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Technical Report

TRADITIONAL FOOD PROCESSING AND SOLAR DRYING IN SUDAN, YEMEN ARAB REPUBLIC, SOMALIA AND PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN

by

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PREFACE

This report by Dr. Speirs deals with the work done in connection with an ILO-executed project on food processing and solar drying which was financed by the United Nations Financing System on Science and Technology for Development (UNFSSTD).

The project duration was from 17 July 1983 until 16 August 1984, during which time an expert was based at the Food Research Centre (FRC), Khartoum - a scientific unit of the Agricultural Research Council (ARC) of Sudan.

However, the activities of the project were not confined to Sudan and the expert spent some considerable amount of time in undertaking missions to the other countries participating in the project; Democratic Yemen, Somalia and the Yemen Arab Republic. In Democratic Yemen, the project activities were conducted through Al Kod Research Centre, a scientific unit of the Ministry of Agriculture and Agrarian Reform, undertaking broadly similar functions to the FRC in Sudan. In Somalia, co-operation was established with the Refugee Agricultural Unit (RAU), of the Ministry of Agriculture, a unit striving to enhance the scope of agricultural output of displaced peoples in Somalia. In Yemen Arab Republic, the expert worked directly with the Ministry of Agriculture.

One of the main objectives of the project was the promotion of technological self-reliance of rural areas in the participating Arab countries. The project activities consisted of assessment of technologies used in the food processing sectors of these countries, selection of appropriate technologies and construction of prototypes and organisation of training programmes and study tours for extension workers, etc.

This report includes a review of food processing sectors of the four participating countries.

CONTENTS

I. INTRODUCTION

It was an objective of the project to promote technological self-reliance by enhancing the capabilities of the rural food processing sector within the region. Implicit within this objective is the notion that a common problem should be evident for which a common solution can be found. This is not unrealistic since the fundamental principles governing good food preservation practices are the same irrespective of the country, commodity or process.

In each of the countries visited by the expert a survey was made of the traditional small-scale sector and comparisons made with the mainstream of large-scale industries. The industrial processes are based, not unnaturally on commercially established manufacturing principles. The rural processes; traditional methods learned by rote are also based on the same fundamental scientific processes. However, in the latter case the parameters governing the process may not be fully understood or controlled to the same extent as in the industrial equivalent. Indeed rural or traditional products are often valued for their unique or individual characteristics.

As expected, a diverse range of products and processes were identified in the region. An evaluation of these showed that in many cases while the basic method was sound, improvements could be made to reduce losses and/or improve quality without adversely affecting the traditional nature of the product.

Sun drying is held to be the oldest food preservation method known to man and is believed to have developed in the Middle East in conjunction with the cultivation of edible food grains. The drying of foods was seen to be the most important process in the various rural sectors of the region studied, reflecting the worldwide importance of this technique.

The region is particularly well favoured for the application of sun drying since it is within the part of the world which receives the highest average level of irradiation. The techniques used within the region have been well documented, as reported within this document and elsewhere, and detailed technical data on possible modifications or improvements are available in the scientific literature.

Subsequent to the study tours, it was decided therefore to concentrate project activities on the dried goods of the region with a view to enhancing the output and quality where possible with all the concomittant benefits this implies.

The approach considered was threefold:

- to improve on existing sundrying methods;
- to introduce processing aids such as blanching and sulphuring;
- to introduce new methods, such as solar drying.

Solar driers are of particular relevance to the region since they can be considered as devices for enhancing sun drying capabilities. At their simplest they can be considered as hot boxes or modified horticultural greenhouses generating hot air which is used to dry foodstuffs. As such their construction and maintenance costs are low and they can be built using simple tools and mainly local materials.

With this consideration in mind, one can considere the country-specific findings of the project.

II. REVIEW OF FOOD PROCESSING IN FOUR ARAB STATES

1. SUDAN

Like most developing countries, Sudan has an increasing population putting greater demands on the agricultural sector to meet the food requirements. The response to this demand has been two-fold with increased agricultural production and more efficient utilisation of existing food-growing and processing capacity. In some instances, attempts to operate the food processing industries at full capacity have been hampered by the logistical problem of obtaining sufficient quantities of raw materials. This is not necessarily due to shortfalls in production of those materials, but can be attributed in part to transport problems such as poor roads which may be open only in the dry season and shortages of vehicles and fuel. Transport costs are high and the distances to reach the marketing outlets are vast. At harvest time, there may be insufficient labour available. These factors combine to provide instances where some of the produce may be left to spoil in the field. To reduce such post-harvest losses, the case for localised smalller processing units can be made. The potential for decentralised processing exists in the rural areas and could complement the activities of the industrial sector.

A range of traditionally processed foodstuffs are described indicating that a wide variety of small-scale food-processing skills are available in rural areas. The popularity of sun-dried produce, the extent of its availability and the comparative ease of its production identifies this sector as worthy of detailed investigation. A complex network is described showing how dried foods find their way onto the Khartoum markets in sizeable quantities. It is difficult to identify the character of the individual farmer/processor as this fragmentary industry has not been subject to any detailed study. Certain major production areas have been located in preliminary studies undertaken by the FRC, where it is anticipated, extension work in the field of improved drying technologies, including solar driers, could be carried out. This work would be undertaken in conjunction with technical and socio-economic studies of existing practices.

The Sudan is the largest country in Africa, about one million square miles. Its area is 8.3 per cent of Africa and 1.7 per cent of the land area

of the world. Of the total area of the country (597 million feddans, with one feddan being approximately one acre), 200 million feddans are suitable for crop production.

The structure of the economy is similar to many low income countries, being heavily dependent on agriculture and mainly on a few cash crops such as cotton, oilseeds and gum arabic. Cotton, previously the major cash crop, is produced mainly in the Gezira and Er Rahad schemes. A large traditional sector characterises agriculture in the Sudan, using traditional implements and techniques. Some 72 per cent of the population are employed in this sector producing 37.2 per cent of the GDP in 1981/82. The modern sector in agriculture constitutes more than 29 per cent and is generally export-oriented. Agriculture contributes more than 90 per cent to the export earnings of the economy. In 1979, cotton contributed approximately 65 per cent, a figure which decreased to 24.9 per cent in 1982 due to the increased importance of other cash crops.

Great importance is placed on the agricultural sector by the Government with about 30 per cent of the total investment in the public sector directed to agriculture (éS327 million for the years 1980/81-1982/83). In addition, a policy of export promotion is being laid out to increase the production of export crops, especially cotton.

The agricultural products are divided into cash crops and food crops. The value to the economy of Sudan of the major cash crops is shown in Table I. The food crops include dura, millet, wheat, rice, vegetables and fruits. Table 2 shows the area and production of food crops in the Sudan for the years 1979/80 and 1981/82.

Population

Due to the high and constant level of fertility, accompanied by declining mortality, the Sudan has a rising population with 43 per cent of its population under 15 years of age. Given the trend, it is likely that the population will continue to rise and the average age will be lower in the future, hence the need for more food which is expected to be provided by an expanding agricultural sector. A government census recently published gives an actual population in Sudan of 21,592,582 for 1983 with a growth rate of 2.8 per cent per annum.

The Sudan has the potential to increase food production to meet the needs of an increasing population since of the 200 million feddans of fertile soil only 40 per cent are currently utilised. Increased food production would enable Sudan not only to become self-sufficient but also to export foodstuffs to neighbouring countries in the Arab world and Africa.

FOOD PROCESSING

Industrial Sector

In conjunction with expansion of the agricultural sector, the existing food production capacity needs to be utilised more efficiently through the development of food processing industries. In recognition of this, the Sudan has a policy of increasing industrial capacity for the processing of cash crops (e.g. oilseeds) and the production of a range of foodstuffs for both the domestic and the export markets. These foodstuffs range from basic commodities such as sugar, to convenience foods like tomato paste and fruit-based drinks.

Processing industries have been established in the Sudan in the fields of oilseeds, fruits and vegetables, confectionary, flesh-foods, sugar, cereals, beverages and dairy products. Some of these are considered below.

Oilseeds - This is one of the oldest and most developed industries in Sudan. Vegetable oils are extracted from cotton seed, sesame seed, groundnut and castor seed. Production capacity is in the order of magnitude of one million tonnes per year; however, utilised capacity is less than 50 per cent of this figure. Camels are used in traditional oil expellers. Developments in this industry have resulted in a programme of introduction of new machinery and equipment. Although there are difficulties in finding raw materials for cotton seed expellers, groundnut expellers have no such problems of supply. The export of sesame and groundnut oil, cake and meal, was worth an estimated éS24 million in 1982.

Sugar - The sugar industry started in 1962 with the establishment of a factory and farm in El Geneid. In 1981, the number of factories and farms had increased to 5 which belonged to the public sector and one in the private sector. The public sector factories produce some 340,000 tons of sugar per annum. The private sugar company (Kenana Sugar Company) is considered to have one of the largest factories of the world, producing 330,000 tons of sugar per annum.

Fruits and vegetables - This processing industry is a relatively new concern in the Sudan having been established for only some 20 years. The factories in this category produce heat-processed and dehydrated products. The principal canned and bottled products are tomato paste, vegetables, peas and beans, and jams. A serious problem experienced is factory operation at less than full capacity due to vagaries in supply of raw materials. This is due to seasonal shortages and also to insufficient raw material being available close to the factory. The infrastructure in rural areas is not developed sufficiently to enable a steady flow of raw materials from the fields to the factory. Dehydrated onion is prepared at a plant established at Kassala in 1965. The factory has a projected capacity of 1,000 tons per annum of dehydrated onion for export, but has been running at less than 50 per cent capacity. This also has been attributed to the non-availability of raw materials at the factory gate. The onion season lasts for 4 months with a further 2 months production possible using stocks.

Dairy products - Milk production on an industrial scale is concentrated near the large consumption centres of Khartoum and Wad Medani. Production of liquid pasteurised milk in these towns is only a small percentage of what the market could absorb, but again the industry is constricted to the problems of transporting a highly perishable commodity to a centralised area. The production of spray-dried milk is also limited by supply of the raw material. At one milk factory they have diversified to produce spray-dried gum arabic and karkadeh (Hibiscus sabdariffa) in order to maintain production in times of shortfall of milk supplies. The dairy and meat processing industries suffer from the additional problem that the largest animal herds are owned by nomads and the presence of the herd near a dairy products factory may be seasonal. A further complication lies in the fact that the possession of cattle is considered meritous per se, and the owner may have little desire to consider his cattle, or their produce, as items of commerce.

Fish and meat - The Sudan has about 2 million hectares of inland water located mainly in isolated areas. Commercial fisheries are not established on a large scale and are concentrated around the major rivers and Lake Nuba. Some salt-water fish are landed near Suakin on the shores of the Red Sea. According to FAO estimates, Sudan has a fisheries potential of 30,000-40,000 tons per annum. Of the total, 70 per cent is assumed to be consumed fresh and the rest dried. Due to lack of cold-store facilities, 50 per cent of the production is spoiled. The Government has a policy of increasing fish and poultry supplies as replacements in the diet for beef which has export potential.

The Sudan has a vast livestock wealth with an estimated (1981) 54 million head consisting of 19.5 million cattle, 18.1 million sheep, 13.3 million goats and 3.3 million camels. There are many traditional slaughterhouses scattered throughout the country. Khartoum province is supplied by two modern slaughterhouses with a capacity of 1,800 cattle and 4,000 sheep daily.

Cereal processing - Cereals are the main staple food of Sudan with an annual consumption of 1.5 million tons of sorghum (dura) and more than 500,000 tons of wheat. Sorghum is used in traditional dishes, usually in the form of wholemeal flour, although decorticated sorghum is also produced. Wheat flour bread is consumed mainly in the cities. Flour extraction from the local wheat is high, some 80 per cent, which gives grey colour and grainy texture to the bread. Most bakeries in Sudan are small concerns with an output capacity ranging from 0.5 to 3 tons per day. It has been said that the hygienic conditions of these small bakeries are very poor and the quality of the bread is inferior. Biscuits are manufactured from imported flour which has the usual extraction rate of 72 per cent. However, production is often reduced due to unavailability of flour.

One of the major problems common to all the industries discussed is the uncertainty of adequate supplies of raw materials. In the rural areas transport and communication difficulties compounded with the rigours of the climate mean that it is not always possible to ensure regular amounts of the correct quality and quantity of foodstuffs.

Traditional sector

While it is essential that the problems associated with the industrial sector are surmounted and the expansion of the agro-industry sector in Sudan continues, it is useful to consider the role of the rural or traditional food processing industries. Although it is impossible to quantify the importance of the traditional sector, such products play an important role in the diet of all Sudanese people. Some of the most popular traditional foods in the Sudan are considered below:

CEREAL PRODUCTS - Cereals provide the basis of the Sudanese diet and this is reflected in the variety of traditional products prepared. Sorghum (dura) is the principal grain consumed while millet (dukhu) is the staple cereal of the rural population in Western Sudan. Both grains provide an adequate dietary supply of protein and carbohydrate. Traditional hand methods are largely employed to prepare flours from these grains. Such methods include the pestle and mortar and the saddlestone. With the first method, grain is crushed by pounding in a hollow stone or wooden mortar. Alternatively, the grain may be crushed between two stones. A typical saddlestone base is a groove or fluted stone and the grain is crushed by working a smaller stone backwards and forwards over the base.

Typical sorghum products are:

Kisra - Kisra is a fermented sorghum bread made from whole sorghum flour. It is the staple diet throughout most parts of the country. Traditionally, sorghum grain is cleaned, ground at home, then the flour is mixed with water, starter (using wild yeasts naturally occuring in the flour) and salt. This mixture is left to ferment overnight in an earthenware container. Water is added to thin the mixture to the consistency of a batter which is spread as a very thin layer using a rectangular spatula on a hot iron plate. Wood or charcoal is used to heat this plate up to approximately 160^{o}C. Baking takes about 30 seconds, then the kisra is removed by fingers and stacked one on top of the other. A good quality kisra must be white in colour, moist and soft in texture. It has been reported that about 79 per cent of the protein and 75 per cent of the calories of the diet of people in the irrigated area of Gezira is derived from sorghum in the form of kisra and aseda (stiff porridge).

In towns, consumption of bread is now higher than that of kisra.

Aseda - (Stiff porridge). Aseda is a popular food in Sudan, particularly in the South and West. The grain must be clean and free of mould. The flour should have a whitish colour (Mayo variety is most suitable). The fermented dough is added to boiling water and the mixture is cooked, with continuous mixing with a wooden stick. The cooking continues until a thick 'porridge' is produced. The aseda should be stiff enough to mould smoothly without cracking to attain a certain shape. Then it is served.

Nasha - (Thin porridge) - Nasha is made from fermented sorghum dough. The dough is mixed with water to a thin consistency. The mixture is cooked until the starch is gelatinised. Sugar and milk are added to improve taste. Nasha is usually served to sick people, young children and lactating mothers. Smooth, creamy, free flowing and light colour nasha is preferable.

Beverages - Sorghum flour is also used for the production of local beer (Merisa) and for several non-alcoholic beverages including Hilu-mur, Abrey and Huswa.

Merisa - In all parts of the Sudan, and particularly in the South, sorghum grain is used for brewing. The Mayo variety is used because of its softness and white colour. The grains are dampened and left to germinate for two days. It is then dried in the sun, and pounded to a coarse flour, i.e. malt. The malt is then mixed with cooked fermented dough, starter and water. It is then left to ferment for 4-5 days. The Merisa produced in this manner is served as an alcoholic drink, unclarified and containing yeast, grain, etc., which makes it an important food, containing proteins and vitamins, contributing nutritionally to the people's diet.

Hilu-mur - Hilu-mur means sweet and stringent and it is a non-alcoholic beverage served during Ramadan. Sorghum flour (wholemeal) is mixed with malted sorghum flour (red Feterite variety) and water to form a fermented dough. Spices, such as pepper, ginger, cinnamon and cardamon are used as well as Karkadeh extract to improve flavour and colour. The dough is then left to ferment for about 5 days. The batter is thinned and baked on hot iron plates until dry. The flakes are removed by hand and left in the sun to complete drying. It is then stored. Hilu-mur is served by first crumbling the flakes and soaking them in water for about 30 minutes before they are strained. The resulting liquid is cooled and has sugar added before drinking.

Abrey Abyed (White Abrey) - Abrey is made using sorghum flour again in Mayo variety. The flour is mixed with water and the dough is left to ferment for 3-5 days in an earthenware container which is tightly closed. The bran is then removed by straining, and spices are added to the fermented batter (fenugreek and cardamon). The fermented batter is spread and baked on a hot iron plate in very thin white flakes, these are then crumbled and soaked in water, and sugar is added. Abrey is served with ice during Ramadan.

Husua - It is also a non-alcoholic beverage made from malted sorghum flour. The flour is mixed with water and is cooked in fat until the colour turns brown. The cooked Huswa balls are soaked in water and left to ferment for one day before being served.

PULSE CROPS - Pulse crops are leguminous plants grown mainly for their edible seeds. They constitute an important source of dietary protein. They are mainly produced in North Sudan as winter crops. The most popular are broad beans (Ful Masri), haricot beans (Fasoulia), pigeon peas (Ads Sudani), and chick peas (Hummous). Most of these crops are sun-dried to increase their shelf-life. They are soaked in water over-night and cooked with meat, onions, and tomato paste to make a stew.

Tames - This is a popular traditional food, made from Ful Masri, or Hummous. Ful masri or Hummous grains are first cleaned and soaked in water over-night. The soaked grains are then rewashed and minced into a fine paste using a meat-mincer manually operated. Spring onions, garlic and parsley are also mixed in. Salt, coriander, chillies and fennel are added to the mixture before it is rolled into small balls and deep fried in a very hot vegetable oil until they cook to a brownish colour. It is served as a breakfast or supper dish, and is often served as a snack in coffee bars and restaurants.

OILSEEDS - The fats in most Sudanese diets are all of vegetable origin. The most important oilseed crops are sesame, groundnut and cottonseed.

Tahina - This is made from sesame seeds. The seeds are cleaned, then roasted and grinded to a fine slurry. The product is then stored in glass jars or plastic bottles. Tahina is used for the manufacture of a traditional food called 'Hallawa tahina' and it is also used as a dressing for salads.

Peanut paste - (Ful Sudani) - The nuts are cleaned and dehulled and roasted. These are then deskinned and the nuts are pounded into a fine paste. The paste is packed into small polythene bags and sold in local markets. Roasted groundnuts and groundnut pastes are products which can prove dangerous to health if prepared incorrectly. Since the discovery of aflatoxins in groundnut meal, considerable effort has been made to ensure that groundnuts entering the world market are aflatoxin free. Aflatoxins are poisons produced by various species of the mould Aspergillus, which develops in incorrectly cured groundnuts. While the early studies on these poisons identified them as responsible for the death of chickens fed with contaminated groundnut meal, it has now been established that aflatoxins are lethal for men and other animals. With traditional groundnut products, it is impossible to monitor aflatoxin levels and the producer may be unaware of the health implications of incorrectly cured or stored groundnuts. Any development of this traditional sector should include developing techniques to ensure the adequate drying of groundnuts.

DAIRY PRODUCTS - In town, fresh milk is available in limited quantities either pasteurised and packaged from dairies as previously described or from donkey-men who ladle volumes from a churn carried from door to door by donkey, directly into your own container. In Khartoum, it is estimated that close to 100,000 litres of milk per day are sold in this fashion, fulfilling some 2 per cent of the demand. The distribution of fresh milk outside the major towns is restricted to areas within easy distance of grazing. Milk is used to make traditional products such as butter, cheese and fermented milk.

Gebna - (White Cheese) - Full cream milk is weighed and strained. It is then heated by placing the milk container into a larger container holding water previously heated to boiling on a wood or charcoal fire. Heating is continued while the milk is stirred until the temperature reaches approximately 85°F. Then the starter, rennet, is added and mixed. Salt is also added, about 6.5 - 7.5 lbs to 100 lbs of milk. The container is left to cool covered with a muslin cloth for 2-2.5 hours. The whey is separated from the cheese by putting it into moulds and straining. The separated whey is boiled and cooled and put together with cheese moulds in tins (ratio 1:4 whey to cheese). The tins are sealed and stored, with only a tiny opening left unsealed for gases and water vapour to escape.

Roob (fermented milk) - Roob is used in making salads, for cooked dishes and also as a drink. Skimmed milk is used for making roob. It is heated for 2 minutes and left to cool before the starter is added. After the starter is added, the mixture is left to ferment for 6-12 hours at ambient temperature before serving.

MEAT AND FISH PRODUCTS - Flesh foods available in the Sudan include beef, mutton, lamb, camel, poultry, goat and fish. Lamb is eaten by preference and is traditionally served at religious festivals. Beef is the most readily available meat.

Sharmout - This is dried meat usually made from beef. The meat is washed and the fat removed. It is then cut up into strips about one foot long and one inch wide, possibly salted and hung side by side on hooks for several days to dry. The dried product is then stored in tins. The drying rate is about 4:1. The dried meat is used in making 'Mulha Sharmout', one of Sudan's national dishes. Traditionally, it is a mixture of dried meat, dried okra (both pounded), onions, and water and is usually served with Kisra and Aseda. Sharmout is generally prepared in the home from surplus meat and is not on sale generally. It is an example of a product peculiar to the individual household and is unlikely to be replaced by an externally supplied product. As such, there is little scope for its industrialisation. In Sudan, fish is of lesser importance than meat in the diet and most fish eaten is consumed fresh. This inevitably limits consumption to areas in reasonable proximity to landing sites. Preference is for fresh water species although marine species are eaten in the Red Sea Province. Dried and salted dried fish are more usually eaten in the South of Sudan or by migrant labour forces in the North. Very little smoked fish is consumed. A cured fish product common to the Northern province is Fasiekh. Fresh fish is split, gutted and has salt added. The fish is then sealed in earthenware jars, or more commonly tin cans, and left for 10-15 days. The fish is then cooked with onions, tomato paste and spices. Fasiekh is usually prepared from third class fish such as Khwara (Alestesbaremose) and Khass (Hydrocon Forahkalii), fish with a low fat content being preferred.

FRUITS AND VEGETABLES - The climate in many parts of Sudan is favourable to the production of sun-dried fruits and vegetables, because for most of the year, the temperature is high (30-40^{o}C) and humidity is low, with long hours of sunshine. Sun-drying processes include washing the fruit or vegetable, cutting it into strips or slices, and spreading these on the ground or

mats. The fruit or vegetable is then left to dry in the sun for at least two days. This process is carried out at home and on a larger scale. One of the problems of sun-drying in this way is that the products are often contaminated by dust, insects, and animals. The long drying time also has the additional problems of deterioration by micro-organisms and enzyme activity. A wide range of sun-dried vegetables and fruits are available in the local market such as dried okra, tomato slices (salsa), onions, Jew's mallow (molochea), limes and dates. Dried okra is available in three forms, slices, whole or powdered. Even when fresh okra is available, there is always a demand for the dried product, since it is an ingredient of the traditional dish 'mulah' described previously. Okra is cultivated throughout the year on irrigated lands, and is also available as a seasonal crop from land watered during the rainy season. The cultivation of okra in cotton growing areas is restricted as it harbours pests detrimental to the cotton plant. It has been said that in recent years okra has become expensive and less readily available. A wild variety of okra 'sara' is preferred dried for inclusion in the 'mulah'.

Dried tomato slices are prepared from crops from irrigated lands and they also are prepared from non-cultivated wild species in western Sudan. They are used in the same fashion as tomato paste. The tomatoes are cut in two, and dried as halves. They are stored in this fashion and powdered immediately before use. Dried tomatoes are extremely hygroscopic and storage of large pieces undoubtedly reduces any tendency to moisture pick-up.

Jew's mallow is usually bought fresh, finely chopped and added to meat dishes. Any excess leaves will be dried whole in the household. In certain parts of Western Sudan, limes are allowed to fall from the tree and are collected from the ground every other day and dried whole in the sun. The quality of the dried fruit is poor and bears little resemblance to the original lime but is considered acceptable by the consumer. Dried limes are not consumed locally but are exported to Saudi Arabia and the Gulf States, where they are used as flavourings. Dates are present in the diet of all Sudanese people, and are of considerable importance. Traditionally an infusion of dates in water is used to break the fast during Ramadan. With some nomadic tribes in the East of Sudan dates and coffee form the basis of their diet. The changes which occur while the dates dry in the sun are usually welcome, giving desired quality aspects. The dried dates familiar to European markets are generally dark-brown, soft and sticky. The varieties of dates grown in Sudan have lower sugar content which results in a harder, drier product.

SPICES AND HERBS - The principal spices preserved are whole chillies, coriander, cardamon and cumin. Ground versions of these are also available. All spices are grown for the home market and are also exported. Chilli is the most popular and is used in the preparation of traditional piquant dishes. Whole chillies are cleaned and dried in the sun, and the dried chillies are then ground to a fine powder. The powder is wetted with small amounts of water, salt and lemon juice and mixed thoroughly before it is served as a separate dish, or is added to the 'mulah', salads or most of the traditional Sudanese dishes. A herb of particular importance in Sudan is Karkadeh. The dried flowers of the Hibiscus sabdariffa are infused to give a beverage. The calyces are soaked in water at room temperature for about two hours, sugar is added to the infusion and it is served with ice as a cold drink. Alternatively, a 'tea' can be made from a hot infusion in the herb which has a traditional use as a medicine for coughs and colds In both cases, the resulting drink has a bright red colour, a fruity acidic taste and is agreeably refreshing. Sudan is the principal producer of Karkadeh with exports to western Europe.

RESEARCH INTO DRIED PRODUCTS

Supply mechanisms

Of the traditional food processes in the Sudan, drying is the most widespread and successful. Produce can be stabilised by sun-drying with only moderate effort in many parts of Northern Sudan where air temperatures are high and humidity and precipitations are low for most of the year. However, in the Southern region, which experiences more cloud over, higher rainfall and more humid conditions, greater care is required to obtain a satisfactorily dried product.

While the process is relatively straight-forward in the North with simple exposure to the sun affecting adequate dehydration in most cases, there is little standardisation and quality control of the dried products. This is reflected in the highly fragmented nature of the traditional producer network.

Surveys of dried goods offered for sale in the three town markets of Khartoum, Khartoum North and Omdurman were carried out. The sale of each commodity is controlled by one central agency which obtains supplies from merchants from the main producing region. These merchants in turn collect

the dried goods from other merchants who tour the sub-regions. These smaller merchants may buy direct from the farmer or alternatively may buy from another travelling merchant who would work his territory of small farms. Thus, the chain of supply from the farmer to the market is complex, with in most cases, not all the links being known.

An estimated 300-500 tons of dried okra is released on the Khartoum markets annually. Most of this comes from Western Sudan. The principal regional collection centres are El Obeid and Kadugli for Nubian Mountrains and Kordofan region, and Nyala for Darfur region. Smaller quantities come from El Gezira. An estimated 100-200 tons of dried tomato enters the Khartoum market mainly from Darful with Nyala and El Fasher as the principal collection centres. Some salsa is also received from Kordofan. Dried red chillies (estimated 200-400 tons) are also obtained from these two towns serving the Darfur region. Karkadeh (estimated 100-200 tons) is mainly obtained from Eastern Kordofan with Er Rahad as the regional market. Dates (estimated 200-400 tonnes) are obtained from all parts of Sudan with the largest production coming from the Dongola region in the North. In this region production has dropped due to land formerly used for date growing being lost to the High Dam Hydro-Electric Scheme. Broad beans (estimated 100-200 tons) also come from around Dongola.

Based on the amount which enters the three towns alone, it can be seen that traditional dried products form a substantial trade element. Consider the traditional process: the individual farmer is unlikely to grade his produce before washing it and leaving it in the sun to dry. Experience will tell him at what point the produce is sufficiently dry for safe storage. It is likely that the goods will be dried to this level since they are sold at this stage by the sack, that is by volume rather than weight. No consideration is given to losses ensued by animals or birds or to the contamination by dust, insects, etc. In case a farmer should consider improving the quality of his produce, the existing incentives to do so are minimal since the combining of each farmer's produce by the regional merchants ensures anonymity.

The dried goods may be stored at the central market for up to one year before being released for sale depending on demand. Typically, the produce is held loose or in sacks in storerooms. Khartoum is fortunate in being relatively arid for most of the year facilitating such lengthy storage in a casual fashion. It is interesting to note that the suppliers of dried beans

from the Dongola region area hold their stock in the North until the end of the rainy season when the humidity in Khartoum drops. Although, generally speaking, market produce is not graded, there is some indication that the consumer has certain preferences. For example, dried tomato is usually sold within six months of receipt to avoid the undesirable darkening with age. Dried beans may be sold in several grades from 'splits' to large ones known as 'super'. The preference for northern grown dates is also worth noting.

Applications of solar driers

Solar drying technology of varying degrees of sophistication can be introduced at different strata of the food processing industry. They can be considered as alternatives to large scale mechanised driers or used to upgrade the traditional produce prepared at the village level.

An example of the first case is work carried out by the Food Research Centre on a forced convection solar drier designed by the Faculty of Engineering of the University of Khartoum. This drier consists of a separate collector and drying chamber to optimise the collection of the sun's rays. An electrically powered fan forces air through the drier to give the most efficient drying times possible. The drier is constructed in mild steel with glass covers on the collector for durability. It is thought that this type of model would have industrial uses as an economically feasible substitute for e.g. mechanical driers used to manufacture dehydrated onions. The high specification of the drier design would ensure a product of comparative quality. The individual units would have a smaller throughput but several such solar driers could be installed at different localities within the onion-growing area, giving an overall capacity similar to a single factory and with the advantages of flexibility of operation. Such a design would be of little interest to the rural small-scale farmer, who is used to simply leaving his produce in the sun. The model is expensive to build, requires a source of motive power and is relatively complex to operate. Further, there is no guarantee that the marked increase in quality would be fully recognised in the market to justify the substantial increase in costs. It is believed that the application of simpler solar driers is relevant to the needs of the rural processor.

Natural convection solar cabinet driers can be made out of locally available materials at minimal costs. These have the advantage of reduced drying times, reduced contamination and spoilage and increased shelf-life for

the dried product. It has been said that products can be easily dried in the sun due to beneficial climatic conditions in many parts of Sudan. However, the use of an enclosed solar drier would result in improved quality due to reduced drying times and isolation of the produce from contaminants. It is possible that the physical act of placing the material in a drier would encourage preliminary sorting with perhaps lower quality produce being sun-dried in the customary fasion, hence leading to an elementary grading. However, the benefits to the farmer of any such grading and improvement of quality have to be established. With a solar drier it is possible to achieve lower moisture contents which bestows a longer shelf-life on the product. This would be of particular advantage with the reported marketing system.

In parts of Sudan where the climate is less favourable for sun-drying, the introduction of solar driers would have the added advantage of allowing foods to be dried which would normally be lost due to spoilage.

Methods of development

One point which has become apparent is that there is an almost limitless variety of food crops available in the Sudan, but not always in sufficiently large quantities. The most commonly consumed are listed in Table III (Annex I). The possibility of drying foodstuffs has been considered in depth by the FRC who have recommended drying methods for a wide variety of fruits and vegetables. However, at this stage it would also be suitable to investigate the preparation of solar dried versions of traditionally sun-dried products.

For the Northern province, this would be mainly fruits, vegetables, spices and herbs. It would be feasible to prepare these using the sun-drying methods developed at the FRC and to compare them with products prepared on the prototype driers to be built. Other than basic drying characteristics, the effect of shade drying and preprocess controls such as blanching and/or sulphiting could be investigated. The development of solar dried fish products would be of most relevance to the needs of the southern part of Sudan. However, due to the highly perishable nature of this commodity, any fundamental research and development would have to be done in close proximity to supplies. It would be essential to obtain market responses to 'improved' solar dried goods. Assuming this to be favourable, or at least indifferent, the response of the primary processor would have to be obtained.

It has been pointed out that there is little detailed information available on the rural dehydration industry and the FRC has instigated a project, involved in collection of such information by making visits to the principal production areas. It should be possible to identify during such work a prominent village farmer as a recipient of a solar drier. First-hand information on the suitability of the drier would then be available, the acceptability of the produce would be established at the grass-roots level and the merits of the technology could be judged by the number of farmers copying this device. Based on information collected from the market surveys, suitable areas for such extension work would be around Northern, Kordofan and Darfur regions.

Table I

Area of production of foodcrops in the Sudan for the years 1979/80-1981/82

Year	1979-80			1980-81			1981-82		
Crop	Area (1)	Production (2)	Average yield*	Area (1)	Production (2)	Average yield*	Area (1)	Production (2)	Average yield*
Dura	6349	263	6956	2068	297	9258	3345	361	
Millet	2320	309	133	2598	491	189	2618	573	211
Wheat	457	233	510	437	218	499	354	163	460
Veg.	61.1	302.4	4949	74	550	7432	81.4	620.7	7625
Fruits	20.1	91.4	4547	72.7	409.8	5637	75.1	522.1	6952
Rice	30	8	267	20	7	350	-	-	-

Source : Ministry of Agriculture, Department of Agricultural Economics, Department of Horticulture (Fruits and Vegetables do not include the Southern region).

*Kg/feddan

(1) In thousand feddans.

(2) In thousand tons.

Table II

Principal cash crops

Year / Commodity	1979	1980	1981	1982
Cotton	(65.0)	(42.5)	(19.2)	(24.9)
	151.3	113.4	68.7	120.1
Groundnuts	(4.3)	(2.2)	(18.6)	(6.9)
	10.0	5.9	66.5	33.2
Sesame	(2.7)	(9.2)	(9.9)	(7.9)
	6.3	24.9	35.3	38.1
Gum arabic	(8.0)	(6.7)	(10.0)	(8.3)
	18.7	18.3	35.7	40.1
Cake and meal	(3.2)	(5.0)	(4.1)	(3.0)
	7.3	13.5	14.7	14.6
Others	(16.8)	(34.4)	(38.2)	(49.0)
	39.1	93.3	136.1	237.0
TOTAL	232.7	271.3	357.0	483.1

*The values in parentheses give the proportionate value of each commodity.

Source : Foreign Trade Statistical Digest, Vol. 15, No. 4, Bank of Sudan, 1982.

Table III

Most popular foods in Sudan

Foodstuff	Comments
I. CEREALS	
Sorghum	Grown and consumed nationally
Wheat	Grown locally and also imported. Consumption highest in urban areas
Millet	Staple in Western part of Sudan
Maize	Less common, confined to Northern Sudan
Rice	Grown small-scale, exported or consumed in urban areas
2. ROOTS AND TUBERS	
Cassava and yams	Main source of carbohydrate in Southern Sudan
Sweet potato	Consumed boiled or roasted in South and Nile provinces Eaten in Central and Northern regions in composite dishes.
3. OILS AND FATS	
Groundnut	Everyday cooking and salad oil
Sesame	Uses as for groundnut
Cotton seed	" " " "
Ghee	Made from cows and goat milk, high consumption among nomads.
4. NUTS AND SEEDS	
Groundnuts	Consumed roasted and in stews and soups
Melon seeds	Roasted with salt
5. PULSES	
Ful Masri (broad beans)	Consumed daily
Lobia seeds	Eaten during Ramadan
Hummous (Chickpeas)	A range of pulses integral to the diet
Fasoulia (Haricot beans)	" " " " "
Ads Sudani (Pigeon peas)	" " " " "

6. VEGETABLES

Okra	Used fresh or dry, cooked with fresh or dry meat
Aubergine	Used cooked or as a salad
Jews mallows	The most important green leafy vegetable, consumed fresh or dried
Green pepper	Used cooked or in salad
Onion	" " " "
Tomato	Used cooked or in salad; also dried, used in stews
Squash and pumpkin	Used cooked
Potato	Used cooked

7. FRUITS

Oranges, limes, grapefruits	Citrus fruits common to all parts of Sudan
Mango	Common in Sudan
Banana	Widely available and cheaper than other fruits
Dates	Widely consumed in all parts of Sudan, especially in the North
Guava	Different varieties available throughout Sudan
Melon	Cheap and readily available

8. MEAT AND FISH PRODUCTS

Beef	High consumption and cheap
Mutton	Preferred, more expensive
Camel	Consumption restricted to some rural areas
Chicken	Popular but expensive
Goat	Popular mainly with nomadic populations
Fish	Consumed fresh or dried in the South and in areas around the Nile
Eggs	Popular but expensive
Milk	Cows or goats, also a range of milk products

During the course of this study it became apparent that a number of bodies are working in food processing and drying. Some of these are noted below.

- National Council for Research, Sudan : The FRC has a project approved by this body entitled 'Study of some traditional food processing and preservation methods in the Sudan'. From information obtained at the markets of Khartoum, the principal production areas of traditional products have been established. It is intended to visit these areas to undertake a six month field survey documenting the traditional processes and obtaining samples for evaluation. Improvement studies will be made with a view to introducing advanced or appropriate technologies.

- Part of the National Council for Research is the Energy Research Institute. Working with the University of Khartoum, Faculty of Engineering, a wide range of solar powered devices have been developed. These are generally intermediate or higher technology devices, an example being the proposed development of solar driven coldstores. The FRC is also involved in this venture.

- Ministry of Education and Guidance : The School Gardening and Nutrition Education Programme. This project is aimed at improving the diets, especially that of children. It started by erecting 20 school gardens in Khartoum province rural areas and training school teachers in gardening, nutrition and methods of nutritional education. Nutrition field workers were recruited and trained to teach rural women in these localities. Elementary food preparation is also covered. A training input for this is provided by FRC.

- United Nations University : A UNU workshop on traditional food technologies; their development and integrated utilisation with emerging technologies. CFTRI Mysore 18-26 July 1983. This workshop was attended by Dr. M. Kareem of FRC. The overall findings of this workshop were that the traditional food sector consists mainly of small units with no standardisation or quality control. It was felt that there was a need for information collection to define the scope of the traditional food sector and its product coverage. It was also thought that traditional technologies should be optimised to give high quality standard products where possible, to provide feasible alternatives to high technology processes. Much of the information on the preparation of traditional foods in this report is made available from a paper presented at this workshop.

II. YEMEN ARAB REPUBLIC

The Yemen Arab Republic, located in the south western corner of the Arabian peninsula, is bounded in the north and east by Saudi Arabia and in the south by Democratic Yemen. The Red Sea coast forms the western border. About 90 per cent of the country consists of a mountainous granite massif, yet the Yemen Arab Republic contains the majority of the arable land in the region. Of a total land area of 195,000 km^2, some 1,500,000 ha are cultivated of which 250,000 ha are irrigated.

Running west to east across the country, four principle zones are encountered with varying altitude, climate and vegetation ranging from tropical through temperate to desert.

The coastal strip or Tihama runs parallel to the Red Sea and measures between 30-60 km in width. This strip is a hot, humid (Table IV) almost waterless semi-desert which occupies almost 10 per cent of the country. Temperatures of 55°C have been recorded with minimum temperatures rarely below 25°. Natural vegetation is sporadic and the dry soils are subject to erosion and shifting sands caused by high winds. However, the fertile plain has potential for agriculture if irrigation is provided. The plain is watered by seven major wadis carrying run-off from the highlands. This flow is largely seasonal and varying in amount. The population in the Tihama is mainly located around these wadis, with the residue found around the ports and fishing villages on the coast. The remainder of Yemen Arab Republic is mountainous and can be divided into 3 regions. Going east from Tihama, the western mountains (300 m - 2200 m) are encountered. These rise further to form the central highlands (2200 m - 3700 m - 2300 m) which then fall away to give the eastern mountains and desert (2300 m - 1100 m). These regions each have different climatic conditions influenced by geographical location and altitude. The fact that the land rises from sea level to 3.7 km within 100 km means that a wide variety of agricultural eco-systems exist. In this upland area the population is found among the terraced mountain-sides, on the banks of wadis cut through the mountains, or on the mainly dry mountain plateaux. The sudden change in altitude undergone by the hot humid air rising from the coastal plain, results in precipitation over the western slopes when the wind blows from the south-west (May - September). During the winter, (October-February), the wind originates in the north-east bringing little moisture.

Another feature of the highly varied landscape is that any rainfall may be very localised. However, as a generalisation, it can be said that any area likely to receive rainfall will experience it during March-April and August-September, and the western facing mountain slopes receive the most. Because of this rainfall, (and to a more limited extent of underground water) 90 per cent of the population of the Yemen Arab Republic can be actively employed in agriculture.

HISTORICAL ASPECTS OF AGRICULTURE

Before the overthrow of the Imam and the radical redirection of the country in 1962, it is thought that the agricultural systems in use throughout the land changed little in the past millenia. During this period, a self-sufficient and fully integrated farming system evolved. This sytem has been said to be ecologically balanced, minimising waste and maximising the use of all products. The system is also economical in water use, simple in technology and compatible with an uncomplicated division of labour based on household organisation.

The system was labour-intensive since many of the lands were marginal and provided only a slender living. Labour was required to cultivate the land and also to maintain and develop the terraces, necessary to retain soil and water. Even when adequate rainfall was available, the harvest never provided a large surplus over the needs of the farmers family. During this period, crop production consisted mainly of grain crops, particularly drought tolerant grasses such as millet and sorghum. A limited amount of fruit and vegetables including grapes, apricots, almonds, figs, green onions, chives, chilli peppers and radishes were grown. Legumes, such as fenugreek, lentils and various pulses were also grown. However, these products were not valued as highly as the cereals and their cultivation was restricted to levels required to meet their own needs. The concept of market gardening did not exist.

The stimulant cash crops, coffee and qat were introduced 500 years ago, and cotton was commercially grown in this century. Alfalfa was grown to fee livestock which was used to provide food, transport and power for cultivation of crops and dung for fuel. Goats, sheep and camels were used mainly for meat and milk, since these animals have lesser demands on water than cattle. Oxen, donkeys and camels were used as draft animals.

The system was finally geared to meet the needs of the extended family who provided the necessary extra labour in times of harvest, planting, etc. While small surpluses may have been sold or bartered, the society was by and large self-contained.

However, since the amount of arable land is finite and the degree of expansion through terracing and reclamation limited by the available technology, the system was not able to accomodate increases in population. This resulted in a tradition of emigration which has remained a fundamental aspect of Yemeni society.

The principal centres of long term migration were Indonesia, the Philippines and Europe, but with the need for labour in the oil-based economies of the Gulf, migration was largely redirected towards this area. Such migration was usually for a shorter time with the displaced males returning home at the conclusion of contracts.

The effects of this migration were many. The overseas earnings remitted increased the family wealth making the traditional farming methods less desirable. Information from the outside world reduced the degree of isolation experienced by the villages. Migration became desirable in its own right and not just as a means of using excess labour. In turn, the farms were neglected as insufficient labour remained to maintain the complex agricultural eco-systems. The increase in migration to the oil-rich states coincided with a period of internal strife as the modern republic assumed its identity. All these factors contributed to the breakdown of the modular self-reliant agricultural system.

Opportunities in the Gulf for a migrant workforce are less now than they were 10-15 years ago as recession has reached this area. Remittances are less significant but still play a major part in the economy of the country. A shortage of males means that 80 per cent of the agricultural activities are carried out by women. This does not mean that the importance of agriculture is not recognised and there is some indication that the Government is attempting to reverse the decline in the agricultural sector. Table 4 gives the domestic food production and food imports with projections to the year 2000 for the Yemen Arab Republic. However, it should be noted that the Ministry of Agriculture and Fisheries has been established for less than 10 years and statistics are limited.

FISHERIES

The Yemen Arab Republic with a coastline of some 600 km has an estimated fish resource of 25,000 - 30,000 tons per annum. About 70 per cent of the present catch of 12,000 tons is made up of pelagic species such as herring, mackerel, sardines, anchovies and tuna.

The local fleet consists of under 1,000 vessels employing some 3,000 fishermen working out of 40 fishing villages and ports. Hodeida is the main fishing port with 40 per cent of the national catch landed. A further 25 per cent (mainly demersal species) are landed north of Hodeida while some 33 per cent (mainly pelagic species) are landed south of this port.

The handling system for fresh fish is often inadequate with insufficient ice or protection from sun to delay spoilage. However, since demand is high, the time between capture and sale is often minimal. Annual fresh fish consumption is estimated at 2 kg per head, ranging from 60 kg per head in the fishing environment to negligible amounts in inland mountain villages. A marked increase in consumption has been noted in the main urban centres which is largely due to improved distribution mechanisms.

Broadly speaking, all Yemeni people appreciate fish and consumption is only limited by availability. Where fresh fish is not available, the processed equivalent will often suffice. Fish products, mostly canned, at a cost of 28 million Yemeni Rials, were imported in 1979. In common with fishermen in Democratic Yemen, a tradition of preservation using artisan methods exists. These are based largely on variations of dehydration techniques. Both salted and non-salted dried products are made. With the method for producing dried salt-fish, pelagic species are sprinkled with salt (10 per cent approximately) and left overnight in a heap. The fish are then washed to remove excess salt and dried in the sun on the sand. A shelf-stable dry fish containing 20 per cent salt and 15-35 per cent moisture (depending on fat content) will be produced after 6-7 days, though the drying period may be extended in humid conditions, or with particularly oily species which dry slowly. The fish may be split or slit in places before salting, if large, to speed the drying process. Very small mackerel, often less than 2 cm long, are dried without salting by simply spreading them on the sand. Such small fish dry readily and the product is sold at inland markets and is called "wasef".

Dried fish is consumed in the hinterland of the country, particularly in the western highlands. The quality of the product is often poor. The fish has a high sand content picked up while drying on the beach. During drying, the fish is subject to the attack of common filth or blow fly Chrysonya megacephala. The fly lays its eggs in the flesh of the fish. The larvae which hatch subsequently devour the flesh. As the fish moisture content falls, the flesh is subject to the ravages of beetles, Dermestes frischii.

However the principal contribution to losses and spoilage of dried fish is made by animals and birds. With, in some cases, unlimited access to the fish, theft by these creatures can account for losses of over 50 per cent of the

catch. The residual fish are further contaminated by the droppings and other filth factors associated with wildlife.

In recognition of these problems, an FAO regional project is investigating methods of improving the quality and reducing post-harvest losses of the catch from the Red Sea. One method being considered is the use of a solar drier to obviate the problems associated with sun-drying of salt fish (the advantages of solar driers are to be discussed further in this report).

Other fish products include dried shark. The traditional processing method includes washing the shark, removing both pectorals, dorsal and caudal fins, and cutting off the head at the gill. The gut is removed and the split body is cut into 7 pieces, scored and salted. After 24 hours, the pieces are washed and placed in the sun to dry. "Hamid", a lightly smoked dried fish product, is also made. The fish are slightly cooked over a smoky wood fire before being spread in the sun to dry. The effect of the smoke will discourage the visitations of insects and flies during drying, reducing the extent of spoilage by these vectors.

LIVESTOCK PRODUCTION

The animal wealth is evenly distributed throughout the traditional farming sector and as such it is difficult to assess the total number of animals. Estimates for 1981 suggest that there are 3.8 million sheep and goats, 900,000 cattle, 60,000 camels and 40,000 donkeys in the country. It is thought that the total number of animals has decreased over the past 20 years. The number of draft animals has fallen as they have been replaced by fossil-fuel powered devices such as tractors for ploughing and carriage, and diesel pumps to lift well-water. A reduction in meat and milk animals can be attributed to an overall reduction in crop production due to the decline of the traditional agricultural methods. As previously mentioned, the farm is a finely balanced unit with the maintenance of animals dependent on cultivated land and crops surplus to the needs of the farmer. When surplusses are not available, retrenching on animal numbers is an obvious step.

Cattle are kept mainly for milk, ghee and meat production. Sheep and goats are kept mainly for meat, although in some instances, the milk is also used after lambing and kidding. Production is highly localised - one notable exception being the manufacture of UHT cow's milk, packaged in plastic paper laminated tetra-bricks, and distributed throughout the country. A smoked cheese is also manufactured in the Taiz area, which is of good quality, if not instantly recognisable as cheese to the uninitiated. The western uplands of

the Taiz-Ibb region receive the highest rainfall in the country and as a consequence, have some relatively lush pastures. Agricultural development projects in this area have as one of their objectives a plan to increase the number of cattle.

In the greater part of the country, there is no need to apply even the most elementary of preservation techniques, since demand far outstrips supply for fresh products. The tradition of self-sufficiency still remains in the villages and it is not usual for one farmer to set himself up as the supplier of daily goods to a whole community. Thus, in the agriculturally employed family, each looks towards the immediate needs of his own family. When a small animal is slaughtered, there is seldom surplus meat requiring preservation. However, the villagers spoken to in the upland areas were familiar with techniques of sun-drying strips of meat (this is common with the inhabitants of hot arid zones of the other project countries). When a larger animal is to be slaughtered, the excellent network of roads in the country means that the meat can be sold fresh in the urban markets. Cattle are considered as capital investments and a means of storing wealth. Their maintenance, a high cost operation, depends on the cultivation of alfalfa which may need to be supplemented, at a cost, with outside sources. Hence, it may be expected that when it becomes necessary to part with an animal, the most profitable path will be followed which means the urban fresh meat market. Indeed, preference for locally grown beef, and the willingness to pay the premium for it, has been identified as a factor contributing to the decline in herd numbers in YAR.

CROPS

Cereals and pulses

Sorghum and millet, drought tolerant grasses are the staple food grains in the country, representing 80 per cent of grain production. Sorghum is by far the most important crop in irrigated as well as rainfed agriculture in upland areas. In the drier Tihama, millet is the principle crop since the low rainfall makes sorghum a high-risk crop.

When fully ripe, the sorghum heads are cut and allowed to dry completely by spreading them on a drying floor in the sun. Sorghum grain is stored loose in the cool north-west facing lower storey of the farmers house. In this fashion, sorghum can be kept for one year without major losses. Under conditions of higher temperature, storage times are reduced and post-harvest losses of 50 per cent can be experienced.

Millet is harvested and stacked in the field to dry. The seed-heads may then be stored in underground pits in a safe condition for up to one year. In irrigated areas, there has been a tendency to replace sorghum with maize. However, this crop still represents less than 10 per cent of the grain harvest.

Wheat and barley have also been grown in the highland areas for centuries. Their cultivation is generally limited to the winter season. The area under barley has declined due to the increased availability of imported wheat flour. In common with most countries, there is a parallel increase in consumption of bread from wheat flour in urban areas. Wheat and barley are grown mainly for household consumption with shortfalls in needs being met by imports. These crops are stored using the same method as for sorghum, although in some instances, wheat purchased from outside may be stored in tins in the house.

All of the cereals are used for breadmaking. Bread plays a major part in the diet of citizens of Yemen Arab Republic, and this is reflected in the variety of breads made, not only in the home, but by commercial bakers. A visit to the bakery in any town market will reveal a variety of unleavened and leavened loaves made from sorghum, millet, maize, wheat, barley, and also from fenugreek flour.

Pulse crops are grown with the grains. In order of importance, these are cowpeas, mung beans, fenugreek, lentils and peas. These crops are used for both feed and fodder purposes.

POTENTIAL CASH CROPS

The main cash crops are cotton and oilseeds, and these are grown only in irrigated areas. Cotton production has dropped due to the lack of investment and production difficulties. This industry formerly provided YAR with its foremost export but it is thought unlikely that it will revive due to depressed world prices and the presence in YAR of more profitable alternatives.

Oilseeds, in particular sesame, are cultivated but usually sold intact as a confectionary item, rather than being pressed to expel the oil. At present, the country's needs for edible oil are met by imports. Increased production of oilseeds crops such as sesame, safflower, groundnut, soyabean and sunflower, together with the installation of pressing plants, could meet the needs. However, as in the case of cotton, it is thought unlikely that these crops would find favour with the farmer who could plant more profitable alternatives.

The most profitable crops for diversification are considered to be fodder, fruits, vegetables and a particularly local phenomenon, qat, Catha edulis.

FRUITS AND VEGETABLES

There is a large demand for fruits in YAR which in the recent past has been largely met by imports. A recent government moratarium on the import of fresh fruits has the objective of increasing consumption of locally grown produce, and in particular, grapes. Fruit production in the YAR, with the exception of grapes, is low. Figures for 1981 give an annual grape production of 64,300 tons with the figure for all other fruit combined as only 80.700 tons. Grapes in fresh and dried form have been traditional exports over centuries. The percentage of grapes dried by the farmer depends on the relative market position of fresh versus dried. The method of converting grapes to raisins in the Sana'a valley was described by farmers. The grapes are spread on top of the vines on the ground in the sun to dry. This direct sun drying can take up to 35 days to reduce the fresh weight of the grapes by 50 per cent. The harvest time is September-November and Table 3 gives the climatic conditions during this period. Some farmers are aware of the technique of checking where the grapes are dipped in lime solutions to break down surface waxes and aid moisture transfer across the skin - to speed the rate of drying. However, this is not universally applied, particularly not among the smaller farmers. The method of drying used is not standard across the grape growing sector. Many farmers shade dry the grapes, a method which takes longer but which is held by most authorities to give a better quality raisin. The decision on what percentage of the crop to dry may only be made after harvest when the market conditions for the fresh fruit become apparent. In the present situation, the shortage of imported fruit has resulted in an amplified market for fresh grapes.

Since the production of all other fruits is far below demand, the question of preservation does not arise. In the upland areas, apricots, peaches, pomegranates, pears, lemons, figs, and apples are grown but the total orchard area is less than 5 per cent of the area under irrigation. Dried apricot and a variety of fruit juices have been produced from this produce in the past when an excess over fresh needs was produced.

On the coastal strip, the cultivation of tropical fruit including mango, banana, and papaya is being encouraged to provide fresh produce for the extensive existing market. A mango pulp drink is packed on the equipment of the UHT milk processing plant. Fruit cultivation is considered a promising

area of development with the advantages of lower labour and moisture requirements over other crops, and providing a valued commodity.

Vegetables have a low priority in the Yemeni diet (compared with meat and cereals) and a relatively limited range of vegetables has been grown in the country. These include chilli peppers, tomatoes, potatoes, garlic, onions, radishes and chives. Production has been largely centred around urban areas in the Tihama. External influences introduced by returning migrants have resulted in increased interest in vegetable consumption, but consumption is static and the country is by and large self-sufficient in vegetable production. Consumption is mainly limited to fresh products. In common with other countries in this region, some dried hot pepper is produced, mainly in the Taiz area. This production is centred around the output of farmers in the mountain villages which is variable and sporadic. Only the red chilli peppers are dried. Both direct sun and shade drying are employed depending on the time of the year (chilli peppers can be grown all-year round). Little thought is given to the effect of drying method on quality, other than the primary consideration of reducing moisture content to a safe level in a sufficiently short time. Drying periods of 7-10 days were quoted. It was stated on several occasions that the fresh chilli would always be preferred and the dried product always considered second-best.

Other than hot pepper, where fresh vegetables were not available, canned produce would be used. There is a tomato paste factory in Hodeida, but all other canned goods are imported.

STIMULANT CROPS

Qat, Catha edulis, is a woody shrub grown extensively in YAR. The fresh immature leaves are chewed daily by 75 per cent of the adult male population for their stimulant properties. As a consequence of demand levels and the high value placed on this crop combined with relative ease of cultivation and guaranteed high returns, increasing areas of land are being planted with this crop. This in turn reduces the amount of land available for other crops.

A variety of Arabica coffee is grown in YAR which is greatly favoured by the local population. Both bean and husk are used and the method of drying the coffee cherry simply relies on placing the fruit in the sun, either on a drying floor or on the flat roofs of the houses. This method contrasts with that common in other coffee growing countries where fueled mechanical driers are used. However, in many coffee growing countries, the harvest coincides with a wet season which renders simple sun drying methods impractical. Demand

for Yemeni coffee is now almost entirely local and growing conditions must be rigorously controlled. Decreasing popularity combined with low profitability means that many coffee growers are switching to qat production.

DEVELOPMENT OF THE RURAL FOOD PROCESSING SECTOR

Of the different regions of the YAR, only the remote eastern highlands leading to the so-called empty quarter, have a continuing tradition of preserving a range of foodstuffs. The method used, as is to be expected with the hot climate, is sun drying. The products made, entirely for local consumption, include dried meat, okra and tomatoes. These products are largely unknown thoughout the rest of YAR. This reflects the difficulty of communication throughout most of the country. It has been noted that YAR contains a multitude of climatic zones within a comparatively small area. This gives a season of almost 12 months for most crops, with fresh produce always being available within the country.

It has also been noted that the production of most crops is less than needs (cereals can be excluded from this discussion since they are essentially preserved at harvesting) resulting in no surplus for storage or preservation. Notable exceptions to this are grapes (in the Sana'a area) and chilli peppers (in the Taiz area). However, preference will always be for the fresh produce. The Yemeni consumer is familiar with fresh produce and any tradition of using dried goods has largely died out. This is another aspect of the radical redirection of Yemeni society in the past 20 years.

Where fresh goods are not available, the consumer, even at village level, will opt for the canned alternative. Exposure to outside influence through migration and the development of a cash based society through the remittances sent home by migrants has led to the infiltration of consumer goods, including convenience foods, at all levels of Yemeni society.

Even the smallest village store contains imported canned foodstuffs. A link with the past has therefore been broken with many Yemeni no longer familiar with previous local practises of food preservation such as salting, drying or pickling (grapes can be used to produce an excellent vinegar). This situation is more common to the industrialised western countries.

The consensus of opinion is that increased fruit and vegetable production would provide employment in the rural sector and yield crops of high value which could be readily assimilated in the market place. The wide variety of climates from tropical to temperate means that an equally wide variety of

fruit can be grown. The potential for production of high quality vegetables has been said to be tremendous since virtually every known vegetable can be grown in YAR. Although it has been said that YAR is self-sufficient in vegetables, per capita consumption is low and increased production would only be beneficial to the diet. It is encouraging to note that the projects that we visited recognise this and are actively promoting increased and diversified fruit and vegetable production.

Other than increasing the availability of produce, the concommitant advantages in the labour situation can be considered. A reduction in migration to Saudi Arabia and the Gulf States has resulted in an increased number of the rural population seeking employment locally. The reduced inflow of remittances will lead to a decrease in the consumption of imported foodstuffs and consumer goods.

The increased availability of family labour (it is thought unlikely that paid employment in any substantial amount will be available in the rural sector) could lead to a revival of agriculture with the production of surplusses. Some of these surpluses could be used to establish an agro-industry on a household or village level providing substitutes for the less readily available imported goods in the villages.

Another area being promoted by the extension workers with whom we spoke, is the development by women of farm gardens. The produce raised would increase the nutritional standard of the family diet and would also provide an income generating activity. Surplus food could be processed into value-added products.

Appropriate food processing technologies considered include fruit preserves (e.g., apricot, peaches) and juices (e.g., pomegranate, apple, pear) which would be direct import substitutes. In addition to this, a range of dried products to complement the existing chilli peppers and grapes could be developed.

The climate in many parts of YAR is ideally suited to sun drying with long hours of sunshine, a hot arid climate and moderate breezes. On the humid coastal strip, sun drying is more difficult, but the production of salted dried goods (e.g., fish) is relatively straight-forward since these are shelf-stable at a higher moisture content. While sun drying could be used to preserve a range of fruit and vegetables, the use of solar driers should be considered. Solar driers are simple devices which enhance the sun's rays resulting in elevated temperatures and reduced drying times. At their simplest, they are dark coloured cabinets glazed with glass or polyethylene which collect the heat of the sun. Within such a device, the foodstuff dries

to a lower moisture content which gives it a longer storage life. Since the product is enclosed, contamination by dust, insects, birds and animals is eliminated which also enhances the quality of the product. Perhaps the most important attribute is that since animals are excluded, theft of the product does not occur, leaving the entire batch of food available for sale or consumption.

It is thought therefore that extension workers involved in developing agro-industries in the rural sector of YAR would benefit from familiarisation with sun and solar drying technologies.

Table IV

Annual climatic record 1982 - Hodeida - Monthly average

Month	Temperature (^{o}C)			Mean	Mean	Mean
	Max	Min	Ave	RH	sunshine hr/day	windspeed (knots)
JAN	28.4	22.5	25.5	72	8.1	13
FEB	29.5	23.2	27.7	69	9.7	11
MAR	29.0	24.8	28.0	74	9.3	14
APR	32.1	26.5	29.4	77	8.1	12
MAY	34.3	28.2	32.0	67	6.7	9
JUN	35.2	28.3	31.5	64	8.0	10
JUL	36.0	30.0	33.1	64	9.2	8
AUG	36.0	30.0	33.0	63	N/A	8
SEP	36.0	29.0	33.0	63	8.0	7
OCT	33.8	26.0	30.2	64	9.2	6
NOV	31.4	25.5	27.5	68	N/A	6
DEC	N/A	N/A	N/A	N/A	N/A	N/A

Figures Courtesy of Civil Aviation and Meteorological Authority
(Data representative of other years)

Table V

Annual climatic record 1982 - Taiz - Monthly average

Month	Temperature (°C)			Mean	Mean	Mean
	Max	Min	Ave	RH	sunshine hr/day	windspeed (knots)
JAN	24.0	16.5	19.4	63	7.1	6
FEB	25.7	14.3	20.5	56	7.9	7
MAR	24.8	17.2	21.5	61	8.6	7
APR	28.5	15.2	22.1	60	9.0	7
MAY	31.0	18.0	26.2	59	8.5	6
JUN	32.7	19.2	26.0	51	9.0	7
JUL	31.0	20.4	26.2	53	N/A	8
AUG	30.4	19.3	25.0	61	N/A	6
SEP	30.0	18.0	24.0	57	7.4	5
OCT	28.0	16.0	21.3	56	9.5	6
NOV	25.2	15.0	21.0	66	7.2	5
DEC	25.6	8.7	16.4	67	8.0	4

Figures Courtesy of Civil Aviation and Meteorological Authority
(Data representative of other years)

Table VI

Annual climatic record 1982 - Sana'a - Monthly average

Month	Temperature (°C)			Mean	Mean	Mean	Rainfall
	Max	Min	Ave	RH	sunshine hr/day	windspeed (knots)	(mm)
JAN	7.0	22.5	15.1	53	N/A	7	6
FEB	10.4	23.5	17.3	54	9.2	4	19
MAR	12.0	23.5	16.1	86	8.1	3	49
APR	12.0	25.0	18.5	68	7.9	2	35
MAY	13.0	27.0	20.0	47	9.6	3	90
JUN	14.9	29.1	22.0	30	9.5	4	0
JUL	16.0	29.0	22.4	43	8.0	3	0
AUG	15.0	28.0	22.0	51	6.5	3	17
SEP	12.1	26.5	19.0	44	9.3	4	0
OCT	10.3	24.4	17.5	53	8.7	4	51
NOV	9.0	23.0	16.0	61	8.7	3	54
DEC	7.2	23.1	14.4	56	7.2	3	0

Figures Courtesy of Civil Aviation and Meteorological Authority
(Data representative of other years)

Table VII

Domestic Food Production and Food Imports 1974-76 with Projections to 2000 for the Yemen Arab Republic.

Commodity	Production (Thousand tons)		Imports (Thousand tons)	
	1974-76	2000	1974-76	2000
Wheat	60.0	197.0	74.0	295.0
Rice	-	-	4.0	12.0
Barley	80.0	192.0	-	-
Maize	77.0	192.0	16.0	13.0
Sorghum, millet	835.0	1555.0	-	-
Sugar, refined	-	-	56.0	160.0
Pulses	70.0	98.0	-	71.0
Sesame	5.0	9.0	-	-
Veg. and Potatoes	210.0	1800.0	-	-
Grapes	35.0		-	-
Other fruit	59.0	918.0	17.0	-
Dates	5.0	b/	18.0	b/
Red Meats a/	46.88	182.3	-	23.0
Milk, cow	59.0	247.0	-	-
Milk, sheep	50.0	134.0	-	-
Milk, goat	128.0	311.0	-	-
Milk, camel	2.0	2.0	-	-
Milk, condensed, dry	-	-	5.0	19.7
Eggs	2.6	11.0	-	-
Fish	11.7	57.0	0.1	-
Veg. oils	2.8	14.0	12.4	42.0
Butter oils	3.4	11.4	0.2	-

a/ Includes beef, mutton and camel meats plus offal and fat.

b/ Not estimated.

Source: L.K. Mubashir, "The Role of Agriculture in the Long Term Economic and Social Development of the Yemen Arab Republic". United Nations Economic Commission for Western Asia, October 1979, Tables 8.1 and 8.2, and Annex 8.

3. SOMALIA

Somalia, located in north eastern Africa, is bordered by Kenya, Ethiopia and Djibouti. It forms a coastal strip of average depth 330 km around the Horn of Africa with a total coastline of 2700 km, giving Somalia the second longest coastline in Africa. The total land area is some 6,400,000 km^2 and is mostly arid or semi-arid. About 70% of the estimated population of 5 million live nomadic and semi-nomadic existences in the hinterland of Somalia. Over 1 million people are thought to live in towns and villages along the coastal strip. The residue of the population, some half million, is located in the principal agricultural area in the south bounded by the Juba and Shabelli rivers. This region contains the most fertile lands in Somalia and has the only two rivers which can be relied on to flow all year.

FOOD CONSUMPTION HABITS

The food consumption habits of the Somalis reflect the traditional nomadic background of these people. The typical diet involves the consumption of relatively few basic ingredients on a regular basis.

The principle animal foodstuff is goat. This is slaughtered on the spot as required, cut into manageable pieces and roasted over charcoal fires. Each animal is totally consumed before moving on and repeating the process afresh with a new animal. In this fashion, there is no surplus or residue for preservation. Occasionally, sheep may be substituted for goat, however, the preparation is the same. Very occasionally, camel will be slaughtered which gives a surplus of meat necessitating elementary preservation. In this case, thin strips of camel flesh will be spread in the sand and simply sun dried. This gives a product of variable quality as the centre of any strips which are cut too thick will not dry before the onset of spoilage or infestation. It may subsequently be used as an ingredient in a stew locally called 'colob' or fried together with tomatoes and onions.

A dried cured product, 'saaf', is obtained by smoking thin slices of camel meat over a wood fire. Alternatively, a salted product, 'solay' is made when salt is rubbed into the camel flesh before sun drying the thin slices.

Camel milk is a main constituent in the Somali diet. It has a peculiar taste, both sour and smoky, due to the method of storage. Milk containers are usually amphorae or gourds covered with reinforcing interwoven basketwork.

Before filling they are 'sterilised' by subjecting them to a smoke. The inside of the pot is scoured with 2 smouldering sticks, then a little milk is added to rinse the container. It is customary to add this milk back to the bulk milk before filling the container. It has been said that this will increase the shelf-life of the milk to 12 hours before the onset of souring. This product is favoured for the feeding of infants. Inevitably, much of the milk will sour before consumption and the combination of smoke and sour is relished by the Somalis.

Beef is rarely available since within the nomadic culture, cattle are considered as capital and are seldom slaughtered for their meat. Cattle will be kept for their milk. Nomads pride themselves on the copious volumes of milk they can consume at a sitting.

Some butter and cheese is made but this is not common. Due to the transient nature of nomadic life, most of the flesh foods and products are eaten within hours, if not days, of preparation. For this reason, poultry and eggs are also largely absent from the diet.

Surprisingly, for a country with such an extensive coastline, fish consumption is almost negligible. This again can be explained by the nomadic herdsmen development of Somali culture with the consequence that the Somalis have turned their backs on the sea. Programmes designed to introduce fish in the market place have had very limited success due to consumer resistance. Similarly, river fish are also not popular.

Animal foods therefore form the major protein source and are also the principal component of the Somali diet. Leguminous protein sources are not common as the constant attention and time required to cultivate beans are also not compatible with a nomadic existence. The roast goat flesh is usually consumed on its own or with bread, pasta (made from wheat flour), rice or pancakes, 'njero', made from maize or sorghum. It should be noted that while meat, and goat in particular, is preferred, a plain cereal dish may form the basis of the diet of low income families.

The wheat products gained favour after being introduced in the colonial period. Rice, maize and sorghum are indigenous crops grown mainly in the agricultural area bounded by the Shabelli and Juba rivers, by the riverside peoples, who are settled farmers.

Maize is harvested when ripe, collected in stalks or bundles in the field and left to dry in the sun for 5-7 days. The leaves are then stripped from the heads and the grain threshed by hand. The grain is stored in especially prepared pits. The site for such a pit is chosen to avoid seepage of

underground water. The pit may be 3m x 4m or 4m x 5m, depending on the required capacity. A fire is lit in the pit to dry and sterilise the walls. The walls are then lined with the maize leaves and stalks and the pit is then filled with the grain. The surface of the pit is covered with the remaining maize stalks and leaves.

The process for sorghum storage is similar except that the grain is removed from the stalks by threshing or beating rather than by hand. In some places, the sorghum is stored in pits on the stalk. It has been reported that this form of storage is most satisfactory with instances of a safe shelf-life of some 30 years quoted.

The most widely available fruits are grapefruit, guava, mango and watermelon. These are all eaten in the fresh form when in season. Dried dates and raisins are available in the market, but these are imported.

Vegetables are not greatly appreciated and many of the varieties such as okra, jews mallow and cowpea leaves, common in other African countries, are absent. The preference is for vegetables introduced to Somalia such as tomatoes, onions, capsicums, chilli peppers, aubergines and garlic. These are grown in the Afgoi region and sold fresh in the Mogadiscio market. There is no tradition in drying vegetables. Although considered a luxury food by many, vegetables are also used in the low income groups to make a sauce to flavour their rice or pancakes when goat is not available.

The traditional food processing sector of Somalia is centred around the animal goods of the largely nomadic people. Consumption is mainly of freshly prepared foods although excess camel meat is preserved by sun drying. Grains are also sun dried and stored for later consumption among the residential farming community.

The climate of Somalia is ideal for the dehydration of foodstuffs using solar energy. A wet season of three months, suitable for growing crops is followed by nine relatively sunny months during which a light breeze constantly blows. As reported above, a limited familiarity with preservation by dehydration exists, which could be developed to give a range of dried foodstuffs.

Vegetables have a limited season during which they are widely available. During the dry season, there are always some vegetables to be found, however, the high price restricts consumption. This affects the low income groups who may depend on a few vegetables to flavour their cereal-based diet.

The production of dried vegetables could therefore have the multiple advantages of increasing rural employment, extending the availability of vegetables and enhancing the diet of Somali citizens.

Integrated Refugee Camp Development Project

It has been proposed that a Integrated Refugee Camp Development Project (IRCDP, SOM/82/02A/NETH), be developed in the four Jalalaqsi camps which shelter about 13,000 households. An ILO presence has been involved in several income-generating activities in this camp since July 1981.

The long-term objective of this project in line with Somali government and UNHCR policy is the self-reliance of refugees in Jalalaqsi. The immediate objectives were stated as regular cash income generated by work of refugees; - production of various commodities by refugees; acquisition of useful and marketable skills; and strengthened refugee associations and particularly the Women Committees.

One income-generating activity being encouraged by the Ministry of Agriculture through the Refugee Agricultural Unit, is the development of agriculture. Already maize and sorghum are cultivated by this unit in Jalalaqsi Camp 1, with plans afoot to develop fruit and vegetable cash crops. The Ministry of Agriculture has also sanctioned the development of 15 ha of land in Jalalaqsi Camp 2 by the IRCDP for the cultivation of fruit and vegetables. In mid-October 1983, this land has been cleared and an irrigation canal was being dug from the Shabelli river which borders the plot. It is intended that this land would be planted for the season January-March 1984. The land has been divided into 60 plots, each to be tended by one family. It has been reported that 75 per cent of the families allocated land have some agricultural experience and each family will have at least three members capable of tending the crops. The crops to be grown are : onion, variety Red Creole, tomato, varieties Moneymaker, San Marzano, chilli pepper, variety Long Red Cayenne, slimpepper.

About 50 per cent of each plot will be allocated to onions and 25 per cent each to tomatoes and chilli. A lesser area will be reserved for watermelon. Seedlings will be grown by the project agriculturalist and distributed to each family. It has been estimated that an average yield of 1500-2000 kg per ha is possible giving a potential overall production of 15 tons onions, 7.5 tons of tomatoes and 7.5 tons of chillies. Assuming a 10 week season, each of the 60 families may therefore produce 25 kg onions, 12.5 kg of tomatoes and 12.5 kg chillies per week. The distribution and sale of this amount of fresh produce,

particularly the chillies, may cause some problems. A local market for fresh vegetables exists and it is also possible to supply Mogadiscio some 3 hours distance by road. However, it is unfortunate that all the producers will be supplying the markets at the same time, depressing prices and inevitably resulting in some losses and spoilage.

It is possible to extend the season of some of these commodities by simple preservation techniques. Fortunately, the climate is ideal after harvesting for such practices, with long hours of sunlight, low humidity and a light breeze.

Of all the crops, onion lends itself most readily to simple stabilisation and storage. The shelf-life of onions can easily be extended to six months through drying and curing. The most common practice is to expose the bulbs to light winds which slowly dry and cure the onions from the outside. In this way, an impermeable shell is formed which helps to preserve the onions. Exposure to intensive sunlight or high temperatures is not essential. For long term storage, a cool dry shaded airy environment is desirable. To ensure a full storage life it is essential that onions are harvested at the correct maturity. The bulbs should be left in the ground until the leaves are three quarters withered. It is unadvisable to irrigate the crop before harvest, a device used by some farmers to increase the crop weight. Adherence to both these points will ensure that the bulbs are lifted with the correct soluble solids to water ratio, ensuring an effective curing. If the onions are lifted from the soil with too high a moisture content, increased spoilage through moulds and rots will be encouraged.

Chilli peppers can be preserved by dehydration. In its simplest form, this practise involves laying the peppers in a thin layer on the ground in the sun. After 4-14 days, depending on climatic conditions, the peppers will be dry and can be stored. Although simple and cheap, this technique has several disadvantages. It may be necessary to scoop them up at night or during rain showers, then lay them out again for further exposure to the sun. Contamination by dust, insects, animals and birds may give a poor quality product. An improvement to this process would be to lay the peppers on top of mats and trays, and if possible, allow air circulation underneath the crop. This would make them easier to handle and the problems of contamination would be also reduced. A marked increase in quality could be attained by the use of solar driers, simple enclosed cabinets which enhance the effect of sunrays. Solar driers have the advantage of reducing drying times, the elimination of contaminants and a lower final moisture content which enhances shelf-life. All these factors contribute to an increase in product quality. However, as

in the case of the Sudan, it has to be established in the market place whether any such increase in quality can command a higher price, justifying the use of the more expensive improved technology. The dried peppers should be stored in sealed containers in a cool dry dark environment to retain the optimum colour and flavour, and pungency. The preparation of ground chilli powder for the market is an example of product value enhancement and it should be possible to prepare this at the village level, or cooperative, using traditional grinding techniques. The grinding of chilli peppers should be delayed as much as possible until sale in order to retain the characteristic piquancy and colour. It has been reported that much of the chilli powder available on the market is of poor quality and possibly extended with other materials. The opportunity therefore exists to supply a good quality chilli powder to an existing market.

Tomatoes may be preserved by drying. In the Sudan, the practice is simply to slice the fruit in half and dry it in the sun. Dried tomatoes prepared from wild species, are used in the rural community in the same fashion as tomato paste. However, the product is not known to the Somali people and it can also not be said whether the varieties being grown will be suitable for sundrying. Although suitable for sundrying most commodities, it is not known if the climate is sufficiently arid in Somalia for drying tomatoes. Tomatoes are hygroscopic and the regions where they are successfully dried in Sudan are exceptionally arid. For these reasons, it is thought that pending the outcome of further investigations, the present crop of tomatoes should be marketed fresh.

Dehydration practices

While the rudimentary preservation of foodstuffs by dehydration at the village level is not widely practised in Somalia, the potential exists to extend this technique. The refugee camp at Jalalaqsi presents a controlled, albeit artificial environment for the initial stages of development of food dehydration skills. It may prove easier to introduce novel techniques in such locations. During visits to agriculturalists at the camp, the writer was met with enthusiasm to learn of techniques for crop preservation. One member of the Refugee Agricultural Unit has identified dried tomato as a product with potential for development believing this would enable some people to prepare tomato sauces to flavour their starchy staples in times of shortages of fresh fruits.

4. PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN

Democratic Yemen is located in the Southern end of the Arabian peninsula. It is bounded in the south by the Gulf of Aden and the Arabian Sea, in the east by the Sultanate of Muscat and Oman, in the north by the Kingdom of Saudi Arabia and in the west by the Yemen Arab Republic. The irregular southern end of the Arabian plateau is formed by ancient granites and partly covered by sedimentary limestone and sands. A flat sandy coastal strip varying in width from 8 - 15 km is present. Moving inland, mid altitude plains (1000-1500 m) are encountered and then high plateaux (1500-2000 m). The plateaux are interspersed with deep valleys and wadis or riverbeds which are normally dry and barren.

An area of importance in the Fifth Governate is the Wadi Hadramout, which runs parallel to the coast some 150 km inland. Isolated and surrounded by mountains and desert, the upper and middle part of the wadi contains alluvial soil and is irrigated by both flood and well-water giving a major agricultural area.

The climate of the country is inhospitable. The coastal plain is hot and humid (see Table VIII for data for 1982), with little rainfall. The inland plateaux benefit from cooler, less humid conditions with higher rainfall. However, it is not uncommon for the north eastern part of the country to receive no water for up to 5 years. Wadi Hadramout experiences a hot arid climate (see table IX for 1982 data), with short heavy unpredictable rain showers often occuring during April and July, through September. During April and May severe dust storms can damage the crops.

The population of the country is low, estimated at between 1.5 -2.0 million. The population of each governate is given in Table X. About 57 per cent of the population is rural, 33 per cent urban and 10 per cent nomadic. Of the urban population Aden contains about 250,000, Mukalla 45,000 and Seiyun in Wadi Hadramout 25,000. Although Democratic Yemen has a light population density, it is unlikely that the country could sustain a substantial increase. This is reflected in the estimated 300,000 Yemenis who work abroad chiefly in other Arab countries and Indonesia.

At present, agriculture and fisheries support 66 per cent of the population and while there is scope for increased fish production, the main constraint on agricultural expansion is water shortage. In recognition of the importance of this sector, the Government has implemented a capital investment programme to include fisheries and agro-industries.

FISHING

This area has a long tradition of fishing and the country's coastal waters constitute one of the richest fishing areas in the world. Cool nutrient rich waters are brought close to the shore by prevailing winds resulting in high plankton density and a resulting heavy fish population. The fish can be easily landed by small local boats. About 30 fishing villages developed along the coast containing some 13,000 fishermen. The main fishing areas with more than 60 per cent of the fishermen are concentrated in the Fifth and Sixth Governates.

The annual catch is estimated at over 800,000 tons (Table XI) and the fishing industry is capable of expansion without depleting fish stocks. The more valuable part of the catch consists of offshore fish, bottom fish, lobsters and prawns. To utilise this catch most effectively, the Ministry of Fish Wealth is encouraging the development of a modern fleet with ice and freezing facilities. Cooperation with other fishing nations, in particular the Soviet Union and Japan, has led to profitable joint ventures exploiting lobster, shrimp and cuttle-fish. Back-up facilities include a fish-meal plant, a cannery and ice plant and cold stores.

The long tradition of fishing is reflected in the variety of traditional fish products. Sardines have always been the largest catch. Traditionally, these have been sun-dried and used for fertiliser or animal feed, but seldom for human consumption. Fish are also dried for local consumption and at the cooperative level, for export to Sri Lanka and East Africa.

Small fish are sprinkled with salt (10 per cent weight) and left overnight in a heap. The moisture content will drop to 15-35 per cent which will render the fish shelf-stable since it contains around 20 per cent of salt. The process shoud be complete in 6-7 days but may be extended due to the humid coastal conditions. The overall time of drying will also depend on the thickness of the fish and will take longer for oily species. The small oily species dried in this fashion are sardine and anchovy. Larger fish may be scored or split before salting to speed the process. Some catfish are also dried for export only as this fish is not eaten by Yemenis.

Fish dried in the traditional manner are subject to extensive post-harvest losses. Birds and animals can carry off over 50 per cent of the fish as they are laid in the sand to dry. During drying the fish are subject to attack from the common filth or blow fly Chrysonya megacephala. The fly lays its eggs in the flesh of the fish which subsequently hatch and devour the flesh.

As drying progresses, the fish are then subject to consumption by beetles, Demestes Frischii.

In recognition of the problems encountered, an FAO project (see Annex 2) has investigated the use of a solar drier to produce dried, salted fish. Using this device, it was possible to obviate the problems associated with sun drying of fish.

Sharks are landed, as unlike other Arab peoples, the Yemenis enjoy this meat. Some 3000-3500 tons per annum are caught, of length ranging from 0.5 m -3.5 m and weight from 1kg - 150 kg. The shark fins are also valuable and are preserved by drying for export.

The traditional method of preserving shark meat involves washing the shark, removing the pectorals, dorsals, and caudal fins, and cutting off the heat at the gill. The gut is removed and the split body is cut into 7 pieces, scored and salted. After 24 hours, the pieces are washed and placed in the sun to dry. The fins are washed and excess flesh removed. They are then lightly smeared with salt and left in the sun to dry. The dried fins are sold in the far east.

No smoked fish products are made as such, though one product called 'hamid' utilises some smoking and roasting before sun drying. The method of preparation is one where a pit is dug in the sand and a small wood fire is lit in the bottom. Pieces of shark or fish are then filled into the hole which is covered and left for 2 days. During this period, the fire will continue to smoulder for some time partially curing and smoking fish. After this period, the fish are removed and dried in the sun. It is thought that this 'fumigation' will reduce any damage to the product by insects or beetle infestation.

Other traditional dried products include octopus and cuttlefish.

LIVESTOCK PRODUCTION

Livestock production in Democratic Yemen contributes to the diet and lifestyle of the people but to a lesser extent than in Sudan or Somalia with their vast herds of millions of head of cattle.

The animal products, meat, milk, eggs, hides and skins, are produced almost exclusively by private farmers and nomadic herdsmen and account for almost 40 per cent of the total value of agricultural production. It is difficult to give exact figures due to the uncontrolled nature of the sector, however, some data are available (Table XII).

A revised census is currently undergoing preparation. For comparison the much smaller figures for state livestock production are given (Table XIII). As beef production is much more limited than in Sudan, the most popular animal is the sheep. Cattle is raised primarily as draft animals. Fodder and forage supplies are limited and drought can result in heavy losses in cattle. Hence, meat production has concentrated on small ruminants and also camels which are more tolerant of the climatic limitations.

The picture is further complicated by the preference for fish of people living in the coastal strip which in turn would also restrict the development of livestock herds. The preference for small ruminants means that little surplus meat is produced at any one time, since one slaughtered animal can be consumed while fresh amongst the extended family of the herdsmen. In some instances, larger animals such as camels or cattle are slaughtered in inland sandy areas and the excess meat is preserved by drying. As in other parts, this process is feasible due to prevalent conditions of high air temperature and low relative humidity.

Due to the diversity of the Yemeni diet (it has been commented on in another report that the Yemenis usually eat several different vegetables in one meal unlike some other peoples who restrict themselves to one item):

Of the livestock products (Table XIV), eggs and milk are popular. Some yoghurt and butter is produced.

CROPS

Democratic Yemen contains an estimated 405,000 hectares of arable land representing only 1.4 per cent of the total land area. Of this amount only 121,000 hectares are actually under cultivation, mainly in Lahej, the Second Governate, and Abyan, the Third Governate. The river valles of the Wadi Hadramout in the Fifth Governate are also fertile and well developed.

Agricultural production is constrained by lack of water and much of the cultivated land is dependent on spate or flood irrigation which limits production to specific crops and certains times of the year when rainfall is high. After the rains in March-April and July-August, the watershed from the mountains irrigates these lands. In the Second and Third Governates, only 20 per cent of the land cultivated is watered from wells, while underground water is commonly used to irrigate soils in the Wadi Hadramout.

Over 60 per cent of the cultivated area is normally under cereals (Table 8) chiefly sorghum and millet and to a lesser extent wheat. Cereals are grown largely as subsistence crops and production is rarely greater than 20 per cent above local needs. In the case of wheat shortfalls in production are met by imports from Australia.

Large fluctuations in annual yield have been reported, being attributed largely to irregularities in flood levels. However, the overall trend has been a reduction in the area under cotton in spite of government attempts to encourage growth in this sector.

Fruit and vegetables are minor cash crops concentrated in areas near population centres. The country has the capacity to meet local demand for most fruit and vegetables, growing tomatoes, carrots, salad vegetables, okra, squash, potatoes, aubergine, melon, banana, mango, citrus and date. Bananas in particular are produced in quantity and it has been recommended by FAO that this crop be produced in larger quantities provided that markets can be found.

Agricultural development is being encouraged in the mid-altitude and highland regions of Democratic Yemen. These regions have more moderate climates and are suitable for the cultivation of potatoes and onions, crops imported at present. Production difficulties due to labour costs in the mid-altitude regions such as Wadi Hadramout are higher than on the coastal plain and are due to acute labour shortages. As a consequence, the people are used to comparatively high wages which must be matched locally if the work force is to be retained. However, in high altitude regions, crops can be grown during the summer when foodstuffs from the comparatively cheaper coastal food production regions are not available. This means that the summer grown produce enjoys a higher market price. The winter crop producing areas of Lahej and Abyan remain the principal fruit and vegetable growing regions of the country. However, the Government is encouraging the development of the complementary summer harvests in the upland regions.

AGRICULTURAL SYSTEMS

The agricultural sector of Democratic Yemen consists of a public and private sector. Agrarian reform laws have limited the private ownership of land to a maximum of 100 ha per family in irrigated areas and 200 ha per

family in rainfall areas. The excess land was nationalised and used to establish state farms. The new small landholders and the traditional farmers were encouraged to join production cooperatives. State farms are managed by the Ministry of Agriculture and Agrarian Reform from which they also receive financial, material and technical support. Cooperatives also receive Government support but most cooperative members cultivate their own land. Cooperatives are on average larger than state farms and their production more diversified. Production and marketing methods of both sectors are characteristic of a centrally controlled economy. Production levels of the various commodities are agreed and the foodstuffs are supplied to the appropriate Government marketing agency, where the produce is to be sold fresh, or to the relevant factory where processed goods are to be manufactured. State farms deliver all their produce directly to the marketing corporation or factories while the production of the cooperative surplus to local needs is made available to the State.

El Fioush tomato paste factory

A national tomato processing concern provides an example of the inter-relationship between the state farms and the various ministries concerned. A tomato paste factory was established in 1975 at El Fioush in the Second Governate. The plant has a capacity to process 120 tons of tomato per day during the season. Production is possible between mid-December and April with output peaking around the main harvest time of February and March.

The Ministry of Industry and the Ministry of Agriculture and Agrarian Reform agree on the required amount of tomato to supply the factory. The state farms responsible for meeting the factory's requirements are located within 20 km of the processing plant. Regular contact between the state farm managers and the management of the processing plant ensures a smooth supply operation.

All the tomato paste is produced and sold to the National Company of Home Trade which is responsible for distribution to the consumers. Present production does not fully meet the requirements of the country and consideration has been given to setting up another plant in the Fifth Governate in a bid to attain self-sufficiency.

An example of an inter-relationship between the cooperative farmers and government agencies can be found in the date farms of the Fifth Governate. Date production is largely contained in the Wadi Hadramout where thousands of farmers collectively provide an annual quota of dates for a date packing plant. Dates surplus to the plant's requirements may also be grown and other fruit and vegetables may be cultivated by the farmer for his own use or for sale. The Hadramout in the Fifth Governate has long relied on wells for irrigation and is the principal area of underground irrigation in the country. In the mid 1970s, there were some 3,500 wells in the Hadramout most of which have been in use for generations. An underground tunnel system for conveying water to the fields with minimal losses by evaporation has been developed.

The lack of roads and a traditional bent towards subsistence farming means that little surplus foods were produced in this area to feed the urban population. A major exception to this is the cultivation of date palms. Dates have been grown in this area for centuries supplying Mukalla, Aden and the outside world. Over 2 million date trees are cultivated in the Wadi, each with the potential to produce 20-40 kg of dates. Over 90 per cent of the palms are cultivated by 5 agricultural cooperatives in the Wadi. This region produces over 70 per cent of the dates grown in Democratic Yemen.

To benefit from this crop a date packing plant has been established at Seiyun which packs 950 tons of dates during the 3-5 month season. The climatic conditions enjoyed by Wadi Hadramout during the harvest season (July-October) means that there are relatively few problems in obtaining a good quality production with a long shelf-life. The principal stages of ripening of dates have been described:

a) Kimm - young green dates;
b) Khalal - the green dates become yellow/pink/scarlet or red
c) Rutab - the ripening period when fruit begins to soften and loses weight;
d) Tamar - the firm fully ripe stage when the dates are sufficiently low in moisture content to prevent fermentation.

Fully matured ripe dates can be considered as a naturally intermediate moisture dried food as the moisture content is sufficiently low to permit a shelf life of over 1 year if stored in cool dry conditions. Some 75 per cent

of the dry matter is sugar of which 60-80 per cent is reducing sugars, rendering the dates soft but safe from microbial attack. The residue of the sugar content is mainly invert sugar which makes the product sticky and hygroscopic, which can result in spoilage if the dates are stored in a humid environment. In some localities, including the coastal strip of Democratic Yemen, the dates will not mature fully on the palm. If high humidity or high levels of rainfall are experienced at the harvest stage, the dates will rot or ferment
before reaching the Tamar stage. In these circumstances, the practise is to remove the dates from the palms at the Rutab stage and mature them artificially. Temperatures of 35-46;C for 18-24 hours are common and maturation is complete when the fruit has lost its translucency and little or no hard tissue remains. Dehydration may also be necessary which may be carried out simultaneously with the maturation phase.

In Wadi Hadramout, the dates pass through the Rutab, Tamar transitions on the tree. The climate is sufficiently dry to permit this. The dates can be washed, graded, pitted and sent to the packing station straight from the palm and the final pack has been said to have a shelf life exceeding 12 months. The simplicity of this process has several advantages. Relatively few quality control checks are necessary and no measure of moisture or sugar content is made prior to packing. Indeed, other than simple grading, the only control step included in the process is disinfestation by chemical means. The dates can be removed from the palms in few pickings, reducing the need for handling and labour costs. This is important in an area where labour is in short supply and expensive. Each tree is picked 4 times during the season and an experienced man can harvest 25 trees a day. The work is skilled, can be arduous in the summer heat and is said not to be popular with the younger workers. To avoid the possibility of labour shortages, the possibility of mechanising this process is being investigated. The best quality dates are generally those which can be picked from the palm at full maturity. As can be deduced from the figure given for the amount packed and the theoretical value for total date production, a large amount of dates are consumed locally. Earlier reports state that reliable figures of date production in the Wadi are not available. Production was estimated at 20,000 tons 10 years ago with present production quoted at less than 4,000 tons per annum. In the past, dates were consumed three times daily but it is said that once daily is more common now in the Hadramout. The drop has been associated with the change in drinking habits from coffee to tea. Dates were a favoured accompaniment with the spicy Arabic coffee but do not go with the now popular sweet tea. Dates are processed for home consumption by forming them into a paste. The dates

are pitted, washed, then placed in the sun for 4-6 hours to remove any excess moisture picked up. The dates are then scooped into a sack woven out of date palm fronds and pressed by foot. The paste formed is stored in a clay jar, often underground and has been said to have a storage life of over 2 years. Whole dates are also stored and sold in baskets woven out of palm fronds.

TRADITIONAL DRIED PRODUCTS

Farmers in Wadi Hadramout also produce a range of dried produce. As can be seen from Table 9, cultivation is possible all year round due to well irrigation giving a diverse range of seasonal crops.

Dried pepper production is widespread. Consumption of red chilli is high amongst the Yemenis and hot sauce is usually served as a sidedish with most meals, and in particular with "zorbian", the national dish. (Zorbian consists of roast goat or lamb served with fragrant rice). It is said that the habit of eating hot chillies was brought back by migrant workers from Indonesia. Farmers in the Wadi Hadramout will grow chilli peppers for their own consumption and also will provide a small surplus for sale on local markets. The chillies are harvested when red and spread out directly on the ground, on straw or on palm fronds. The chillis are dried in a layer of 2-4 cm deep and turned only once or twice during drying. It is appreciated by the farmer that handling should be minimised to prevent damage to the peppers. There is some variation in the method of drying. Some farmers dry in shade to protect the peppers from direct sunlight which can cause the peppers to darken, an undesirable quality attribute. However, other farmers dry peppers directly in the sun. The difference seems to be because of different weather conditions at opposite ends of the pepper season. Drying times of 10-30 days were quoted depending on the time of year. Ideally, peppers should be shade dried, however, this may not be feasible in the cooler moister months of winter, in which case, direct exposure to the sun may be the only way to reduce the moisture content to a safe storage level in a sufficiently short time.

If the peppers are to be sold, the dried produce is graded on the basis of size, appearance (degree of wrinkle and translucency of testa), and absence of defects (blemishes and brokens). If the peppers are for personal consumption, they may be stored whole or else ground into a powder. Purchasing the peppers whole has the advantage that a powder of the desired piquancy can be prepared. The seeds are much hotter than the testa and can be omitted/included in the flour depending on preference.

The traditionally clay-brick built houses of the area are relatively large, airy and cool. Each farmer would have a store room, usually on the ground or first floor, reserved for dried products. A farmers annual production of dried pepper has been estimated at 40-100 kg. It is unlikely that production levels will increase greatly although there is a shortage of red chilli pepper in Democratic Yemen, being met by imports. The harvesting of peppers is a labour-intensive job. Each plant has to be picked regularly to remove the ripe pods and the value of the dried pepper is not considered sufficient to justify the work input.

As previously mentioned, labour is expensive and in short supply in Wadi Hadramout and this problem is a recurrent one when considering the development of agro-industries in the area.

Dried tomatoes are also produced by the farmers and these are retained for their own consumption. During the peak tomato season in February, the excess fruit over fresh needs, are cut in half, spread on palm mats and dried in the shade. Drying times of 10-30 days have been quoted. The dried seeds may be kept back for planting in the next season and the remainder of the dried tomatoes will be powdered. The use of this product is similar to that in the Sudan, with dried tomato powder being used by the rural population as a base for sauces, similar to the means of tomato paste consumption by urban populations.

Garlic is popular and it is customary to preserve the required number of bulbs for the whole year. The bulbs are lifted from the soil when fully matured (at this stage the leaves must be three quarters yellow) and plaited in bundles of 20 bulbs. The bundles are hung over a rope strung up in a cool dark store. This may be done by the farmer, or alternatively many families will purchase a year's supply of garlic and store it in this fashion.

Onions are also a popular crop. Onion bulbs should be harvested at the same degree of maturity as garlic to ensure the maximum storage life. Household quantities of onions are stored in dry sand. The bulbs are layered between 7 cm beds of sand and kept in this fashion in a cool, dry store until required. The quality of the stored onion is very good with a smooth crisp brown shell with no signs of mound or spoilage. It has a shelf-life of some 8-9 months. Commercial quantities of onions are stored in heaps in sheds. Some varieties do not cure well and have poor storage qualities. This has been attributed to the practise of some farmers of irrigating the crop immediately before harvest. The bulbs pick up extra moisture resuting in an overnight gain and a higher price for the farmer. However, the higher

moisture content means that it is difficult to store the onions without spoilage due to mould, or fermentation. In some instances, shelf-life of 2-3 months only. The same problem can be met if the bulbs are lifted from the soil before they are fully matured and the leaves mostly withered. A traditional dried product is made from onions, which is stored and used in times of shortage. Onion bulbs and leaves are chopped finely and mixed with chopped garlic and spices, the mixture is formed into balls and dried in the sun. The product is hard, completely dry and has a very long shelf-life.

Limes are sun dried for export. Whole limes are spread in the sun and left until completely dry. The practise is similar to one carried out in Sudan. The dried limes are exported to other Arab countries where they are crushed and used as a flavouring for rice. They are also used for cleaning gold and jewellery. A traditional lime pickle is also made. Limes are cut in two and placed in jars with common salt, chilli peppers, cinnamon and other spices, and flavourings. The product is ready for consumption after 40 days.

In general, it can be said that, other than the cultivation of dates, the cooperatives of the Wadi Hadramout do not cultivate any crops for the purpose of organised sale in the dried form.

Abyan

For comparison, visits were made to farmers of a cooperative operating near El Kod in the Third Governate. This area has the advantage of proximity to the urban markets of Aden and with the agricultural areas around Lahej in the Second Governate, provides the principal agricultural production in Democratic Yemen. The Abyan farms lie on a coastal strip and experience humid conditions. The vast majority of the lands are spate irrigated which restricts cultivation to the time when water is available. This affects local work patterns. Unlike Wadi Hadramout, where the farmers are totally dependent on their lands, many farmers in Abyan work their lands for only part of the year, holding down another job for the remainder of the time. Labour costs are also lower in this governate. This combination of circumstances is reflected in the agricultural output. About 30 per cent of the dates grown in Democratic Yemen come from the coastal areas, Shabwa and Hadramout Governate. In this area, unlike the Wadi Hadramout, the dates are picked from the palm before they are fully mature and are ripened artificially. The prevalent conditions of high humidity at the time of harvest means that a large percentage of the dates would rot on the palm if left to mature naturally.

Red chilli peppers are grown and marketed in the dry form through the cooperatives. Due to price incentives, there is little of this produce sold in the fresh form. One farmer said that he produced about 150 kg dried pepper last season and had increased planting this year to yield an estimated 500 kg.

His method of drying was to pick the red peppers and spread them on straw in the sun. After 10 days, immediately before dawn, the peppers would be pressed flat. This procedure is said to give a flat attractive shape to the pepper and reduce spoilage. Immediately before dawn is the most humid time of the day and the peppers would absorb moisture during the night making them pliable. Applied pressure would 'iron' out any wrinkles and give the peppers a better appearance. After this process, the peppers are left in the sun for a further 15 days to dry.

The pepper season lasts from December through May and the peppers will be pickled about 6 times during this period to ensure uniformity of ripening. Happily, the one month necessary to dry a batch of peppers coincides with the time interval between crops.

At a demonstration farm (part of an ILO Support Services Project), hot pepper was being grown intercropped with lime, mango and banana. The peppers were intended to give a quick cash return until the fruit trees had reached maturity.

These peppers would also be sold in the dried form. The customary method would be to leave the peppers in the sun for one month before moving them into the shade for a further two weeks drying. The dry peppers would be graded on the basis of size and blemishes.

A comparison of drying practices in the Third and Fifth Governates

In the inland wadis of the Fifth Governate, the climate is more suitable for the sun drying of crops. Long hours of sunshine, low humidity and a light breeze provide almost ideal conditions for rapid moisture removal giving a high quality dried product. An example of this is the local practise of drying composite vegetable balls containing chopped onion. Onion is highly hygroscopic and onion flakes or powder must be stored at a moisture content less than 5 per cent to avoid spoilage. In many localities, it is only possible to prevent rehydration by storing the chopped onions in hermetically sealed containers. The fact that this is not necessary in Wadi Hadramout can be attributed to the arid conditions. However, there are times when the humidity does rise, reflected in longer drying times for tomatoes and chillies

and the requirement to expose these crops directly to sun rays.

On the coastal strip of the Third Governate these latter practises described are customary with drying times around one month quoted, and direct exposure to the sun mandatory.

In these circumstances, the crops would benefit from the application of improved drying technology, perhaps by the use of solar driers. Detailed descriptions of these devices are available, but at their simplest, they can be considered as devices for intensifying the properties of the sun. The principle advantages can be summarised as follows:

- reduced drying times;
- enclosed environment excludes contamination by insects, animals and dust;
- a lower final moisture content can be attained resulting in longer storage life.

The sum of these factors means that a product of higher quality can be attained in a shorter period.

Table VIII

People's Democratic Republic of Yemen, Ministry of Agriculture and Agrarian Reform - El Kod Agricultural Research Centre*

Month	Air temperature (;C)			Mean RH	Mean sunshine hr/day	Mean wind km/hr	Rainfall (mm)
	Average	Max.	Min.				
January	25.3	29	20	81.5	8.2	7.0	10
February	26.2	30	21.3	82.2	8.3	6.4	Nil
March	26.8	31	20.3	83.0	8.1	6.6	35.5
April	28.4	33.1	22.1	81.0	7.2	6.0	Nil
May	29.6	35.2	23.7	78.3	10.2	5.2	Nil
June	31.7	36.8	25.6	78.7	8.8	5.0	Nil
July	32.0	37.0	26.3	75.0	7.0	6.2	0.5
August	31.2	35.7	25.8	80.2	6.8	6.7	0.3
September	31.1	36.3	25.0	83.4	7.2	5.5	1.0
October	27.6	33.3	21.0	82.5	9.6	6.0	1.7
November	26.6	31.6	18.3	81.3	9.2	5.4	0.2
December	25.6	29.5	19.7	83.3	7.3	6.0	8.5

*Latitude 13;05' North; longitude 45;20' East; elevation 15 m.a.s.l.

Table IX

Annual climatic record 1982

Seiyoun Meteorological Station*

Month	Temperature (;C)			Mean	Mean	Mean	Rainfall
	Min.	Max.	Average	RH	sunshine hr/day	wind km/hr	(mm)
January	12.6	27.2	19.9	77.6	7.8	2.7	33.0
February	16.8	31.6	24.2	73.6	7.6	5.1	2.2
March	17.4	34.6	26.0	64.6	8.7	5.0	16.3
April	18.6	35.3	27.0	60.5	8.1	3.4	1.1
May	20.0	37.1	28.0	54.8	9.7	4.0	--
June	22.8	41.1	32.0	55.6	7.9	3.7	--
July	25.6	41.6	33.6	50.1	7.4	4.4	--
August	25.1	41.1	33.1	54.8	7.3	3.7	68.1
September	21.4	38.6	30.0	62.9	8.6	2.1	--
October	16.5	34.4	25.5	62.6	9.2	3.4	--
November	15.3	31.4	23.3	68.0	8.2	2.7	--
December	12.3	27.8	25.5	74.8	7.9	2.8	--

*Latitude: 16; North; longitude 49; East; elevation 700 m a.s.l.

Table X

Area and population census of May 14, 1973

Governates	Population (1000)	Area (miles^2)
First	291	2,695
Second	273	4,929
Third	311	8,297
Fourth	162	28,536
Fifth	451	32,991
Sixth	61	25,618
Thamoud	41	27,000
Total	1590	130,066

N.B. In 1980, the Governates were re-organised and reduced to six.

Table XI

Fish catch by sector

(in tons)

	Pelagic species	Demersal species	Cuttlefish	Deepsea lobster	Shrimp	Others
Public sector						
1980	8722	1167	2106	338	19	81
1981	8377	1693	804	355	11	66
1982	478	2792	1467	183	12	10
Joint coops.						
1980	-	19094	7513	426	40	251
1981	-	27281	2173	496	122	-
1982	-	27549	1372	121	376	-
Local coops.						
1980	34772	-	-	-	-	-
1981	21596	-	-	-	-	-
1982	20424	-	-	47	-	-
Private sector						
1980	15000	-	-	-	-	-
1981	15000	-	-	-	-	-
1982	15000	-	-	-	-	-

Source : Ministry of Fish Wealth

Table XII

Livestock in People Democratic Republic of Yemen

	1977	1978	1979
Cattle	90,000	100,000	110,000
Sheep	855,000	870,000	970,000
Goats	1,145,000	1,180,000	1,300,000
Asses	130,000	160,000	160,000
Camels	100,000	100,000	100,000

Source : FAO Production Yearbook.

Table XIII

Meat production in State farms and projected output for 1983

Year	Dairy cattle			Beef cattle		Bullock	
	Number of heads	Total milk produced (tons)	Milk marketed	Head slaughtered	Meat obtained (tons)	Head slaughtered	Meat obtained (tons)
1981	2035	3085	2420	240	79	700	210
1982	1467	2621	2189	163	65	500	150
1983	1467	2428	2040	147	36	400	100

Source : Ministry of Agriculture and Agrarian Reform.

Table XIV

Livestock products

(in tonnes)

	1977	1978	1979
Mutton/lamb	6,000	6,000	6,000
Goat meat	5,000	5,000	5,000
Cows milk	7,000	7,000	7,000
Sheep milk	11,000	11,000	12,000
Goat milk	24,000	24,000	25,000
Hen's eggs	1,500	1,600	1,600

Source: FAO Production Yearbook.

Table XV

Agricultural production and needs in Democratic Yemen

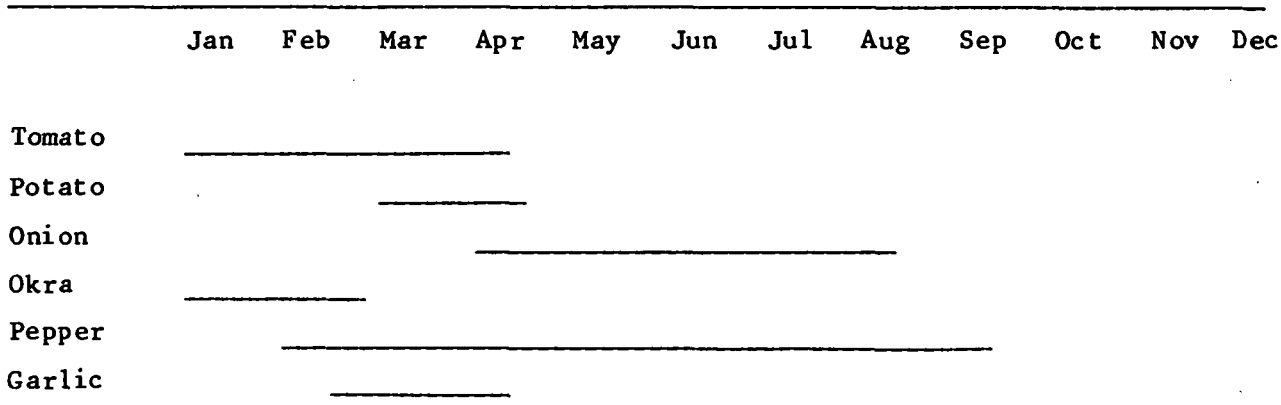
(in tonnes)

Crop	1980		1981		1982	
	Local	Imports	Local	Import	Local	Imports
Wheat	5.42	194.0	5.88	105.0	N/A	188.0
Maize	1.24	-	1.70	-	-	-
Rice	-	42.0	-	71.9	-	65.5
Sorghum	7.71	-	11.24	-	-	-
Other grains	0.12	4.0	0.12	-	-	-
Tubers	2.14	5.27	8.41	3.31	5.64	3.95
Sugar	-	48.12	-	37.55	-	48.0
Vegetables	15.86	2.55	22.13	-	15.46	3.77
Fruits	10.1	5.15	9.6	7.09	9.69	9.59
Red meat	0.28	2.55	0.27	5.69	0.17	4.64
White meat	0.14	2.04	0.28	4.24	0.44	6.72
Milk products	1.95	12.22	1.95	11.96	2.32	17.72
Fish	89.62	6.73	77.9	2.89	69.73	3.98
Eggs	16.1	32.2	14.9	30.4	22.4	40.1

Source: Ministry of Agriculture and Agrarian Reform, Department of Statistics.

Table XVI

Harvest times in the Wadi Hadramout



Source: Horticulture Section, Department of Agricultural Research and Extension, Seiyun.

III. SUMMARY OF FINDINGS AND CONCLUSIONS

Sudan, Somalia, Democratic Yemen and the Yemen Arab Republic are countries with their own cultures, customs and traditional practises. Within each country a wealth of diversity exists with different combinations of climatic, geographic and socio-economic factors giving rise to local means of food production, storage or processing, and food consumption habits in different parts of the rural sector. It is difficult therefore to establish common national threads and the extent to which generalisations affecting the four countries can be made is very limited. However, the following observations can be made.

The existing artisan skills in each country vary. In Sudan, a wide variety of cottage industries exists and the rural agro-industrial sector is well defined. A market system has been developed providing a mechanism for supplying traditionally prepared products to consumers in towns and villages. The traditional sector runs parallel to, and complements the developing modern food processing industries.

In Somalia, existing food preservation expertise is minimal, restricted to grain storage techniques in the small settled agricultural sector. The majority of the population, nomads in the hinterlands and settlers in towns and villages have no history of processing food to add value to it or to preserve it.

In Democratic Yemen, a range of traditional products is made in the rural communities, though the variety is less than in the Sudan. The importance of the agro-industrial sector is recognised and the contribution of the small farmer and fisherman supplying fresh and processed goods to meet local needs is being encouraged.

In Yemen Arab Republic, the social upheavals of the past years has resulted in a decline of agriculture with a concomittant loss of rural industries. The country relies almost entirely on imports to supply local needs for processed foodstuffs. It is hoped that this trend can be reversed.

As anticipated, dehydration is the principal method of preservation used. The four countries all share a hot, dry, sunny climate and examples of sun dried products could be found in all localities visited. Sudan has the largest range of dried goods ranging from dried vegetables such as tomatoes, chilli peppers and okra to fish and meat. Democratic Yemen also produces dried meat, fish and vegetable products. In Yemen Arab Republic, the dried goods produced were more limited though chilli pepper, meat, fish, grapes and coffee were processed in this fashion. In Somalia, in common with other countries, dried meat was prepared, reflecting the Bedouin or nomadic influence in this region.

Traditional breads are produced in each country from millet and sorghum, drought tolerant grasses well suited to the environment. Consumption of these is sadly on the decline due to preferences for wheat flour products. With the exception of some sorghum products, fermented products are absent from the region. Similarly, sugar or honey preserves are not made. Preservation by the use of salt is limited to fish products on the coastal strips of all the countries with the exception of Somalia. Pickled products are known albeit to varying extents in each country. As with dried meat, familiarity with these products reflects the close relationship between man and domestic animals.

In the countries where a tradition of food processing exists, this is reflected in the variety of foofstuffs eaten. At its most highly developed, as seen in Sudan, the result is a range of compound dishes which include a variety of ingredients. A national dish is prepared entirely from dried foods. Similarly, in Democratic Yemen, it was observed that Yemenis consider that they eat a balanced diet with vegetables playing an important part of the meal. An acquired taste for spicy food has resulted in a large consumption of chilli peppers in both fresh and dried form.

In Yemen Arab Republic, where a tradition of food processing was known, the population values a varied diet, though many traditionally prepared products such as pomegranate juice and dried apricots, are now no longer produced.

In Somalia, where a tradition of rural food technology has never existed, the diet is much more meagre, often restricted to meat and a carbohydrate filler. The absence of fruit and vegetables is worrying from a nutritional viewpoint.

The findings of the study tours showed that the rural food processing industries of the four project countries were diverse and relatively unresearched. Where traditional methods and processes had been studied and documented, the information was in many cases scanty. This is no reflection on workers in this field, but rather indicates the highly devolved and cellular nature of industries in the rural sectors. Common trends could be established. Drying, using the sun's power, proved to be a technology common to all the rural peoples of the four countries. This is hardly surprising bearing in mind the high levels of insolation recorded in this region. Work was therefore carried out to determine whether existing drying technologies could be adapted to overcome acknowledged quality deficiencies and, in the case of locations where food drying is relatively unknown, whether appropriate drying methods could be introduced. As such, consideration was given to the modification of traditional drying practices and the introduction of novel techniques.

Improved sun drying

Traditional drying practices common to the region involved laying the foodstuffs directly on the ground until, after sufficient exposure to the sun, the foodstuff is considered dry and collected up. This method has several disadvantages, not least being the presence of dust with the food. Such food may contain faeces, insect larvae and spores within its contaminants. This problem can be simply obviated by raising the food from the ground involving the use of mats, trays or racks. This simple modification to the traditional practice had already been considered within the context of the FRC project on traditional foods and sun drying racks were available for demonstration and teaching purposes.

Pre-process operations

Another consideration to improve the traditional process is the inclusion of pre-process operations, such as blanching or sulphuring, to the drying process. Consultation of the scientific literature in these fields produced a range of recommended processes for fruits and vegetables which were tabulated. The equipment necessary for these steps is of simple manufacture and can be of local origin. Blanching can be carried out using boiling water or steam produced over a charcoal stove. Sulphuring is simply done by exposing the foodstuff to a controlled amount of burning sulphur contained in a wooden box.

Alternative drying techniques

The limitations of sun drying have been described and the alternative to upgrading this technique in some cases may be the introduction of more controlled (albeit more expensive) alternative driers such as fuelled mechanical driers or solar powered driers.

However, driers which depend on fossil fuel to generate the hot air required to dry foods are not considered appropriate to the needs of the rural sector, while driers which depend on wood or other biomass are more commonly found in countries within the tropical rainforest belt. In sub-Saharan and other semi-desert locations, deforestation is a serious problem and the supply of wood and/or charcoal for cooking purposes is diminishing. Since such locations benefit from high temperatures, low humidities and long hours of sunshine, there should be no need to supplement solar radiation by burning fuels.

Solar drying

A feasible alternative to sun drying which produces dried foods of better quality is solar drying - a technology where the drying power of the sunrays is enhanced by the use of a solar collector.

This device, often a simple black heat absorbant surface is used to heat air above ambient temperatures. The heated air is subsequently used to dry the food. A solar collector with the means of containing the heated air and passing it over a foodstuff has all the essentials of a solar drier.

Solar drying technology has been developing for some twenty years giving rise to design features which have been tried and tested at various research institutes throughout the world. In many cases however, the route from research and development to extension work and acceptance by the end-user is less well documented. A survey of the state of the science identified design types which, in the author's view, would prove most suitable for use in the rural sector of the project countries. Of these, two designs were well proven. The simple cabinet drier has world-wide usage and a version has been developed by UNESCO. The second more complex design incorporating a separate solar collector and drying chamber, developed by the Asian Institute of Technology, Bangkok, has also been shown to be effective. The third type of solar drier, referred to as the 'tent', is a simplified version of the cabinet drier, which was used to dry fish in Bangladesh and was included, in consideration of the importance of dried fish in Democratic Yemen.

These three proto-types were constructed from available building materials using the skills of a local carpenter. The raw materials were those typically found in a builders yard. The cover material used was polyethylene film for reasons of cheapness and local manufacture. Where black wooden surfaces were indicated, this was achieved by applying black matt finish paint, of local manufacture. Where black film was indicated, black polyethylene sheeting, also of local manufacture, was used.

A fourth solar drier of higher technical specification was available at FRC. This drier, constructed of steel with glass covers on the collectors, was a forced convection unit dependant on power to drive a fan. As such, the unit was probably too sophisticated for the needs of the end-user to which this project was aimed, but would serve as a useful comparison when the proto-types came to be tested.

At this stage, it had been hoped to methodically evaluate the effectiveness of the proposed improved drying technologies and proto-types developed. Drying trials were to be carried out using the foods which were customarily dried in the rural sectors to give a measure of the characteristics of comparative drying rates. This could not be done due to two major limitations.

(a) Simple monitoring equipment required to record temperature and humidity profiles during the drying cycle was not available. Some essential items had been ordered but the time constraints of the project, compounded with the difficulties of locating and shipping specialist tools, meant that these items were not at hand during the period of the author's stay in Khartoum.

(b) The dehydration section of the FRC was geared to carry out simple quantitative analyses such as moisture content. However, due to chronic power shortages in Khartoum, electricity was not available at any time during the working day. This severely restricted output since all the laboratory equipment was dependant on a main power supply.

It may be mentioned at this stage, that the specialist tools ordered are designed for field work and as such are independant of external power sources. When they are eventually delivered, there is no reason why the FRC should not be able to undertake substantive work with them.

Evaluation of the effectiveness of the improved techologies was therefore restricted to empirical assessments of quality, such as visual examination and simple organoleptic evaluation.

Further to the construction of solar driers, the logical step in the training course was to use them to conduct drying studies. For the remainder of the course, a range of foodstuffs were dried; onion slices, tomato slices, carrot slices, sweet potato slices, beetroot slices, whole chillies, whole okra, banana slices, meat strips, and fish strips. The methods used for processing fruit and vegetables were described in the manual. Where blanching was called for, this was effected in a pot of boiling water, heated over a charcoal fire. Sulphuring was carried out by placing the prepared food on wooden trays inside a wooden box, and exposing the food to an environment of burning sulphur. Simple rock sulphur is readily available on the local market.

Meat was dried by firstly removing bone, fat and gristle and subsequently cutting the lean meat into strips and drying them. Fish was filletted, cleaned and dried in strips. The fish used were local freshwater river species which are not customarily salted. For the benefit of the Yemeni trainees, for whom dried salted fish has an economic importance, the expert described the process, referring them to an on-going project in their homeland (described in the study tour report), for practical experience in solar salt-fish drying technology.

In all drying practicals, solar dried produce was compared with sun dried samples (using racks). It was not possible to make use of the forced convection solar drier built by the FRC due to the lack of power.

The drying trials were carried out on the roof of the FRC in the month of May, customarily the hottest, driest month in Khartoum. Shade temperatures in the early afternoon were in excess of 45^{o}C with relative humidity less than 20 per cent. Consequently, there was no difficulty drying the food by either sun or solar means. It was however difficult to assess the relative merits of each technology, a difficulty compounded by the lack of monitoring equipment, since there was little difference in the comparative rates of drying. Both sun and solar drying gave dry products equally rapidly, after 24-48 hours of exposure. Unable to carry out even a simple moisture content test, it was not

possible to show the trainees that the solar dried produce may have inherent quality advantages over the sun dried sample. In most cases a visual assessment of the quality of the sample prepared in each way gave little difference. In the case of the banana and fish, the cabinet solar drier gave an inferior quality product. Due to excessive internal temperatures (estimated at over 80°C), the fish muscle cooked and the banana slices blackened. With greater process control, it would have been possible to advise the trainees more fully on adjustment to the drier which could be made to avoid over-heating. Where a visual assessment of quality indicated that solar dried produce was superior to sun dried produce, this was due to an exclusion of flies and dust from the former. Flies could be seen visiting produce exposed on the drying racks, and their role as vectors of disease explained. May is the month when Khartoum is particularly affected by 'haboobs', dust storms, and the presence of dust in the atmosphere could be felt, even on the roof of the FRC some 20 metres above the ground. The experience of working in a dusty atmosphere demonstrated the advantage of drying foods in the enclosed environment of a solar drier, even if the equipment was not available to give a measure of the acid insoluble ash contents of the dried goods. The quality advantages of the inclusion of the pre-process stages of blanching and sulphuring in some processes was clearly shown. For example, blanched sweet potato dried as a milky white colour compared to the brown unblanched control. Sulphured tomato slices retained their bright red colour on drying, while the unsulphured controls darkened. Sulphured produce had the additional advantage of repelling flies during sun drying.

The separate collector and drying chamber design was agreed to be the most effective, but probably the most difficult in design and concept for the small farmer to build. By reducing the plastic film content as much as possible, the drier was simplified and fortified without compromising its efficiency. Also, it was considered that while the chimney aided the air flow through the drier, its omission from the design would not greatly reduce the food drying capacity of the unit but would ease construction and potentially, improve stability. This type of drier should be most successfully adopted by larger farms since its design is geared towards comparatively high throughput.

The cabinet drier was considered the most robust and durable design minimising the use of easily damaged plastics. The unit was thought to be the one most easily to built with a variety of local materials. Problems of

over-heating and poor circulation with the cabinet had been observed during drying but these can be overcome by simple modification to operational technique as the user becomes more familiar with the characteristics of the model. At its simplest, the solution is to drill more holes in the base of the unit to increase air flow.

While the advantages of pre-process steps to improve quality were noted, the trainees thought their introduction to the rural food processor was at this stage premature. Blanching involves the use of time and fuel, while the burning of sulphur can be unpleasant and unpopular. In either case, it was thought that the processor would not be convinced that the extra effort was worthwhile simply for the extra aesthetic value added to the food. It was considered that efforts should be concentrated on providing information on drying methods to introduce dried foods where none had existed before, or, to give substantive rises in quality of existing products rather than considering the finer aspects of quality enhancements.

It has been suggested that the cabinet drier may be suitable for small users while the more specialised drier with the separate solar collector may be appropriate to larger scale application. The smaller units may be particularly appropriate to the needs of the kitchen garden producer where a small surplus over own needs is dried and sold to supplement income. This application may be particularly useful in income generating activities geared to improve living standards of rural women. Similarly, the small tent is cheap and easy to use thus allowing the processor to retain flexibility of operation while still imparting quality advantages to the end product. Since the investment cost and technical content is low, this device might also find a use with the small family unit. The larger unit could be used by a farmer who is harvesting a crop such as okra or chilli pepper in Sudan, with the intention of selling a quantity in a conventionally accepted dry form. In all cases, however, an estimation of the amounts available for drying from each food producer group should be established before deciding on the scale of the drying operation.

Conclusions

The promotion of appropriate technologies in food processing varied from country to country reflecting that each of the lesser developed Arab countries have different development priorities. It is therefore thought that any

further work in this field should be implemented on a national basis thereby concentrating on specific indigenous problems, and permitting greater scope for in depth studies.

Further work is required to ensure that driers of the correct technical specifications are designed. Evaluation of the proto-types built to determine optimum operating conditions for drying local produce was not possible during the initial phase of the project due to an absence of technical equipment. While the determination of such parameters as moisture content, air temperatures, humidities and flow rate, daily insolation values and drier bed depth loading may have little meaning to the farmer or rural food processor, it is essential that these facts are available to ensure that the recommendations made to improve drying methods are correct.

While national research institutes provide a basis for organising activities, it is essential that any further development should be co-ordinated through an agency responsible for disseminating information to the rural population. The collation of further information on existing rural technologies can be carried out in conjunction with the other development activities. In this fashion, a more complete picture of the technical and socio-economic aspects of the food processing can be attained.

Any future programmes would thus best comprise two complementary activities; on the one hand, collection of data and adaptation work and on the other hand, extension work. The collection of data and the adaptation work would be necessary to increase the existing level of documentation on rural practices, to evaluate the effectiveness of such practices and to make recommendations to improve on them or introduce novel practices, as appropriate. To ensure that this "research and development" function is not operating in vacuo, it would be essential to channel information in both directions between the rural food processor and the food technologist through extension workers. In this fashion, the specialised knowledge and facilities available at the national research institutes can be directed towards the rural sector.

One way of doing this would be by concentrating activities in rural technology centres which are intended to act as an intermediary between the national research institute and the target group in their (limited) area of influence. The function of these centres is to assess the technological needs

of the target group (in this case in the field of food processing), to introduce the appropriate technology, to undertake the necessary research and development to adapt this new technology to local conditions, to provide supporting services in the organisation of production of appropriate technology devices, to disseminate the newly introduced technology, to train the end-users in the application of this technology and to assist the producers in the marketing of the produce. This last aspect is especially important since it has been noted that no sorting or grading of produce is practised in many cases and there may thus be no financial incentive for a rural producer to market produce with enhanced quality characteristics. For this purpose, it may be necessary to carry out a detailed market survey to identify which (if any) quality aspects the consumer prefers. It may be considered necessary to provide initially a financial incentive to encourage rural processors to meet higher quality standards. Supplementing the processor's income in this fashion until the improved product becomes established would reduce the risks, help to cover any additional costs during the introduction of new driers and help to ensure the long term success of the venture. Rural technology centres could be located in the principal agricultural production areas and manned by a food technologist and an extension worker.

In the Sudan, three areas have been identified which would potentially benefit from such developments. Kassala region, Kordofan province and Northern province have been selected because of their great existing need for food processing technologies and because the necessary infra-structure to spread these technologies is, to a great extent, already present. At the request of the Government, a fully-fledged project document for the establishment of a number of rural technology centres in these regions, has been prepared.

In Democratic Yemen, three areas have also been identified, namely, Abyan, Lahej and Hadramout Governates, which would benefit from the introduction of rural technology centres. An extension network exists and the need for upgraded food processing techniques has been clearly identified.

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