G.T.	L.	B.	H
										M	M	M
18.	Houselike	X		X				X		7.8	7.2	2.4
19.	"	X		X				X		7.2	4.2	2.4
20.	"			X			X	X		3.6	3.6	2.4
21.	"			X	X			X		4.8	3.9	2.4
22.	Attached to L. House			X			X		X	3.0	2.4	2.4
23.	Houselike	X			X			X		9.6	3.6	2.4
24.	"			X			X	X		3.6	3.0	2.4
25.	"			X	X			X		3.6	3.6	2.4
26.	"			X	X			X		6.0	3.6	2.4
27.	"			X	X			X		4.8	4.2	2.4
28.	"			X	X			X		3.6	3.6	2.4
29.	"			X			X	X		6.0	5.4	2.7
30.	"			X			X		X	6.0	5.4	2.4
31.	"			X	X			X		3.6	3.0	2.4
32.	"			X			X		X	4.8	2.4	2.4
33.	"			X	X			X		12	3.6	2.4
34.	"			X			X		X	3.6	2.7	1.95
35.	"			X			X		X	3.6	2.7	2.4
36.	"			X			X		X	5.4	4.8	2.4

Appendix 5: Continued

Farmer Interviewed	Type of storage facility	FLOORS			WALLS		
		CO	TR	Ear	Ti	Sto	Mud
37.	Houselike			X	X		
38.	"			X	X		
39.	"			X			X
40.	"			X	X		
41.	"			X			X
42.	"			X	X		
43.	"			X	X		
44.	"			X	X		
45.	Attached House			X			X
46.	"			X	X		
47.	"	X			X		
48.	Pit			X			
49.	Houselike	X			X		
50.	Attached House	X				X	
51.	Houselike			X			X
52.	"			X			X
53.	Granary		X				X
54.	Houselike			X	X		

ROOF		DIMENSION		
C.I.S.	G.T.	L	B.	H.
		M	M	M
X		9.0	4.8	2.4
X		3.0	2.7	2.4
	X	3.0	2.4	2.4
X		3.6	3.0	2.4
	X	4.8	4.2	2.4
X		6.3	3.9	2.4
X		5.4	4.8	2.4
X		3.6	3.0	2.4
X		3.6	3.0	2.4
X		4.2	3.6	2.4
X		10.8	3.6	2.4
X		2.7	1.2	1.2
X		4.2	3.6	2.4
X		3.0	3.0	2.7
X		3.6	3.0	2.4
X		5.4	3.6	2.4
X		4.5	3.6	2.1
X		4.2	3.6	2.4

Appendix 5: Continued

Farmer Interviewed	Type of storage facility	FLOORS			WALLS		
		Co	TR	Ear	Ti	Sto	Mud
55.	Attached House			X			
56.	Houselike			X	X		
57.	"	X			X		
58.	"	X			X		
59.	"	X			X		
60.	"			X			X
61.	"			X			
62.	"	X			X		
63.	"			X			X
64.	Attached House			X			X
65.	Houselike			X	X		
66.	"	X			X		
67.	"			X	X		
68.	"			X	X		
69.	"			X	X		
70.	"	X			X		
Glade Total		16	2	53	46	1	23

SOURCE: Survey carried in February - June, 1977.

ROOF		DIMENSIONS		
C.I.S	G.T	L.	B.	H.
		M	M	M
X		3.0	2.1	2.4
X		6.0	4.7	2.4
X		12.0	6.0	2.4
X		4.2	3.0	2.4
X		3.6	2.4	2.4
X		4.2	3.6	2.4
X		4.5	3.0	2.4
X		9.0	3.0	2.4
	X	6.0	5.4	2.4
X		3.0	3.0	2.4
X		4.2	3.0	2.4
X		7.8	4.2	2.7
X		4.8	4.2	2.25
X		4.2	3.3	3.0
X		6.0	3.6	2.4
X		5.4	3.6	2.4
	Average	5.57	3.74	2.4
61	10			

Appendix 5: Continued

Notes:

Co = Concrete

TR = Timber raised

Ear = Earth

Ti = Timber

Sto = Stone

C.I.S. = Corrugated Iron Sheets

G.T. = Grass thatched

L = Length

B = Breadth

H = Height

M = Meters

APPENDIX 6

CLIMATICAL FACTORS THAT AFFECT POTATOES IN STORES

Weekly average absolute temperature in improved granaries in Molo Feburuary - June 1977

D A T E	GRANARY 1 °C	GRANARY 2 °C	GRANARY 3 °C	AVERAGE °C
4.3- 6.3	13.9	14.04	13.1	13.7
7.3-13.3	12.5	12.18	11.0	11.9
14.3-20.3	12.6	11.8	11.4	11.9
28.3- 3.4	12.8	12.5	12.3	12.5
4.4-10.4	12.9	12.4	11.9	12.4
11.4-17.4	12.8	12.1	11.8	12.2
18.4-24.4	12.5	12.8	11.5	12.3
25.4- 1.5	13.0	12.8	11.9	12.6
2.5- 8.5		12.1	11.8	12.0
9.5-15.5		13.8	12.3	13.1
16.5-22.5		13.4	12.2	12.8
23.5-29.5		13.7	12.4	13.1
30.5- 5.6			12.3	12.3
66.6-12.6			11.6	11.6
13.6-17.6			11.4	11.4
			Average	12.4

Range = 13.7 - 11.4 = 2.3°C

SOURCE: Potato storage trials (Feb-June 1977)

Appendix 6: Continued

Weekly average absolute temperature in house potato piles in Ngecha (February - June, 1977)

D A T E	Pile 1 °C	Pile 2 °C	Pile 3 °C	Average °C
25.2-27.2	18.25	18.5	18.25	18.3
28.2- 6.3	17.45	17.6	17.5	17.5
7.3-13.3	17.55	17.6	17.65	17.6
14.3-20.3	17.3	17.55	17.4	17.4
21.3-27.3	16.65	17.1	16.75	16.8
28.3- 3.4		17.7	17.6	17.7
4.4-10.4		17.95	17.85	17.9
11.4-17.4		17.9	17.8	17.9
18.4-24.4		18.0	17.9	18.0
25.4- 1.5		17.6	17.65	17.6
2.5- 8.5		17.85	17.45	17.7
9.5-15.5		17.95	18.0	18.0
16.5-22.5			17.75	17.8
23.5-29.5			17.15	17.2
30.5- 5.6			17.0	17.0
6.6-12.6			17.75	17.8
			Average	17.64

Range = 18.3 - 16.8 = 1.5°C

SOURCE: Trial carried out between
(February - June, 1977)

Appendix 6: Continued

Weekly average absolute temperature inside house potato piles (February - June 1977)

D A T E	Pile 1 °C	Pile 2 °C	Pile 3 °C	Average °C
4.3- 6.3	15.00	14.00	14.0	14.3
7.3-13.3	13.95	13.1	13.2	13.4
14.3-20.3	13.1	13.55	13.6	13.4
21.3-27.3	13.6	14.1	14.4	14.0
28.3- 3.4	14.1	14.1	14.5	14.2
4.4-10.4	14.3	14.25	14.3	14.3
11.4-17.4	13.7	13.5	13.55	13.6
17.4-24.4	14.1	13.3	13.55	13.7
25.4- 1.5	14.5	13.6	14.05	14.1
2.5- 8.5		14.0	14.0	14.0
8.5-15.5		13.75	13.8	13.8
16.5-22.5		14.35	14.4	14.4
23.5-29.5		14.30	14.4	14.4
30.5- 5.6			14.4	14.4
6.6-12.6			14.6	14.6
13.6-17.6			16.25	16.3
			Average	14.2

Range = 14.6 - 13.4 = 1.2°C

SOURCE: potato storage trials (February - June, 1977)

Appendix 6: Continued

Weekly average absolute temperature in pits
(February - June, 1977)

D A T E	Pit 11 °C	Pit 2 °C	Pit 3 °C	Pit 4 °C	Average °C
28.3- 3.4	19.55	19.4	19.65	20.95	19.9
3.4-10.4	20.05	20.0	20.0	21.0	20.3
10.4-17.4	20.3	20.1	20.2	20.95	20.4
17.4-24.4	20.95	20.75	21.2	21.35	21.1
24.4- 1.5	21.5	21.4	21.35	21.5	21.4
1.5- 8.5		22.25	21.85	21.5	21.9
8.5-15.5		23.1	22.95	21.8	22.6
22.5-29.5		23.7	24.1	23.8	23.9
29.5-5.6		28.35	27.4	28.6	28.1
5.6-12.6			27.6	24.5	26.1
				Total	225.7
				Average	22.6°C

Range = 28.1 - 19.9 = 8.2°C

SOURCE: potato storage trials
(February - June 1977)

Appendix 6: Continued

Weekly average absolute temperature in potato pits in Meru (February - June 1977)

D A T E	Pit 1 °C	Pit 2 °C	Pit 3 °C	Pit 4 °C	Average °C
25.3-26.3	27.25	25.90	27.5	21,75	25.6
27.3- 3.4	30.05	30.20	27.05	22.2	27.4
3.4-9.4	31.50	35.30	27.6	22.55	29.2
10.4-16.4	27.70	27.85	29.0	23.0	26.9
17.4-24.4		26.25		23.0	24.6
25.4- 1.5				23.6	23.6
2.5- 8.5				24.5	24.5
9.5-15.5				26.8	26.8
				Average	26.1°C

Range = 29.2 - 23.6 = 5.6°C

SOURCE: potato storage trials (February - June 1977)

Appendix 6: Continued

Weekly average absolute temperature in potato pits in Ngecha (February - June 1977)

D A T E	Pit 1 °C	Pit 2 °C	Pit 3 °C	Pit 4 °C	Average °C
4.4-10.4	27.55	27.0	27.25	26.7	27.1
11.4-17.4	28.40	26.9	26.7	26.25	27.1
18.4-24.4		25.9	25.75	25.85	25.8
25.4- 1.5		25.4	25.2	25.05	25.2
2.5- 8.5		22.75	22.1	22.9	22.6
9.5-15.5		24.2	24.05	22.95	23.7
16.5-22.5				23.15	23.2
23.5-29.5				23.45	23.5
30.5- 5.6				23.7	23.7
6.6-12.6				22.35	22.4
				Average	24.43

Range = 27.1 - 22.4 = 4.7

SOURCE: potato storage trials (February - June 1977)

Appendix 6: Continued

Weekly average absolute temperature inside potato granaries in Meru (February - June 1977)

D A T E	Granary 1 °C	Granary 2 °C	Granary 3 °C	Average °C
19.2- 5.3	16.9	18.4	16.4	17.2
26.2- 4.3	16.3	16.1	16.2	16.2
5.3-11.3	15.9	15.8	15.9	15.9
12.3-19.3	16.3	16.0	17.7	16.7
20.3-26.3	16.0	16.3	16.5	16.3
27.3- 2.4	17.2	16.9	17.0	17.0
3.4- 9.4	17.3	17.4	17.3	17.3
10.4-16.4	17.2	17.2	17.4	17.3
17.4-24.4	17.2	17.3	17.2	17.2
25.4- 1.5		16.7	17.0	16.9
2.5- 8.5		16.5	16.7	16.6
9.5-15.5		16.3	16.8	16.6
16.5-22.5		16.5	16.5	16.5
23.5-29.5			16.2	16.2
30.5- 5.6			15.5	15.5
6.6-12.6			16.1	16.1
13.6-15.6			16.0	16.0
			Average	16.6

Range = 17.3 - 15.5 = 1.8°C

SOURCE: potato storage trials (February - June 1977)

Appendix 6: Continued

Weekly average absolute temperature in granaries in Ngecha (February - June 1977)

D A T E	Granary 1 °C	Granary 2 °C	Granary 3 °C	Average °C
25.2-27.2	18.3	18.7	18.2	18.4
28.2- 6.3	17.9	17.9	17.8	17.9
7.3-13.3	17.2	17.8	17.9	17.6
14.3-20.3	17.7	17.8	17.7	17.7
21.3-27.3	17.6	17.7	17.7	17.7
28.3- 3.4	17.8	18.1	18.0	18.0
4.4-10.4	18.1	18.4	18.2	18.2
11.4-17.4	18.3	18.2	18.0	18.2
18.4-24.4		18.0	17.9	18.0
25.4- 1.5		18.2	17.9	18.1
2.5- 8.5		18.2	18.1	18.2
9.5-15.5		18.3	18.2	18.3
16.5-22.5		18	18.0	18.0
23.5-29.5			17.4	17.4
30.5- 5.6			17.1	17.1
6.6-12.6			17.5	17.5
			Average	17.9°C

Range = 18.4 - 17.1 = 1.3°C

SOURCE: potato storage trials (February - June 1977)

Appendix 6: Continued

average temperature inside house potato piles in Meru (February – June 1977)

D A T E	Pile 1 °C	Pile 2 °C	Pile 3 °C	Average °C
19.2 – 7.3	18.0	14.3	17.0	16.4
26.2 – 4.3	15.95	15.35	15.7	16.0
5.3 – 11.3	16.05	16.05	16.05	16.1
12.3 – 14.3	16.2	16.6	16.25	16.3
20.3 – 26.3	16.35	16.5	16.3	16.4
27.3 – 2.4	16.75	16.9	16.95	16.9
3.4 – 9.4	16.9	17.0	17.05	17.0
10.4 – 16.4	17.15	17.1	17.2	17.2
17.4 – 24.4	16.35	16.45	16.6	16.5
25.4 – 1.5	17.0	16.9	16.9	17.0
2.5 – 8.5		16.9	16.95	16.9
9.5 – 15.5		13.95	16.45	15.2
16.5 – 22.5		16.05	16.5	16.3
23.5 – 29.5		16.0	16.45	16.2
30.5 – 5.6			16.0	16.0
6.6 – 12.6			15.05	15.1
13.6 – 15.6			16.0	16.0
			Average	16.3

Range = 17.2 – 15.1 = 2.1°C

SOURCE: potato storage trials (February – June 1977)

APPENDIX 7

Potato storage trial - weights

Type of store	NGECHA		MERU		MOLO	
	Weight	Birgin treatment	Weight kg	Birgin treatment	Weight kg	Birgin treatment
Pit 1	948.48	-	1245.00	-	812.80	-
Pit 2	863.25	-	1261.00	-	861.30	-
Pit 3	790.71	-	1301.00	-	876.60	-
Pit 4	774.00	X	711.00	-	954.85	X
Wooden store 1	2255.16	-	1958.00	-	2187.70	-
Wooden store 2	2275.60	X	1939.00	-	2165.40	X
Wooden store 3	2285.20	X	2036.00	-	2173.40	X
House						
Pile 1	785.10	X	802.00	-	669.25	-
Pile 2	792.60	X	806.00	670	670.60	-
Pile 3	783	-	710.00	-	595.50	-
Bags 1	392.80	-	420.00	-	303.00	-
Bags 2	379.80	-	420.00	-	303.00	-
Bags 3	385.30	-	420.00	-	303.90	-
	13712.80		14029.00		13422.90	

SOURCE: potato storage trial carried between (February - June 1977)

"Schluter" store NJABINI:	Date filled	Weight Kg
	21.3.77 (for $\frac{3}{4}$	29947.30

APPENDIX 8

Sample total farm acreage and acreage in potatoes in 1st season 1977 in Kibirichia - Meru

Farm No.	Total farm size	Farm under potatoes	Farm No.	Total farm size	Farm under potatoes
	ha	ha		ha	ha
1.	10.8	1.2	33	3.2	1.6
2.	9.56	1.2	34	3.04	0.7
3.	3.2	1.6	35	3.2	2.0
4.	3.12	1.6	36	3.2	1.6
5.	2.4	0.05	37	10	1.4
6.	16	0.8	38	4.8	0.6
7.	3.2	0.8	39	4.0	1.2
8.	4	0.2	40	2.4	1.2
9.	2.5	1.6	41	3.8	1.6
10.	2.4	1.2	42	4	1.2
11.	2.4	1.6	43	3.2	0.8
12.	6	1.2	44	3.2	0.4
13.	4.8	2.0	45	2.4	1.2
14.	3.5	1.6	46	20.8	1.6
15.	13.8	2.8	47	3.3	1.0
16.	2.96	0.8	48	3.3	0.2
17.	16	1.2	49	4.2	0.6
18.	5.5	0.8	50	4.5	0.8
19.	4.5	2.0	51	6.4	2.0
20.	7.3	1.6	52	3.2	1.2
21.	7.5	2.4	53	3.0	1.6
22.	2.4	0.4	54	3.2	1.2
23.	6	0.4	55	1.6	0.4
24.	6.4	2.0	56	3.6	2.4
25.	5.6	1.6	57	7.1	2.8

Appendix 8: Continued

Farm No.	Total farm size	Farm under potatoes		Total farm size	Farm under potatoes
	ha	ha	ha	ha	ha
26.	3.2	1.2	57	2.8	0.3
27.	4.2	0.8	59	4.8	2.0
28.	3.7	1.0	60	4.0	0.8
29.	3	0.9	61	6.4	2.0
30.	3.6	0.8	62	3.2	1.6
31.	2.4	1.2	63	4.8	0.8
32.	3	0.8	64	5.1	1.6
			65	2.9	0.2
			66	4.0	1.6
			67	3.8	1.6
			68	4.8	1.6
			69	0.8	0.8
			70	2.4	0.8
			71	2.9	1.2
		Total		268.4	87.3
		Average		5.2	1.23

SOURCE: Survey carried in Feb-June 1977

APPENDIX 9

Weekly wholesale average prices in Wakulima wholesale market and Kibirichia markets - 1976, 1977.

Weeks	Wakulima (Shs. per bag of 100 kgs) 1976	1977	Kibirichia 1976	1977
1.	-	62.50	20.00	25
2.	..	52.50	18.00	30
3.	52.50	62.50	18.00	32
4.	57.50	57.50	18.00	32
5.	-	-	20.00	35
6.	57.50	57.50	25.00	40
7.	62.50	57.50	27.40	55
8.	62.50	62.00	26.30	55
9.	-	65.00	26.00	55
10.	62.50	67.50	-	40
11.	62.50	67.50	-	40
12.	69.50	52.50	-	40
13.	-	52.50	-	40
14.	62.50	55.00	-	40
15.	72.50	-	-	40
16.	77.50	-	-	40
17.	72.50	55.00	-	45
18.	82.50	60.00	-	55
19.	102.50	72.50	-	55
20.	92.50	67.50	-	60
21.	72.50	77.50	-	65
22.	62.50	82.50	-	70
23.	72.50	80.00	-	65
24.	62.50	102.50	-	95
25.	52.50	102.50	30.00	95
26.	62.50	92.50	30.00	95
27.	62.50	122.50	30.00	95
28.	62.50	127.50	30.00	95

Appendix 9: Continued

Weeks	1976	1977	1976	1977
29.	-	147.50	25.00	100
30.	62.50	155.00	30.00	100
31.	62.50	162.50	32.00	105
32.	-	-	32.00	115
33.	-	-	25.00	-
34.	-	-	30.00	-
35.	92.50	-	31.00	-
36.	62.50	-	37.30	-
37.	62.50	-	43.00	-
38.	62.50	-	50.00	-
39.	-	-	-	-
40.	-	-	-	-
41.	-	-	-	-
42.	77.50	-	-	-
43.	82.50	-	-	-
44.	82.50	-	-	-
45.	82.50	-	-	-
46.	-	-	-	-
47.	92.50	-	-	-
48.	97.50	-	-	-
49.	77.50	-	-	-
50.	77.50	-	-	-
51.	77.50	-	-	-
52.	-	-	-	-

SOURCE: Traders in Kibirichia and H.C.D.A. Records.

APPENDIX 10

Monthly wholesale gross margins for potatoes bought at Kibirichia and then sold in Wakulima Wholesale market (1976 - 1977)

Month	Kibirichia wholesale prices	Wakulima wholesale prices	Wholesale gross margins mark up
1976.			
Jan.	18.00	55.00	37
Feb.	25.00	60.80	35.80
March	26.00	64.00	38.80
Apr.	-	70.80	-
May	-	87.50	-
June	-	67.50	-
July	30	60.00	30.00
August	32	62.50	30.50
Sept.	31	71.50	40.50
Oct.	45.60	62.50	16.90
Nov.	-	80.80	-
Dec.	-	85.00	-
1977.			
Jan.	32.00	58.75	26.75
Feb.	46.25	60.00	13.75
March	55.00	63.10	8.10
Apr.	40.00	53.75	13.75
May	53.75	63.75	10.00
June	73.75	85.60	11.85
July	95.00	110.00	15.00
August	105.00	148.10	43.10

SOURCE: H.C.D.A. Records
Mbogoh S.K. Production and marketing of potatoes in Kenya.
M.Sc. Thesis 1976, Nairobi

Survey carried in February - June 1976.

APPENDIX 11

Average potato prices in Kibirichia market and Wakulima wholesale market between 1974 - 1977

KIBIRICHIA

Shs/bag 100 kgs

	1974		1975		1976		1977	
	Monthly	Quarterly	Monthly	Quarterly	Monthly	Quarterly	Monthly	Quarterly
	Shs.	Shs/bag	Shs.	Shs/bag	Shs.	Shs/bag	Shs.	Shs/bag
1.	33.75		22.50		18		32.00	
2.	34.60	33.45	30.60	28.30	25	23	46.25	44.40
3.	32.00		31.90		26		55.00	
4.	30.00		39.70				40.00	
5.	29.00	29.00	50.00	44.85			53.75	55.80
6.	28.00						73.75	
7.	25.00		27.80		30		95.00	100.00
8.	28.00	27.00	25.60	27.30	32	31.00	105.00	
9.	28.00		28.50		31			
10.	36.30		31.20		45.60			
11.	40.00	39.10	25.00	29.00		45.60		
12.	41.30		30.75					

Appendix 11: Continued

	Monthly	Quarterly	Monthly	Quarterly	Monthly	Quarterly	Monthly	Quarterly
	Shs.	Shs/bag	Shs.	Shs/bag	Shs.	Shs/bag	Shs.	Shs/bag
WAKULIMA:								
1.	50.40		66.10		55		58.75	
2.	56.25	58.00	69.40	68.75	60.80	60.2	60.00	60.60
3.	67.40	70.75			64.80		63.10	
4.	71.10		78.90		70.80		53.75	
5.	79.40	66.00	99.40	89.20	87.50	75.30	63.75	67.70
6.	47.50		89.40		67.50		85.60	
7.	41.50		60.00		60.00		110.00	
8.	42.50	44.50	54.40	4.60	62.50	64.70	148.10	129.05
9.	49.40		49.50		71.50			
10.	50,00		60.70		62.50			
11.	74.00	65.70	65.00	61.70	80.80	76.1		
12.	73.00		59.60		85.00			

SOURCE: 1. H.C.D.A. files

2. Mbogoh S.K. production and marketing of potatoes in Kenya, M.Sc. Thesi 1976, Nairobi.