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INDUSTRIAL APPLICATIONS OF BREAD-FRUIT.

SI/MOT/77/801.

MONTSERRAT.

Terminal report.

Prepared for the Government of Montserrat
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of S.P. Sondhi, tropical foods expert

United Nations Industrial Development Organization
Vienna

id.78-2595

Explanatory notes

The monetary unit in Montserrat is the East Caribbean dollar ($EC). During the period covered by the report, the value of the East Caribbean dollar in relation to the United States dollar was $US 1 = $EC 2.70.

Use of a hyphen between dates (e.g., 1960-1965) indicates the full period involved, including the beginning and end years.

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millions.

References to "tons" are to metric tons.

References to "gallons" are to British imperial gallons; one British imperial gallon equals 4.545 litres.

The following technical abbreviations are used in this report:

ha	hectare (2.47 acres)
DCP	digestible crude protein
TDN	total digestible nutrients
IU	international units

The following abbreviations of organizations are used:

ECCM	East Caribbean Common Market
CARDI	Caribbean Agricultural Research and Development Institute

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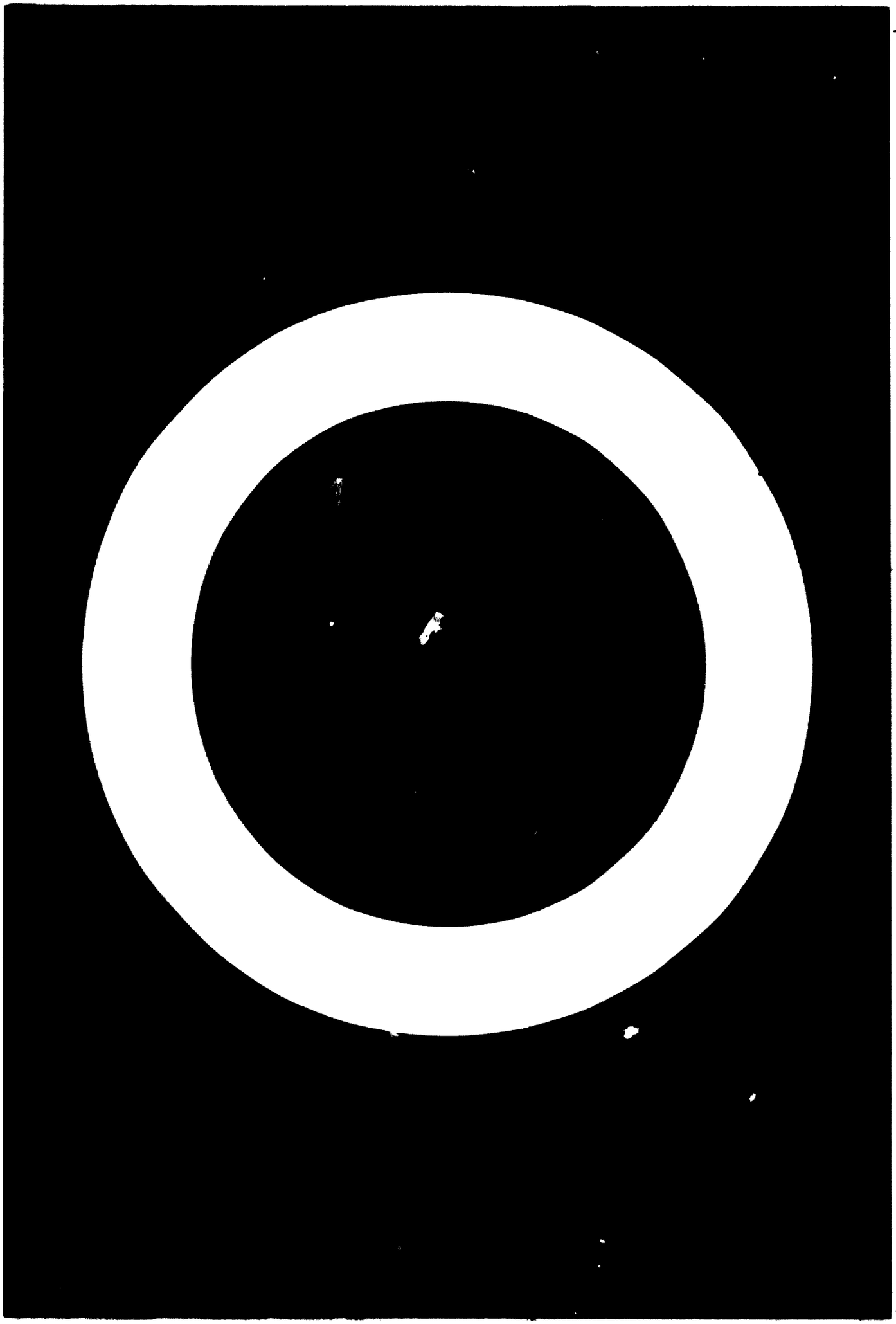
ABSTRACT

At the request of the Government of Montserrat, an expert in tropical foods was sent by the United Nations Industrial Development Organization (UNIDO) to Montserrat to survey local resources of fruits and vegetables and propose commercial uses for the large annual surpluses of bread-fruit. The expert was also to investigate the possibility of converting wastes of the bread-fruit plant into animal feed. His mission was financed under the Special Industrial Services programme.

There are approximately 7,300 bread-fruit trees in Montserrat, yielding some 1,000 tons of seedless bread-fruit annually. Of this amount some 700 tons is surplus, and a great deal of the fruit is wasted owing to inadequate storage facilities and methods of preservation. The expert has stressed the need for proper horticultural care of the bread-fruit plantations and has suggested ways of reducing the wastage. He has also indicated a number of ways in which the bread-fruit plant can be commercially exploited.

His main recommendation envisages the building up of a small-scale food-processing industry based on bread-fruit and other important tropical crops. The goods to be processed at the proposed multipurpose plant (canned, curried and pickled bread-fruit and bread-fruit chips) would take up part of the surplus fruit, and the rest could be made into flour. The products could be sold on the local market in place of imported processed foods and flour, and also marketed in neighbouring islands or exported to developed countries.

The other recommendations have to do with the manufacture of starch from bread-fruit, the production of animal feed from bread-fruit and other agricultural wastes, and the extraction of latex from bread-fruit plants for use in manufacturing paints.



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INTRODUCTION

Montserrat is one of the seven smaller English-speaking islands of the eastern Caribbean. It is a British colony and a member of the East Caribbean Common Market (ECCM). It is only 102 square kilometres (39½ square miles) in area and has a total population of approximately 13,000.

The island is mountainous and the climate tropical. Rainfall averages 101-152 cm (40-60 in.) a year but it is unevenly distributed over the island. Although the potential land area for agrioultural development is 7,000 hectares (ha) (17,297 acres), i.e. 60 per cent of the total, agriculture occupies only 23 per cent (2,317.5 ha or 5,860 acres) and permanent tree crops and temporary crops account for only 37 and 212 ha (97 and 523 acres), respectively, of the farm land used.

Owing to the favourable climatic and geographical conditions, several fruits and vegetables grow semi-wild on the island. Bread-fruit is both cultivated and grows wild; it is abundant but largely wasted. Two thirds of the total bread-fruit crop is believed to be surplus, and as no arrangements exist for processing or otherwise using the surplus fruit, some $EC 15,430 is lostannually. Moreover, neither the Government nor the growers have given serious thought to the horti-cultural care of the bread-fruit plantations on the island, and the Department of Agriculture has not included the new plantations of this fruit in its development plan for 1975-1979.

There are also large surpluses of other tropical crops: pineapples, mangoes, citrus fruit, guavas, tomatoes, hot peppers, coconuts and tamarinds. Yet food is a major item of import; it accounted for 25 per cent of all imports in 1976, including 30,684 kg (67,645 lb) of processed and preserved fruits and vegetables (worth $EC 130,313) and 650,314 kg (1,433,672 lb) of meal and wheat flour.

Montserrat has only a small home market for fresh fruits and vegetables, but some 12,000 tourists visit every year, which adds to local demand. Most of the produce that is not consumed at home is exported. However, shipping facilities from Montserrat to the rest of the Caribbean area are undependable, causing a bottle-neck in exporting. As a result there is a huge amount of wastage and the growers have to sell at throw-away prices.

The island has a thriving fishing industry, and livestock are numerous. But there is no cattle- or poultry-feed plant and, consequently, 219,570 kg (484,060 lb) of poultry feed (worth $EC 183,281) and 32,124 kg (70,820 lb) of prepared animal feed (worth $EC 27,839) had to be imported in 1976.

A food laboratory and a pilot processing plant attached to the Department of Agriculture are engaged in investigating, developing, testing and setting standards for the local fruits and vegetables intended for processing. Montserrat is a participating member of the newly organized Caribbean Agricultural Research and Development Institute (CARDI) which is expected to play an important role in assisting the island in carrying out research.

There are two small fruit-processing units on the island. One is engaged in extracting lime juice and lime oil and in 1976 exported 31,615 litres (6,956 gallons) of juice and 982 kg (2,165 lb) of oil worth $EC 65,050. The other unit is a home-run operation that puts out only as much as is required locally; it has no machinery. Its main products are jellies, jams, sauces and juices. In addition there is a plant for bottling carbonated beverages of international brand, which meets the local demand for soft drinks.

Montserrat has three refrigerated units with a combined storage capacity of approximately 23 tons. They are normally used for storing imported meat and poultry products intended for local consumption.

The total working population is estimated to be 3,769. The unemployment rate is noticeably higher among young people; in the 14-19 age group it is 12 per cent for males and 27 per cent for females. Thus there is a need for developing industries in order to create more jobs for these people, which in turn would contribute to economic stability.

The main sources of water are wells and springs. About 5 wells and 17 springs supply 4,090,500 litres (900,000 gallons) a day; the installed electrical capacity is 3.8 megawatts.

Montserrat has developed an industrial estate for the purpose of fostering industrial activities. A few such activities have already started, while others are at various stages of planning or execution.

The Government wants to establish an industrial base on which to build a balanced and healthy economy. By setting up profitable industrial and manufacturing enterprises based on local raw materials and talents, it would be able to reduce dependence on external aid and trade.

To this end, the Government requested assistance from the United Nations Industrial Development Organization (UNIDO) through the United Nations Development Programme (UNDP). A four weeks' study (later extended to six) was authorized, under the UNIDO Special Industrial Services programme, to prepare a techno-

economic feasibility report on the industrial applications of the bread-fruit plant. The study was made by a bread-fruit industry expert during a mission to Montserrat from 5 January to 16 February 1978.

Although bread-fruit is a staple part of the diet in many Caribbean islands, no work had been done previously on its industrial applications. The expert's duties therefore were:

(a) To assess the present quantity and quality of bread-fruit and its potential as a raw material in the future;

(b) To assess the potential domestic market for locally produced animal feed made from bread-fruit and other indigenous raw materials;

(c) To assess the availability and cost of water, electricity, labour, transportation etc. in order to determine the viability of a small-scale animal feed plant;

(d) To evaluate the possible application of solar or wind energy as a means of reducing the running costs of the above unit;

(e) To consider the possibility of a technology transfer based on used equipment from feed mills that have been enlarged or modernized.

The study has revealed a number of possible commercial applications in addition to the production of animal feed. Montserrat has the basic infrastructure required for industrial development, and there is scope for establishing agro-based small-scale industries that would both reduce the present wastage of bread-fruit and also exploit other important commercial crops on the island.

I. FINDINGS

Survey of the availability and quality of bread-fruit

The name "bread-fruit" (Artocarpus altilis) seems to have been derived from the fact that the fruit is rich in starch. The bread-fruit is native to the Malayan Archipelago.

Number and location of the trees

According to a 1972 report on agriculture, bread-fruit plantations occupied 1.4 ha (3.5 acres) of land, i.e. only 3.6 per cent of the total land (39.3 ha or 97 acres) under tree-crop cultivation. In addition, there were 2,624 bread-fruit trees growing wild about the island. But no data were available on the total number of bread-fruit trees.

Most of the trees are scattered along the road sides or located deep in the valleys, on the tops of inaccessible mountains or in backyards. The study was too short to count individual trees, and therefore the help of the local forest rangers and horticultural field staff was sought to get the number of trees in their respective areas. According to their estimates, the approximate total number of bread-fruit trees is 7,300. The distribution of trees given below shows that the bread-fruit plantations are concentrated in the eastern, west-central and northern parts of the island.

	Number of trees
Southern	700
West central and northern	2 000
Eastern	4 000
Central	600

Only some 5,000 of these trees are accessible. The remaining 2,300 are within the high hills, where there are no feeder or approach roads that can be used to collect the fruit.

Types and characteristics of the bread-fruit

A full-grown bread-fruit tree, 12-18 m (40-60 ft) high, is very attractive with its large, ovate, leathery leaves. It produces separate male and female flowers on the same tree. The male flowers are produced on long, yellow pendulous catkins and the female ones as short, thick, club-shaped, prickly structures. The female flowers develop into the fruits, which are oval in shape and generally 10-15 cm (4-6 in) in diameter;

they are green when immature but turn brown and then yellow as they ripen. Their stalks are short and thick. The tree requires a warm and humid maritime olimate and thrives best on coastal plains; it can be propagated from seeds or from subterranean root suckers. When young, the plant grows best in the shade, but later it needs full exposure to the sun.

The bread-fruit has two distinct varieties, one with seeds and the other seedless. The trees of the two varieties do not differ in external form. The type with seeds is of little economic importance. The fruit is useless in oulinary preparations but the seeds, which are small and resemble chestnuts, are often eaten roasted or boiled. The seedless variety is the one popularly cultivated in Montserrat. It is believed to be a sport of the mother variety that has been perpetuated vegetatively through human efforts. Its fruits have a mass of whitish, mealy pulp which is consumed in numerous ways. It is always eaten cooked.

Among the seedless varieties of bread-fruit, white-heart and yellow-heart are the most prevalent on the island. The former is considered to be better and it is generally preferred for planting in orchards and backyards, whereas the latter grows wild and is scattered about the island.

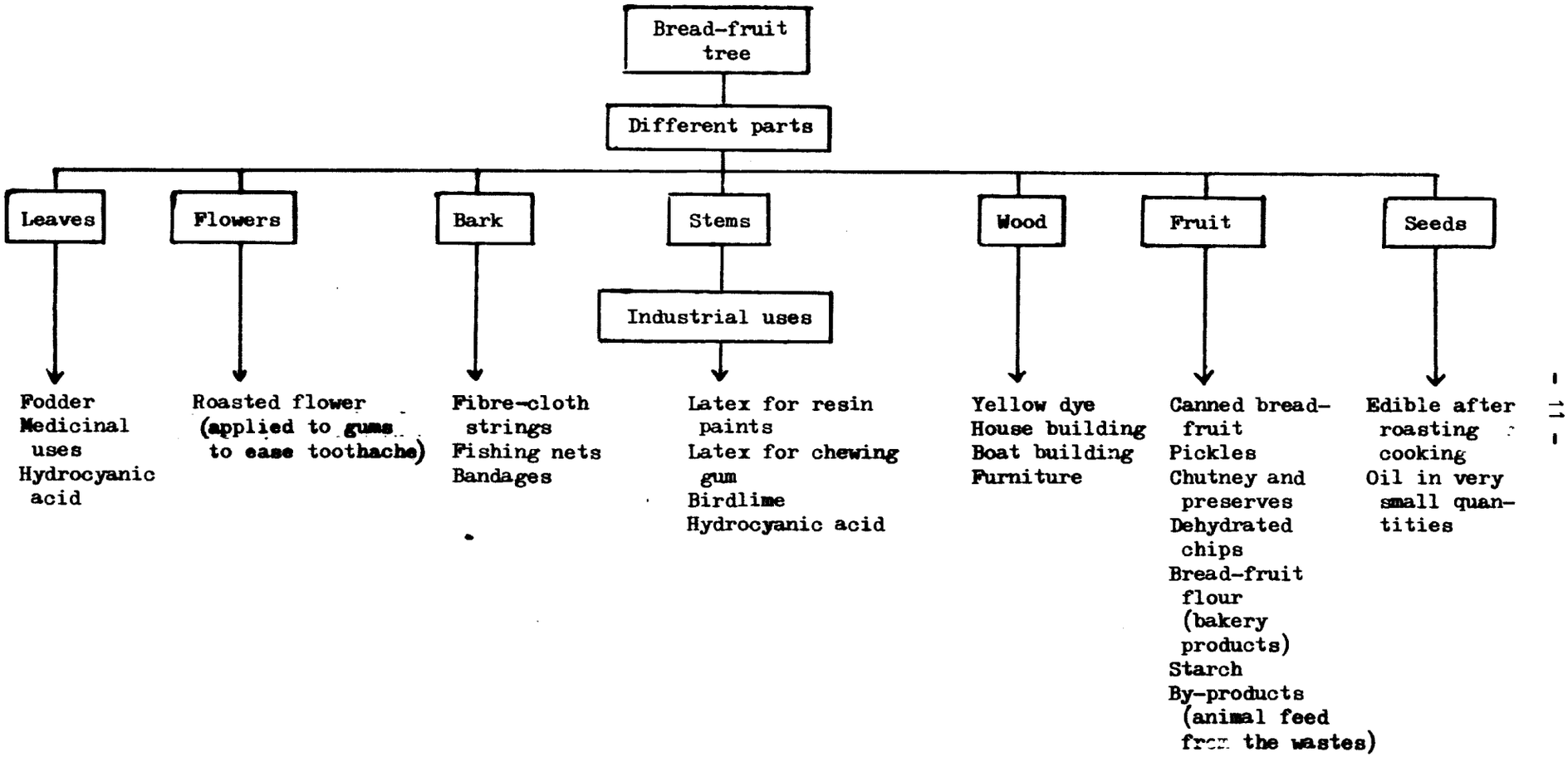
The main components of the bread-fruit are the following:

	Percentage
Water	79.5
Carbohydrates	17.9
Protein	1.5
Minerals	0.9
Fat	0.2

Because of the high carbohydrate content, comparing favourably with that of such fruits and vegetables as bananas and potatoes, bread-fruit is considered almost a staple food in the islands.

The figure on page 11 gives the uses of the different parts of the bread-fruit tree. Almost all of the tree can be used commercially, but in view of the specific needs and resources of Montserrat, the parts most suited for industrial exploitation there would be the fruit, the leaves, the stems and the wood.

Figure. Uses of the bread-fruit tree



The fruit

Bread-fruit is highly perishable in nature owing to its high carbohydrate content. The ripe, raw fruit is not good to eat beoause it is insipid. At the outset, therefore, various ways need to be studied of lengthening the storage life of the fresh fruit so as to prevent spoilage.

The leaves

The leaves of the bread-fruit plant are relished by cattle. They are used for medicinal purposes in some parts of the world, e.g. in Ambon, where the ashes of the leaves are applied to the skin to treat a herpes-like ailment, and in Java, where the powder of the roasted leaves, mixed with water, is applied for an enlarged spleen. Moreover, the leaves contain a trace of hydrocyanic acid. But in Montserrat it will be most economical to use the leaves, together with the peels and cores, as fodder for animals.

The stems

The stems of the bread-fruit plant contain latex, which is used for caulking boats. In some Pacific islands, coloured earth is mixed with it to make a paint for canoes. Birdlime can also be made from the latex.

The wood

The wood of the bread-fruit tree is moderately hard (specific gravity 0.473). It is light yellow when freshly cut and turns light brown later. It contains yellow dye. It is straight and somewhat coarse grained but it is not difficult to work. It seasons well and may be used for beams, posts, rafters, flooring etc.

Average yield in relation to amount consumed

Normally a vegetatively propagated bread-fruit plant begins to bear when it is 5-6 years old, whereas seedling trees may begin bearing a little later, when they are 8-10 years old. The fruit may appear about 60-90 days after inflorescence. In Montserrat, the main season of the bread-fruit is from June to September, though some odd crops are available year-round. According to the literature (Wealth of India), an eight-year-old tree that is well cared for yields an average of 700-800 fruits annually. But in Montserrat the average

yield is 100-150 fruits annually. Premature dropping of the fruits and no horticultural care of the plants outside of cultivated areas may be the reasons for the low yield. The average weight of a mature bread-fruit is slightly less than 1 kg (2 lb). Therefore, an average of approximately 1,000 tons of bread-fruit is produced annually on the island.[1/]

No statistical data are available on the actual consumption of bread-fruit in Montserrat. It is believed that barely 30 per cent (300 tons) of the total bread-fruit crop is consumed on the island annually, owing to the following factors:

(a) The briefness of the main bread-fruit season (3-4 months);

(b) The highly perishable nature of the fruit;

(c) The lack of refrigerated storage facilities;

(d) The problem of harvesting the whole produce quickly since the trees are scattered;

(e) The fact that the better crops come out during the same season;

(f) Limited local demand.

The balance of 700 tons is surplus, except that a small amount, in its ripe state, is used as pig meal. The value of this surplus is some $EC 15,430.

Harvesting, storage and preservation of bread-fruit

Harvesting

The fruit is mature when it turns yellowish-green, the reticulation on the surface dilates and the fruit stalks give way with comparative ease. The fruit should be harvested for eating when it is still hard to the touch. After this stage, it becomes yellow, soft and yielding to the pressure of the fingers.

Since the fruits are borne at the ends of the branches, care should be taken during harvesting that they do not fall on the ground. A pole with a hooked knife at one end should be used, to which a long bag or net is attached to catch the cut fruit. Fruits allowed to fall on the ground are bruised and do not keep more than a day.

[1/] According to statistics on overseas trade, 1,955 lb of fresh bread-fruit was exported to Antigua in 1976, but this volume was exceptional.

Storage and preservation

Studies carried out elsewhere have shown that, left in the open, the bread-fruit softens the day after harvesting, but when stored at 12°C it starts to soften on the fourth day and at 7°C at the end of seven days. Although the fruit stays firm longer when refrigerated, it shows signs of chilling injuries. This deficiency may be alleviated by sealing the fruit in polythene bags, use of which at 24.5°C extends storage life from 3 to 14 days and at 15°C from 8 to 21 days. Indeed, the bags extend storage life considerably at both high and low temperatures. The fruit retains a fresh, green appearance and when it eventually ripens, it does so normally. This gradual ripening process is similar to that of plantains, which ripen much slower at high than at low humidites. In polythene bags containing bread-fruit the humidity quickly rises to 100 per cent.

Since cold storage facilities are very limited in Montserrat, other suitable methods such as wax coating, gas storage and radiation could be tried. The last two methods may not be feasible owing to limited resources and technical know-how, but wax coating would be a practicable and effective means of protecting produce during storage, transportation and marketing. The wax can be applied just after harvesting in orchards, warehouses or markets or at home by consumers. It is reported that the best results have been obtained when the wax emulsion has been used at the orchard, that is, as soon as possible after picking. The advantages of the wax emulsion method are that (a) it is economical since wax is cheap; (b) the wax is harmless and can be washed off; and (c) the process of application is simple.

Montserrat could consult CARDI on the choice of a suitable means of prolonging shelf life; the Institute could be requested to make a detailed study of the subject. The local food laboratory could co-ordinate experiments with CARDI.

Review of other important crops

Besides bread-fruit, there are large surpluses of other tropical crops:

	Annual surplus in kilograms (pounds)
Mangoes	23 000 (50 000)
Pineapples	7 000 (15 000)
Guavas	2 000 (5 000)
Tomatoes	250 000 (550 000)
Limes	23 000 (50 000)
Sour oranges	2 000 (5 000)
Hot peppers	5 000 (10 000)
Carrots	23 000 (50 000)

Most of these fruits and vegetables are exported to neighbouring islands through the Development Finance and Marketing Corporation after the limited home demand is met. According to statistical data on overseas trade in 1976, the export value of these commodities was $EC 34,950. (Cotton lint and seeds were the foremost agricultural export commodities; they accounted for approximately 71 per cent of agricultural exports.)

II. COMMERCIAL USES OF THE SURPLUS FRUIT

Of the various bread-fruit products that have been tested and marketed in other parts of the world, those disoussed below seem most suitable for manufacturing in Montserrat. Based on these products, a small-scale fruit-prooessing industry could be started which would use up the yearly surplus of bread-fruit.

The foods that can be made from the fruit include canned, pickled, preserved and dehydrated goods, for which standard production processes are outlined. The dried bread-fruit oan also be used to make starch.

Canned, preserved and pickled products

Canned bread-fruit

The fruit should be selected for canning at the right stage of maturity. The washed fruit is prepared by peeling, cutting, coring eto. and then blanched and put into sterilized cans into which hot brine is poured. The cans are exhaust sealed, processed for a specific time and temperature, cooled and stored.

Bread-fruit curry

After the fruit is prepared as above, it is boiled and a semi-cooked curry is made by frying it in oil with spices according to specific recipes. The curry is poured hot into sterilized oans which are exhaust sealed and prooessed as above.

Bread-fruit chutney

The fruit is prepared to give it the desired shape. It is then cooked until thick along with spices, onions and garlic which are tied, usually, in a muslin bag. Sugar, salt and, lastly, acetic acid are added to the mixture, which is cooked until it attains 68°-70° Brix (total soluble solids). The bag is then removed and the product poured into clean glass jars, sealed, cooled and stored. Other products such as preserves and candy can be made from the bread-fruit using the same method but leaving out the spices.

Bread-fruit pickles

The prepared fruit is blanched and salted (pickled). It is then mixed with vinegar or oil containing extract of spices. The pickle is put into clean jars and sealed.

Dehydrated products

Dehydration is done mechanically in closed chambers, under controlled conditions, so that the produot retains an attractive appearanoe, is nutritive and tasty and oonforms to hygenic standards. The underlying principle of preservation is to remove moisture to a level at which mioro-organisms cannot grow and spoil the product, without impairing other qualities.

When moisture is removed, the bulk of the material, its weight and frequently volume as well, is greatly reduoed, and this reduces in turn the packaging and transport oosts, an important faotor in view of Montserrat's inadequate shipping facilities.

The market for dehydrated products is expanding because they are cheaper than canned products. There may be good soope for dehydrated bread-fruit ohips, whioh are suitable for many oulinary uses including preparation of flour by grinding. They oan also be eaten like fried potatoes. Other orops such as potatoes and bananas could be dehydrated in the same unit so that proocssing oould continue all year.

The composition of dried bread-fruit is as follows:

	Percentage
Water	8
Ether extraotables	2
Crude fibre	4.7
Total nitrogen	0.68
Ash	4.2
Staroh	72
Caloium	0.44
Phosphorus	0.13

Bread-fruit chips

After washing, the fruit is peeled and cored. The edible flesh is sliced about 6 mm (1/4 in) thick and chopped 6 mm x 13 mm x 13 mm (1/4 in. x ½ in. x ½ in). It is blanched and then dipped into a dilute solution of potassium metabisulphite for a few minutes. The concentration of the solution must be carefully controlled by making frequent analyses in order to ensure conformity with the food-law standards of the island. The slices are

then dried in a mechanical drier. The dried chips are sorted, graded and packed in suitable packages; they can also be made into flour by grinding.

Flour

The dried bread-fruit contains approximately 72 per cent starch and 18 per cent other carbohydrates, which compares favourably with the composition of the raw material (wheat flour) required for the manufacture of bakery goods. Therefore bread-fruit flour, made by grinding dried bread-fruit chips, could be fortified with wheat flour and used in bakery products.

According to overseas trade statistics for 1976, 650,314 kg (1,433,672 lb) of meal and wheat flour was imported to the island that year. If the wheat flour were fortified with even 3-4 per cent of bread-fruit flour, the rest of the annual bread-fruit surplus would be utilized and the island would save on the import of wheat flour by at least 30 tons a year, or $EC 45,000. Any deficiency in protein or mineral salts in the fortified flour could be corrected with the addition of soyabean flour and mineral salts. As a matter of fact soyabean flour is now considered an essential ingredient of the flour mixture used for the manufacture of bakery products in most of the developed countries.

Experiments would have to be made to determine the percentage of bread-fruit flour to be used in the wheat flour. The finished product should be consistent in taste, flavour, appearance etc.

Starch from bread-fruit

Experiments have shown that starch can be made from bread-fruit. Although a detailed study would have to be made to confirm the techno-economic feasibility of the undertaking, bread-fruit would theoretically be an extremely cheap raw material to use in manufacturing starch because it is both abundant and surplus. Starch could also be made from other local crops, such as tapioca (cassava) and tamarind seeds.

As starch has many applications besides its use in food, e.g. in sizing textiles and as a general adhesive, little difficulty is likely to be met in marketing it at competitive prices in textile-producing countries. Depending on the grade and quantity of starch produced, it might also be possible to set up auxiliary industries for making adhesives or powders (e.g. baking powder and custard powder).

Principal by-products, including animal feed

As stated earlier, animal feed can be made from the leaves, cores and peels of the bread-fruit plant, in combination with the wastes of other crops. The stems yield latex and the wood yellow dye.

Animal feed

As bread-fruit has a high percentage of starch, it is difficult for animals to digest. It also has a high moisture content, making it uneconomic to process the fruit before converting it into animal feed. In view of these negative factors and of the island's need to import food for human consumption, it would be advisable to use the bread-fruit solely for human beings rather than as cattle-feed. Nevertheless, studies have revealed that the peel and core of the bread-fruit contain very little starch in the parenchyma cells underlying the outer surface up to 1 mm (0.04 in.) in depth. They also appear to be rich in pectin, but as animal feed is needed, it would be more economic to use the wastes for feed than for pectin.

It is estimated that approximately 50 tons/year of bread-fruit wastes would be available for this purpose. A balanced feed could be prepared by combining these wastes with other abundant agricultural wastes. The peels and cores would have to be dried, mixed with the other ingredients called for in the formula, pulverized to the desired mash and packed into bags.

The annex contains descriptions of several of the raw materials that could be mixed with bread-fruit wastes to produce animal feed. It also gives a number of possible formulations for the feed.

Latex

Latex can be extracted from the stems of the bread-fruit plant and used for caulking boats and making paints and birdlime.

Yellow dye

The wood of unproductive bread-fruit trees can be used for the manufacture of yellow dye. It can also be used to start certain wood-based industries.

III. SUMMARY OF FINDINGS

The main findings of the study, including possible uses of the bread-fruit plant, are recapitulated below.

1. Some 7,300 bread-fruit trees grow wild in Montserrat, but only 5,000 trees are accessible.

2. Approximately 1,000 tons of seedless bread-fruit is produced annually, of which nearly 300 tons is eaten fresh and the remaining 700 tons (including 200 tons of inaccessible fruit) is surplus and largely wasted. White-heart and yellow-heart are the principal seedless varieties of bread-fruit cultivated on the island.

3. The average annual yield of the individual bread-fruit plants is low (100-150 pieces of fruit per tree), which may be due to the premature dropping of the fruits or to lack of horticultural care.

4. A great deal of bread-fruit is wasted owing to lack of proper storage facilities. The ripe bread-fruit is highly perishable, and too insipid to eat raw, necessitating the use either of cold storage or of other methods of preservation such as wax coating.

5. At present the island's surplus bread-fruit and other important commercial crops, such as pineapples, mangoes, tomatoes, guavas, citrus fruit, carrots, potatoes and hot peppers, are exported to neighbouring islands. But owing to undependable shipping facilities from Montserrat, there is considerable wastage, which could be lessened if a small-scale, multipurpose fruit-processing and dehydration plant were established. The processed foods thus obtained could be sold on the local market and also exported.

6. The commercial possibilities of bread-fruit are numerous; it can be canned or pickled, or made into chutney, preserves or dehydrated chips.

7. The dehydrated chips could be ground into flour which, mixed with wheat flour, would be suitable for the manufacture of bakery goods.

8. Bread-fruit is rich in starch and it can be used for the commercial manufacture of starch. As bread-fruit is both abundant and surplus in Montserrat, it might be possible to produce a starch from it that could be marketed at competitive prices in textile-producing countries. It might also be possible to start auxiliary industries for making adhesives and powders.

9. Being very starchy, the bread-fruit cannot be easily digested by animals and is therefore unsuitable for animal feed. Nevertheless, bread-fruit wastes (peels, cores and leaves) can be mixed with other agricultural wastes to produce a highly digestible animal feed.

10. Latex can be extracted from the stems of the bread-fruit plant and used for caulking boats and making paints and birdlime.

11. The wood of unproductive bread-fruit trees can be used for the manufacture of yellow dye or for starting certain wood-based industries.

IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Montserrat has ideal natural resources, agroclimatic conditions and basic infrastructure for industrializing on a small scale in order to build a balanced and healthy economy. To achieve this goal, the island has to harness its three main resources, agriculture, forests and the sea.

In agriculture, Montserrat cannot develop horticulture without simultaneously developing a small-scale fruit-processing industry that would take up the surplus in agricultural produce and promote horticulture by bringing about increased production of fruit and vegetables. Nonetheless, it may not be economically viable to set up a fruit-processing unit based solely on a single seasonal raw material like bread-fruit. Other surplus commodities for which potential demand exists at home and abroad should also be processed so that the unit can be run year-round. These include pineapples, mangoes, citrus fruit, guavas, tomatoes and hot peppers.

The advantages of processing these commodities are as follows:

(a) The island would save $EC 130,000 annually on imports;

(b) The growers would get higher returns for their produce because of increased local demand and less wastage;

(c) Jobs would be created;

(d) The island would earn more by exporting finished rather than fresh commodities and could also convert its wastes into by-products (animal feed);

(e) Ancillary industries could be developed to support the processing unit.

As Montserrat is a member of the ECCM, it would probably be able without difficulty to sell its processed products within the Caribbean area. There may also be marketing possibilities in certain developed countries. Regarding the processing and marketing of bread-fruit, it is cheaper, because of lower packaging costs, to make the fruit into pickles, preserves and dehydrated chips than to can it. The more expensive canned products could therefore be exported to developed countries and the others distributed at home and in neighbouring islands. (A firm in Jamaica is already exporting canned bread-fruit to the United Kingdom of Great Britain and Northern Ireland, which shows that demand for the product exists.)

Although a fruit and vegetable preservation industry would have a special role in taking up surpluses and promoting horticulture, market limitations might make it impossible to use all the surplus bread-fruit (700 tons annually) in this way. However, some of it, say 20 per cent (140 tons), could be canned and dehydrated, depending on market demand. Other means would have to be found of using the remaining surplus, such as adding bread-fruit flour to wheat flour and manufacturing starch from bread-fruit.

Recommendations

Most of the recomendations set out below could be carried out partially or wholly by the pilot plant and food laboratory attached to the Department of Agriculture.

1. It is recommended that the Government consider setting up a multipurpose small-scale processing and dehydration plant for the manufacture of products from bread-fruit and other important commercial orops. This would save $EC 130,000 annually in the importation of processed goods and use up part of the surplus bread-fruit. The rest could be converted into bread-fruit flour and, combined with wheat flour, used in making bakery products. This would reduce imports of wheat flour by at least 30 tons and save an additional $EC 45,000 annually. In setting up such an industry, the following steps should be taken:

(a) A study should be made of the storage requirements and methods for prolonging the shelf life of bread-fruit and other perishable commodities, in both fresh and processed states. The study could be undertaken by CARDI, and the Montserrat food laboratory could collaborate whenever experiments needed to be performed under local climatic conditions. A necessary part of this effort would be to educate the local people, by means of training and demonstration, about the importance of fruit preservation;

(b) A detailed market survey is needed of present and future annual demand for processed agricultural products in Montserrat and the neighbouring islands. Simultaneously, an assessment should be made of the economic viability of the products by costing the finished goods and then comparing prices with potential competitive brands;

(c) The average yield and surplus quantities of agricultural produce other than bread-fruit should be ascertained and the varieties chosen that could be processed in the same unit as the bread-fruit;

(d) Based on the market survey and the assessment of resources, a project should be prepared for the establishment of a multipurpose food-processing plant;

(e) A standard mixture of wheat and bread-fruit flour should be selected by experimenting with different proportions of each flour.

2. A study should be made of the technc-economic feasibility of manufacturing starch from bread-fruit with special reference to the comparative quality and quantity of existing commercial starches.

3. Based on the specifications proposed in the annex, formulations can be worked out for balanced animal feeds composed of bread-fruit and other agricultural wastes.

4. A techno-economic feasibility study should be made on manufacturing paints and varnishes from the latex of the bread-fruit plant.

Annex

ANIMAL FEED FROM AGRICULTURAL AND OTHER WASTE PRODUCTS

According to 1977 data, livestock consisted of cattle (1,861), pigs (2,250), sheep (3,042), goats (2,790) and fowl (16,796). In view of the proposed milk-processing plant to be set up, an increase in the number of cattle is likely in the near future. Expansion of the pork and poultry industry will depend on the availability of feed. In 1976, 219,570 kg (484,060 lb) ($EC 183,281 worth) of poultry feed and 32,124 kg (70,820 lb) ($EC 27,839 worth) of prepared animal feed were imported. At present there is no cattle- or poultry-feed plant in Montserrat.

To reduce dependence on imported prepared animal feed, an effort should be made to convert local agricultural wastes into feed. Fish wastes and meat scraps could be used for this purpose as well, and there are a number of other protein-rich raw materials on the island, e.g. cotton seed, ground-nuts and coconuts, that would also serve.

The main points to be kept in mind in choosing a good formula for animal feed are economic and nutritional value and energy-giving properties. A balanced feed consists of carbohydrates, proteins, vitamins and minerals in the proper proportion. The following paragraphs discuss waste products from which animal feed can be made and suggest, in some cases, specific formulations using the material in question. General formulations for cattle, poultry and pig feed are given at the end.

Agricultural and other wastes

Mango-seed kernel

Many mango trees grow on the island. Mango-seed kernels oould be made available in large quantities as a by-product of the proposed fruit-processing unit. A veterinary research institute in India has investigated the possibilities of using mango-seed kernel as animal feed. It is reported that the nutritive value in digestible crude protein (DCP) and total digestible nutrients (TDN) is comparable to that of sorghum and rice bran. A concentrated mixture can contain up to 40 per cent mango-seed kernel without any detrimental effect on adult bullocks. A few combinations of mango-seed kernel and other materials, used for cattle feed, are given below:

		Parts by weight
(a)	Ground-nut cake	20
	Wheat bran	20
	Gram	20
	Cotton seed	10
	Mango-seed kernel	10
	Other	20
(b)	Ground-nut cake	25
	Mango-seed kernel	20
	Rice bran	25
	Maize	20
	Other	10
(c)	Mango-seed kernel	40
	Maize gluten	20
	Maize cake	5
	Guar churi	5
	Ground-nut cake	20
	Rice polish	10

Tamarind seeds

A number of tamarind trees grow wild on the island. Tamarind seeds are a good source of protein and energy. To make the seed palatable to cattle, it should be finely ground and soaked in water for an hour before feeding. It is best, however, to use it in combination with other ingredients, in the following proportions:

	Parts by weight
Sesame cake	35
Maize or barley	20
Rice bran	10
Tamarind seed	35

Tapioca waste

Experiments have been made in other parts of the world on using tapioca waste as an ingredient in cattle and pig feed. It is reported that DCP is 2 per cent and TDN 64 per cent in dry matter intended for ruminants. Growth and lactation studies of cattle fed concentrated mixtures in which tapioca waste replaced all of the maize (protein) have proved its suitability as an ingredient in animal feed.

Tapioca or cassava is a tuberous crop grown all over the island. Its leaves are also supposed to be a rich source of protein, and tapioca leaf meal can be fed to lactating cows. No differenoe has been observed in body weight, milk yield or fat content when 50 per cent of the ground-nut cake has been replaced by tapioca leaf meal in the ration of the milk cattle.

Cashew-apple waste

At present there are only a small number of cashew-apple trees on the island, but efforts are being made to cultivate more. Cashew-apple fruit is a waste of the cashew-apple tree. It is reported that it can replace some of the grains in the feed of ruminants or poultry. Dried cashew fruit contains about 9.5 per cent protein.

Tomato pomaoe

Tomato pomace has 14.3 per cent DCP and 41 per cent TDN. After drying and grinding it can be used as one of the ingredients of a concentrated feed mixture in proportions of up to 34 cent.

Citrus peel

It is reported that lemon peels can make up one third of a concentrated feed mixture without lowering the nutritive value of the feed and thus affecting the health of the buffalo bulls to which it is fed. It is further reported that orange peels contain a high proportion of soluble sugars with a digestibility of 85 per cent and a protein content of 6 per cent. On Montserrat, lime peel could be substituted for other citrus peels, since it is abundantly available as a by-product of lime-juice processing.

Pineapple waste

It has been reported that pineapple waste mixed with maize grain, wheat bran and molasses has been sucoessfully fed to animals as a souroe of energy; when supplemented with high-protein ingredients it is specially liked by dairy animals. It has been tried, with limited success, as a fattening ration for pigs. The composition of ensilage made out of pineapple tops and leaves, molasses and urea is similar to that of the commonly used grass ensilages.

Wastes of sea products

Montserrat has not yet tapped its marine raw-material resources for industrial uses. There is potential for developing a fish-processing industry, so that the various wastes of sea products could be used in animal feed. Some of these are as follows:

(a) Frog meal. Twice as much frog meal as fish meal, by weight, can be used in poultry rations for growth purposes and egg production;

(b) Fish wastes. Fish meal has been accepted as a balanced source of protein for poultry, pigs and new-born calves. The quality of the product depends mostly on the methods of processing. A high fat content is not desirable since the meal becomes rancid in storage and causes fishy flavours in eggs, meat or milk. A scientifically processed fish meal has an average of 46.7 per cent protein and 27.8 per cent mineral matter. It can replace cotton-seed meal in dairy cattle rations.

Meat scraps

Meat scraps are the most widely used protein supplement of animal origin in poultry feed.

In addition to the above, there are a number of other protein-rich raw materials available on the island that could be used for the manufacture balanced animal feeds; these include cotton seed, ground-nuts and coconuts. If Montserrat wishes to be self-sufficient in animal feeds, these materials would have to be exploited. After their oils had been extracted, their cakes (as by-products) could be combined with the wastes mentioned above, including bread-fruit waste, and fed to animals. Another possibility would be to process sugar-cane into molasses, which, mixed with urea and ensilage, can be used as cattle feed; sugar-cane tops, which are relished by cattle, could also be added. A formula based on crude protein content, and including bread-fruit wastes, is given below:

	Parts by weight
Bread-fruit wastes	25
Ground-nut cake	37
Wheat bran	25
Molasses	10
Mineral mix	3

Typical animal feed formulations

Typical formulations for cattle, poultry and pig feed are given below:

Cattle feed	Percentage by weight
Ground-nut cake	35
Maize	20
Gram husk	15
Mineral mix	1
Salt	2
Poultry feed	
Yellow maize	20.2
Wheat bran	9.4
Rice polish	28.2
Ground-nut cake	23.5
Fish meal	5.2
Molasses	3.7
Lime peel	2.3
Bone	1.1
Mineral mix	0.3
Vitamin mix	0.1
Pig feed	
Rice polish	40
Wheat bran	11,5
Ground-nut cake	3
Mineral meal	2
Yellow maize	23
Mustard oil cake	9
Fish meal	10
Bone	1
Common salt	0.5

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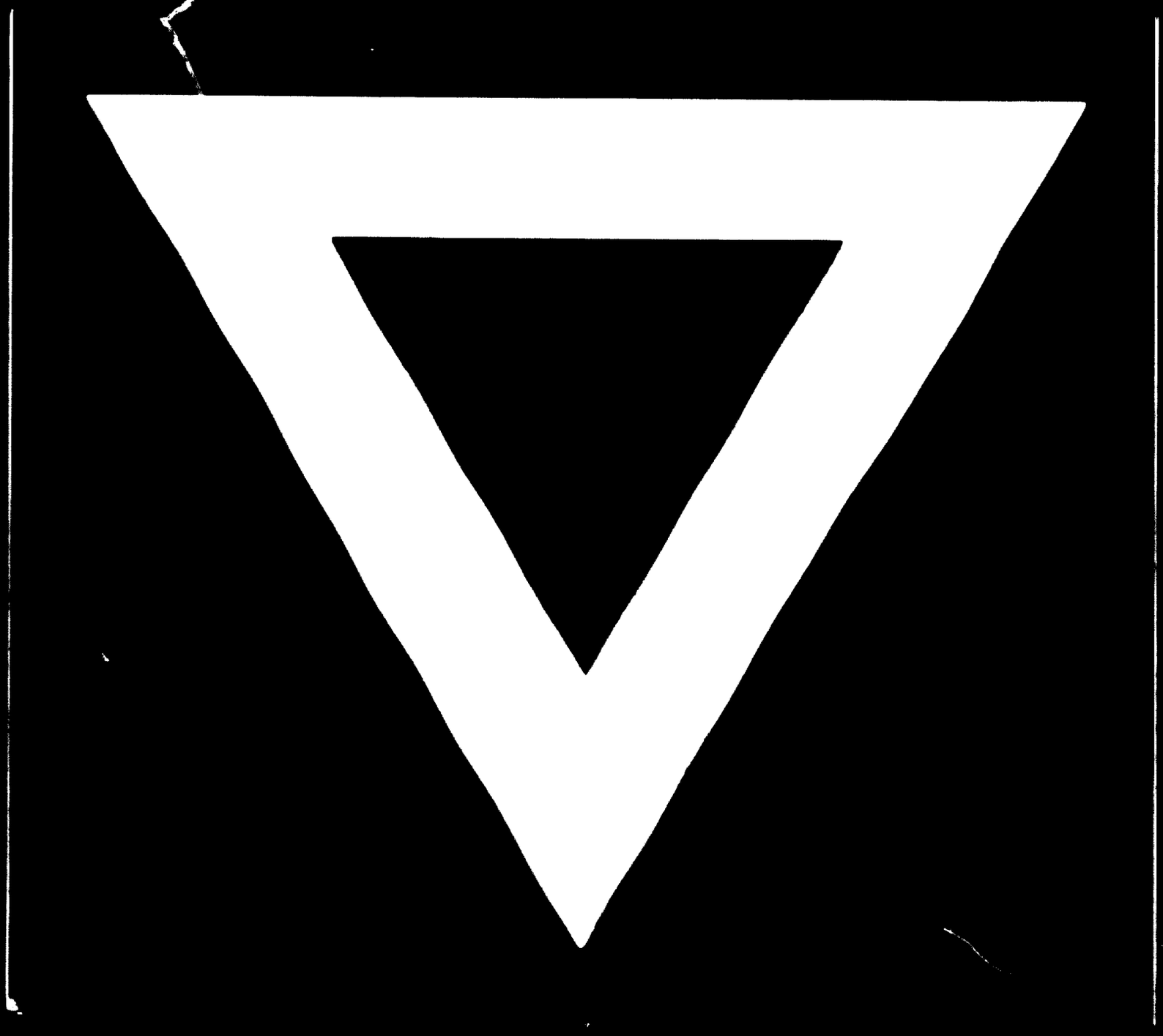

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