THE POSSIBLE UTILIZATION
OF
WEST INDIAN CROP RESIDUES
FOR FEEDING LIVESTOCK

BY

Neil M. Jarrette

YEAR III DIPLOMA, JUNE 1953.
"The West Indies are a classic example of an exchange economy, relying as they do upon the proceeds of their staple agricultural exports such as sugar, cotton, cacao, arrowroot, citrus and coconuts, to enable them to import the food, clothing and other goods which they have never produced in adequate variety or quantity." (1) The indirect result of this is that until a few years ago animal husbandry played a secondary role in Caribbean economy, the dominant note being production for export. Up to 1920, and later in many territories, it occupied a position ancillary to the cultivation of export crops, a practice which was economically sound, since as Bryan Edwards (4) observed in 1801, it was cheaper for the planter to use the revenue from these highyielding crops to buy provisions and grain from others than to raise these himself. Hence up to this time the livestock industry remained insignificant, haphazard and the pursuit of private enterprise alone. It was built around nondescript Creole breeds and frustrated by shortage of funds, lack of any definite governmental policy, and heavy mortality amongst temperate breeds imported with a view to upgrading the stock.

But the West India Royal Commission of 1938, in stressing the need for a greater production of meat, milk, poultry and eggs if a better balanced diet were to be provided for the population of the West Indies, touched off a general awareness of the importance of animal husbandry throughout the area, an awareness which has grown remarkably during the last few years with the result that there has been a marked increase of all types of stock in most of the territories. In 1941, the Inspector General of Agriculture for the West Indies (2) pointed out that from the standpoint of economics and of nutrition of the local population, livestock held by far the most promise for agricultural development. In Jamaica in 1942, the Agricultural Policy Committee of Trinidad (2) stressed that the keeping of livestock should be encouraged primarily to assist in stabilizing the system of agriculture and to improve nutritional standards. In 1943 the Anglo-American Caribbean
Commission further championed the cause of livestock in Agricultural Systems. But the matter was not allowed to rest there. In 1944 the Agricultural Policy Committee of Antigua drew attention to the increased yields and improvement of soil conditions that would accrue from wider use of pen manure, whilst its counterpart in Jamaica advocated crop diversification and mixed farming as basic to the success of the small and medium scale agriculturist.

Since then great strides have been made in practically every territory as regards improvement of stock, increase in their number, and a raising of the levels of management and feeding employed. But the livestock industry in the West Indies is not yet secure on its feet. Much remains to be done - "the scope for improvement is infinite." (2)

THE PROBLEMS

Detailed surveys carried out on animal husbandry in the Caribbean (2) show that two main problems stand out from the others. These are:

a) Disease

b) Management

DISEASE

Much work has been and is being done in combating disease, and though several diseases continue to constitute a serious menace to animal health, encouraging progress has been made in many quarters, notably in the eradication of tick fever. However, adequate quarantine control is still lacking in many of the smaller territories, as are veterinary services.

MANAGEMENT AND FEEDING

As regards Management, this presents something in the way of a dilemma from the start, as the ground work in this field is only now being done. In general the system prevailing at present is primitive. Though stall feeding is practised it is exceptional over the area as a whole. In the main animals are pastured during the day on poor grasses, and tethered at night with little or no shelter. Limited pasture land and a severe dry season are aggravating features in many cases. Moreover, Woodman, E. (1948) found that Barbados soldiers
were generally appreciably lower in protein content than pasture roughages of temperate climates, the same being noted for Trinidad fodders by Duckworth (1949).

Protein contents of sugarcane tops and of sour-grass would be considered average for tropical fodders on the whole, and these have much higher dry matter contents that temperate climate roughages. This intensified their deficiency of protein when fed to dairy cows, owing to the restriction imposed on bulk intake by the animals' capacity. The maintenance ration must therefore be made up with a concentrate even before estimating the production, thus the feed bill is considerably increased. Correct feeding of high yielding cows is therefore expensive, owing to the large quantities of concentrate necessary.

It will be readily understood, therefore, that the need for pasture improvement is a pressing one. In this respect, useful work has been done at the Imperial College of Tropical Agriculture, while the Institute of Tropical Agriculture in Puerto Rico is currently engaged in testing various grasses for fodder.

Meanwhile a valuable side-issue, and one which presents tremendous possibilities for exportation, is being neglected, and this is the utilization of crop residues which could easily have the two-fold effect of converting a previous waste into a welcome asset and contributing largely towards lowering the high costs of proper feeding necessitated by importation of concentrates from elsewhere.

The aim of this report has been to collect as far as possible all work done on the utilization in this manner of the more important residues in other countries, with reference to the possibility of such work being duplicated here on the same or similar crops, bearing in mind that such duplication could have naught but beneficial effect.

The writer feels that this is a subject of tremendous importance at the present time, and one of which the territories concerned are being forced to become increasingly conscious, owing to the current trends in world prices.

A general dearth of work done on this subject coupled with the fact that much of it is not applicable to conditions obtaining here
has rendered this work into a task of respectable proportions, but the attempt has been made throughout to weed the grain from the chaff, including, however, any information whose nature suggests that it may be useful as a pointer to those for whom this report is intended.
CURRENT UTILIZATION

At present, utilization of residues from this crop in the West Indies amounts for all practical purposes to nil, though recently feeding trials have been conducted at Bodles Experimental Station in Jamaica on Citrus Waste Pulp. All skins, rag and seeds left over at the processing factory of the Co-Operative Citrus Grower's Association in Trinidad are dumped in the wastelands across the road from this factory. However there is general appreciation of the big part citrus residues play in livestock feeding in certain parts of the U.S.A., notably Florida and California, and also in Palestine, and thoughts are now being turned to methods of converting what is now an increasing liability into a valuable asset. Thus the Co-Operative Citrus Growers' Association expects to complete the installation of a pulp processing plant by September 1953.

AVAILABILITY IN THE WEST INDIES

Some idea of the availability of citrus residues will be got from the table which follows:

<table>
<thead>
<tr>
<th>VALUE OF</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPORTS OF CITRUS &amp; CITRUS PRODUCTS</td>
</tr>
<tr>
<td>FROM THE WEST INDIES(5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trinidad &amp; Tobago</td>
<td>1950</td>
<td>$2,206,438</td>
</tr>
<tr>
<td>Jamaica</td>
<td>1950</td>
<td>£643,387</td>
</tr>
<tr>
<td>Dominica</td>
<td>1949</td>
<td>$46,358</td>
</tr>
<tr>
<td>Antigua</td>
<td>1951</td>
<td>£100</td>
</tr>
</tbody>
</table>

The citrus industry is expanding rapidly in those areas within the West Indies where the crop is grown. In Trinidad new areas are constantly coming under cultivation as the crop takes over from uneconomic cacao, from cane in localities where transport costs are high, and from coconuts on estates subject to Red-Ring disease. In Jamaica the Citrus Growers' Association has just opened a new processing factory.

There are three by-products of the citrus industry which can be used
as livestock feeds. These are:

a) Citrus Pulp (both fresh and dried)

b) Citrus Molasses

c) Citrus Seed Meal

and comprise about 40 - 45% of the total factory production.

CITRUS PULP

The first investigations into the efficiency of this as a feed for livestock were conducted at the Florida Experiment Station. They consisted of the feeding of dried grapefruit peel, rag, and seed prepared by Seth Walker to six Jersey cows, (1) in addition to their regular feed. Five of these cows increased in milk production, from which John M. Scott (6) concluded that the dried product tended to increase milk flow, or at least make nutrients available to the cow. Commercial scale drying in America came about through the promising results obtained when, later, a Duval County dairymen fed to some of his Guernsey cows some of the dried grapefruit peel made available when a proposed venture to export it for pectin manufacture fell through. Since then, citrus wastes have been absorbed more and more into the livestock industry until 1947-48 an estimated 140,000 tons of dried citrus pulp were produced in central Florida.

DIGESTIBILITY AND FEEDING VALUE

Fresh citrus pulp contains about 85% moisture and 15% dry matter as compared with 90% dry matter in the dried pulp. Dry matter is somewhat different in the two, in that in the latter volatile essential oils of the peel have evaporated, and calcium has been added in the drying process to liberate the bound water. Thus the pulp is a highly dilute concentrate. Marsh-Seedless grapefruit and Navel oranges are slightly lower in protein than in seed-oil owing to fewer seeds being present. Fat content is also lower for the same reason.
TYPICAL FEED ANALYSIS OF DRIED CITRUS PULP

<table>
<thead>
<tr>
<th>Component</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Protein</td>
<td>6.2</td>
</tr>
<tr>
<td>Fat</td>
<td>1.5</td>
</tr>
<tr>
<td>Crude Fibre</td>
<td>13.0</td>
</tr>
<tr>
<td>Nitrogen free ext.</td>
<td>63.0</td>
</tr>
<tr>
<td>Ash</td>
<td>4.3</td>
</tr>
<tr>
<td>Dry Matter</td>
<td>92.0</td>
</tr>
</tbody>
</table>

Dried citrus pulp is low in protein and fat, but high in carbohydrate content, hence its classification as a bulky carbohydrate feed.

The minerals present are mainly phosphorus, potash, and lime (from the drying process). According to a determination by the Army and Pries method, its net energy value as compared with various other carbohydrate feeds is shown below:

<table>
<thead>
<tr>
<th>Feed</th>
<th>Net Energy (Henke)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus Pulp</td>
<td>91.59</td>
</tr>
<tr>
<td>Beet Pulp</td>
<td>74.57</td>
</tr>
<tr>
<td>Wheat Bran</td>
<td>50.91</td>
</tr>
<tr>
<td>Alfalfa Hay</td>
<td>36.92</td>
</tr>
</tbody>
</table>

As regards Vitamin content, biological assays with rats showed that it contained less than one-half an international unit of Vitamin A.

Digestibility trials conducted at Texas, Florida, California and Palestine have shown in the main that for milk production dried grapefruit and orange refuse are practically equivalent to dried beet pulp. A concise resumé of the Florida trials is presented below and may be taken as representative of all others.

**COMPOSITION, COEFF’S OF DIGESTIBILITY, AND DIGESTIBLE NUTRIENT**

*(PER CENT) OF CITRUS REFUSE*

<table>
<thead>
<tr>
<th></th>
<th>DM</th>
<th>CP</th>
<th>CFb</th>
<th>NFE</th>
<th>CFat</th>
<th>Ash</th>
<th>TDN</th>
</tr>
</thead>
</table>
| **Dried Orange Pulp**
| Composition   | 96.05 | 5.84 | 10.64 | 64.74 | 0.69 | 4.13 | -   |
| Coeff’s of Dig. (ave) | 36.57 | 92.91 | 86.51 | 6.59 | - | - | -   |
| Dig. Nutrients | -   | 2.14 | 9.99 | 57.30 | 0.05 | - | 59.55 |
| **Dried Grapefruit Refuse**
| Composition   | 91.77 | 4.94 | 11.94 | 69.60 | 1.06 | 4.23 | -   |
| Coeff’s of Dig (ave) | 24.83 | 71.52 | 92.43 | 79.37 | - | - | -   |
| Dig. Nutrients | -   | 1.23 | 8.54 | 64.53 | 0.84 | - | 75.98 |
It is thought that the low digestibility of crude protein may be due to heating of the pulp during drying.

FATTENING

Kirk, W.C., et alia(11) carried out 120-day tests in Florida to test the value of dried citrus pulp and fresh grapefruit for fattening cattle. Twenty-eight steers with 50% Brahman blood were used, and the following results were obtained:

<table>
<thead>
<tr>
<th>FEED USED</th>
<th>AVERAGE DAILY GAIN</th>
<th>T.D.N. REQ'D FOR 100 LB GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground snapped corn</td>
<td>2.37</td>
<td>539</td>
</tr>
<tr>
<td>Dried Citrus pulp</td>
<td>2.17</td>
<td>466</td>
</tr>
<tr>
<td>Dried Citrus pulp &amp;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lb ground snapped corn</td>
<td>2.53</td>
<td>484</td>
</tr>
<tr>
<td>Fresh grapefruit</td>
<td>1.98</td>
<td>456</td>
</tr>
<tr>
<td>Fresh grapefruit &amp;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lb ground snapped corn</td>
<td>2.15</td>
<td>457</td>
</tr>
</tbody>
</table>

In each trial all animals received the same amount of hay and cottonseed meal, but the amount varied for the three trials.

ENSILAGE

Extensive experiments have been done with some success in Palestine regarding the ensilage of fresh citrus peels. The finely-cut peels were ensiled in pits in alternate layers of peel and straw, where they underwent a lactic acid fermentation. In the course of this, the pH of the pulp increased while the pectin content slightly declined.

Bondi(15) showed that the Nitrogen free extract and sugar of both orange and grapefruit peels ensiled for eight months had decreased, and that the silage was free of spore-forming rods.

The Digestibility Coefficient for the nitrogen free extract exceeded 90% and the feeding value of the ensiled pulp was 16% higher than that of whole fruits. The silage compared well in digestibility with more common silages.
PALATABILITY

While all these products were found to be palatable to cattle, some were decidedly less so than others; thus, beef and dairy cattle were observed to eat the citrus seeds and rind before the peel, consuming this latter when after a time most of the volatile oils had evaporated. Dried grapefruit pulp and dried orange peel are more palatable to dairy cattle than orange and lemon pulps. The bitter principle (narangin) did not appear materially to affect palatability. Cattle preferred silages of citrus press cake, those mixed with hay, mixed with sugarcane, and plain citrus pulp silage in the order named.

The whole grapefruit is readily eaten—a good outlet for cull fruit, but such use should be restricted to well-grown stock. For young stock the fruit should be quartered or sliced lest it cause stomach disorders.

EFFECTS ON THE ANIMALS AND THEIR PRODUCTS

In all cases of feeding, dried citrus pulp imparted beneficial effects in condition generally, as shown by a sleek and glossy appearance of the hair, and improved thickness of the flesh. Also, it had a mildly laxative action when fed as a large proportion of the ration.

Excellent results were obtained regarding milk production and general conditioning of dairy cows.

CITRUS MOLASSES

In the preparation of dried citrus pulp part of the moisture content of the fresh pulp is pressed out before drying and after treating with lime to remove bound water. The press juice contains about 6% of fruit solids—mainly sugars and also the bitter principle—narangin. When this press juice is evaporated to about one-thirteenth of its volume (about 70% solids) the product is Citrus Molasses.

Citrus molasses was first produced commercially in Florida in 1941-42 canning season, during which some 2500 tons were produced. In 1951 the production had increased to 70,346 tons as facilities for its recovery became available. Citrus molasses is now
available to individual feeders in Florida, and its feeding potentialities are being widely tested.

There is a potential production of one ton of molasses per two tons of dried citrus pulp.

PALATABILITY

Becker, R.B. et alia(10) fed plain citrus molasses to 34 dairy cows in Florida, and noted that eight of these ate it on the first offering, seventeen on the second, and twenty-six on the third, which showed that cows learned to like the product in a plain form, though it was less palatable in this state than when mixed in their feed. When the ration contained 5 and 10% of citrus molasses dairy cows consumed both offerings with little or no hesitation. The same result was obtained when citrus and blackstrap molasses were blended in three-to-one and one-to-one ratios.

It appeared that the narangin content was responsible for some degree of refusal. But recently a process has been developed whereby narangin is removed. Also, palatability was improved by returning the molasses to dry citrus pulp, the resultant product being "molassed citrus pulp" or "sugar-sweet citrus pulp", for which some demand has arisen in Florida.

DIGESTIBILITY AND FEEDING VALUE

A typical analysis of citrus molasses showed the following composition:

<table>
<thead>
<tr>
<th>Component</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter</td>
<td>67 - 75</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>3.4 - 5.0</td>
</tr>
<tr>
<td>Nitrogen-free Extract</td>
<td>56 - 66</td>
</tr>
<tr>
<td>Ash</td>
<td>3.5 - 5.3</td>
</tr>
<tr>
<td>Reducing Sugars</td>
<td>21 - 32</td>
</tr>
<tr>
<td>Non-Reducing Sugars</td>
<td>15 - 20</td>
</tr>
<tr>
<td>Fibre</td>
<td>-</td>
</tr>
<tr>
<td>Fat</td>
<td>Very little</td>
</tr>
</tbody>
</table>

Limited steer feeding work has indicated that citrus molasses is nearly equivalent in feeding value to blackstrap and beet molasses. Becker, R.B., Arnold, P.T.D., Davis, G.K., and Fouts, E.L., (10) applied the digestion coefficient computed from 30
trials conducted with blackstrap and beet molasses to estimate the feeding value of citrus molasses, and concluded that the latter provided 1.4% of digestible crude protein and 56.7% total Digestible Nutrients, based on 69.9% of dry matter in the molasses.

EFFECTS ON ANIMALS AND THEIR PRODUCTS

Feeding trials conducted on grade Shorthorn steer calves to determine the feasibility of replacing part of the ground snapped corn in a normal steer-fattening ration with citrus molasses showed that:

a) Citrus molasses replaced one-half of the ground snapped corn without reducing gains, finish, or yield of steer calves fed to "low-good" grade.

b) Steers fed citrus molasses seemed to have better appetites and were easier to keep on feed.

c) Such replacement resulted in higher hay consumption and a greater intake of dry matter owing to stimulated appetite.

There should be no effect on milk flavour if the animal is fed just after milking.

The faeces of the calves fed citrus molasses appeared somewhat softer, although no tendency to scour was apparent.

SILAGE

Satisfactory results were obtained when citrus molasses was used in place of blackstrap molasses in silages of Napier grass and pigeon pea, these being taken as representative of the non-saccharin grasses in the first case and fresh legumes in the other, neither of which will make a desirable silage without addition of molasses.

CITRUS SEED MEAL

This is the residue from seeds from which the oil has been extracted. Up to the present it is not produced in sufficient quantity to find extensive use, but owing to its high protein content (35%) it holds promise as a protein supplement. Investigations into its feeding value were instigated by this fact, by the fact that citrus seeds are included in the pulp, and by the results of feeding trials conducted earlier at the Florida Agricultural Experiment
Station Poultry Department, which indicated that the product is toxic to chicks.

PALATABILITY

When fed to steers, citrus seed meal was eaten readily.

With swine it proved unpalatable even at levels as low as ten percent of the ration.

FEEDING VALUE

(A) STEERS

Three lots of two-year-old Hereford steers (4 steers to each lot) were used to determine the value of citrus seed meal in growing and fattening cattle. The protein supplement was provided in these three lots by quantities of cottonseed and citrus seed meals which varied between the lots but which were constant within each lot. The results of this trial are tabulated below:

<table>
<thead>
<tr>
<th>PROTEIN SUPPLEMENT</th>
<th>TOTAL GAIN/LOT</th>
<th>AVE. DAILY GAIN/STEER</th>
<th>DRESSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonseed Meal</td>
<td>951</td>
<td>1.93</td>
<td>62.2</td>
</tr>
<tr>
<td>(50% cottonseed Meal)</td>
<td>976</td>
<td>1.99</td>
<td>61.2</td>
</tr>
<tr>
<td>(50% citrus seed meal)</td>
<td>991</td>
<td>2.02</td>
<td>63.0</td>
</tr>
</tbody>
</table>

Thus, citrus seed meal proved just as valuable as cottonseed meal in meeting the protein requirements of growing and fattening steers, and was apparently utilized just as efficiently as a source of energy.

SWINE

A trial/somewhat similar nature was conducted at the same time with swine, using citrus seed meal in varying quantities as a protein supplement. The results of this trial are shown below:

<table>
<thead>
<tr>
<th>RATION</th>
<th>AVERAGE DAILY GAIN/PIG</th>
<th>FEED REQ'D PER 100LB GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.86</td>
<td>406</td>
</tr>
<tr>
<td>Control + 10% citrus seed meal</td>
<td>1.15</td>
<td>459</td>
</tr>
<tr>
<td>Control + 25%</td>
<td>0.30</td>
<td>1006</td>
</tr>
</tbody>
</table>
(In the control ration the protein supplement was provided by a mixture of peanut meal and fish meal. The peanut meal was decreased as the citrus seed meal was increased.)

These results clearly showed citrus seed meal to be harmful to the pig at levels as low as ten per cent of the ration, and demonstrated that it should not be included in swine rations.

EFFECTS ON THE ANIMAL AND ITS PRODUCTS

No harmful effect was observed on cattle fed citrus seed meal. There were no indications of toxicity apparent. General appearance, weight gain, shrinkage in transit to market, carcass yields and grades all served to put citrus seed meal on par with cottonseed meal as a protein supplement.

With pigs the opposite was the case. On a ration containing ten per cent citrus seed meal the animals had rough hair coats and a general unthrifty appearance, both conditions being more pronounced as the proportion of this meal in the ration increased.

SUMMARY AND CONCLUSIONS

As the citrus industry in the West Indies moves from strength to strength the formidable quantities of surplus material in the form of peels, pulp and seeds grow in proportion, and the problem of their disposal becomes increasingly urgent. The only solution is the production of citrus meal to be used as cattle fodder.

Citrus pulp can be fed fresh or in the dried state. The latter is to be preferred since it is more sanitary, more convenient, and entails less labour in feeding. Moreover, cattle fed the fresh pulp, although consuming less water, were more difficult to keep well bedded.

Dried citrus pulp is a bulky carbohydrate concentrate, but, whilst it is useful as a supplement to leafy roughages where these are scarce – a condition which exists throughout most of the West Indian territories – it cannot replace these entirely. At least 4 pounds daily of leafy hay, or its equivalent in fresh green forage, is essential for thrift and regular reproduction, owing to their Vitamin A content. In addition, where citrus pulp and meal are fed, cattle must be kept supplied with a suitable mineral mixture, as these products are rather deficient in this respect.
In storage, citrus pulp may become a definite fire hazard due to its tendency towards spontaneous combustion; its feeding value may also be lowered as a result of moulding owing to its slightly hygroscopic nature. Hence, if it is to be kept for any length of time, ensiling is recommended. Experiments show that its silage compares favourably in digestibility with more common silages.

As regards its use as a feed for swine or poultry, citrus pulp is decidedly unsatisfactory, since the seeds which are normally present in it have been found to be toxic to these animals.

Citrus molasses has been shown to be almost on par with the well recognised blackstrap and best molasses in respect of feeding value.

In general, citrus pulp and meal are more suited for dairy feeding, though useful for general purposes, their most notable attractions for dairy cows being palatability, digestibility, energy value and laxative qualities.
COCONUT MEAL

This is a by-product in the manufacture of coconut oil from copra, which consists of the dried, broken pieces of coconut meats. The oil makes up about two-thirds of the dried copra and is removed under pressure, leaving behind it a nutty-flavoured, aromatic press cake of light grey to brownish colour, which is much relished by cattle and sheep as coconut-oil meal.

The value of coconut meal as a feed for livestock is generally appreciated throughout the West Indies, and wherever copra is made the resultant meal is put to this use. In addition there is a lively trade of this commodity between the islands.

The ravages of periodical larceny, coupled with the somewhat lackadaisical methods of management employed in the past render correct estimation of coconut yields somewhat difficult. However, 50-60 nuts per tree per year and 200-300 nuts per acre per year are taken as average.

Coconut meal figures prominently in feeding programmes in all the territories. In St Vincent production would meet requirements were it not for the fact that it is used there as manure. In Trinidad yields have been greatly depressed lately, largely owing to the high incidence of Red-Ring disease, so that here too, demand exceeds production.

Production figures for each island are unavailable.

However, export figures are recorded, and those reproduced below may give some indication of the state of the industry in the area.

EXPORTS OF COCONUTS AND COCONUT PRODUCTS FROM THE WEST INDIES

<table>
<thead>
<tr>
<th>TRINIDAD &amp; TOBAGO (1950)</th>
<th>Quantity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total exports</td>
<td>$ 651,507</td>
<td></td>
</tr>
<tr>
<td>Copra</td>
<td>14,000</td>
<td>256,858</td>
</tr>
<tr>
<td>Coconut oil (unrefined)</td>
<td>44,190</td>
<td>76,824</td>
</tr>
</tbody>
</table>

(P.T.O.)
<table>
<thead>
<tr>
<th>Island</th>
<th>Year</th>
<th>Nuts</th>
<th>Meal</th>
<th>Oil</th>
<th>Quantity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAMAICA (1950)</td>
<td></td>
<td>no</td>
<td>lb</td>
<td>gals</td>
<td>32,614</td>
<td>£ 282</td>
</tr>
<tr>
<td>ST VINCENT (1949)</td>
<td></td>
<td>no</td>
<td>lb</td>
<td>gals</td>
<td>11,860</td>
<td>£ 73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,679</td>
<td>£ 754</td>
</tr>
<tr>
<td>NEVIS (1951)</td>
<td></td>
<td>lb</td>
<td></td>
<td></td>
<td>2,944,161</td>
<td>$277,810</td>
</tr>
<tr>
<td>MONTSERRAT (1951)</td>
<td></td>
<td>no</td>
<td></td>
<td></td>
<td>24,447</td>
<td>$ 932</td>
</tr>
<tr>
<td>BRITISH VIRGIN IS. (1951)</td>
<td></td>
<td>no</td>
<td></td>
<td></td>
<td>39,835</td>
<td>-</td>
</tr>
</tbody>
</table>

In St Vincent in 1951, 368,719 pounds of coconut meal were made and consumed locally. Total production of coconuts was estimated at 10,000,000 nuts.

The above table does not accurately represent production in any island, since no mention is made of the great quantities of nuts, meal, etc consumed locally.

**DIGESTIBILITY AND FEEDING VALUE**

A typical California analysis of coconut meal yielded the following composition:

<table>
<thead>
<tr>
<th>Component</th>
<th>Range</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>6.9 - 15.7</td>
<td>10.55</td>
</tr>
<tr>
<td>Protein</td>
<td>18.5 - 22.4</td>
<td>20.69</td>
</tr>
<tr>
<td>Fat</td>
<td>6.5 - 10.7</td>
<td>8.78</td>
</tr>
<tr>
<td>Fibre</td>
<td>5.7 - 14.7</td>
<td>9.00</td>
</tr>
<tr>
<td>Nitrogen-Fibre Ext</td>
<td>39.6 - 49.5</td>
<td>44.41</td>
</tr>
<tr>
<td>Ash</td>
<td>5.1 - 7.0</td>
<td>5.97</td>
</tr>
</tbody>
</table>
There is considerable variation in composition according to the method of manufacture and to the quality of the raw material used, but in the main coconut meal differs from linseed and cottonseed meals only in that it contains considerably less protein, and usually more fat. This latter constituent is the most variable, and is dependent on the amount of oil extracted from the copra. Some meals imported into California were found to contain over 20% fat.

DIGESTIBILITY

Numerous trials with sheep, steers, and pigs in the U.S.A. have demonstrated that coconut meal is highly digestible, ranking well up with the other oil meals and with the cereal grains in this respect. The following table shows the general results of these trials.

<table>
<thead>
<tr>
<th>Component</th>
<th>Range</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>75 - 90</td>
<td>82</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>75 - 90</td>
<td>85</td>
</tr>
<tr>
<td>Fat</td>
<td>96 - 100</td>
<td>90</td>
</tr>
<tr>
<td>Fibre</td>
<td>23 - 75</td>
<td>50</td>
</tr>
<tr>
<td>Nitrogen-free extract</td>
<td>80 - 87</td>
<td>83</td>
</tr>
</tbody>
</table>

When compared with various other concentrates, coconut meal was found to have a higher percentage of digestible protein than wheat bran, barley and beet pulp. Other factors used in comparison are shown in the table which follows:

| Digestible Components of Coconut Meal and Other Concentrates (Percent) |
|---------------------------|----------------|----------------|----------------|----------------|
|                           | Coconut Meal  | Cottonseed Meal| Barley Bran    | Dried Beet pulp|
| D.M.                      | 73.3           | 72.9           | 78.5           | 57.3           | 61.2           |
| Protein                   | 17.6           | 34.0           | 9.4            | 12.0           | 4.2            |
| Fat                       | 8.6            | 8.1            | 1.4            | 2.7            | -              |
| Fibre                     | 4.9            | 5.2            | 2.4            | 2.8            | 14.5           |
| N.F.E.                    | 56.8           | 20.3           | 63.2           | 36.8           | 50.5           |
| Ash                       | 3.8            | 4.2            | 1.0            | 1.8            | 1.2            |
Thus, coconut meal ranks close to barley and cottonseed meal in digestibility and in total nutritive components. In digestible carbohydrates and fat it compares well with barley and dried beet pulp, and in this respect exceeds both cottonseed meal and wheat bran by 15 - 20 per cent.

Its nutritive ratio, though wider than that of cottonseed meal, is close to that of wheat bran and considerably narrower than those of barley or beet pulp.

Hence coconut meal is well adapted to supplement starchy feeds - like the cereal grains and beet pulp, or most medium protein feeds - like wheat bran, middlings, or shorts, in compounding rations for farm stock.

**NET ENERGY**

Armsby (1) expressed the relative values of various feeding stuffs in terms of their net energy, based on their contents of digestible components.

<table>
<thead>
<tr>
<th>FEED</th>
<th>NET ENERGY VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonseed Meal</td>
<td>90.0</td>
</tr>
<tr>
<td>Ground Barley</td>
<td>89.9</td>
</tr>
<tr>
<td>Linseed Meal</td>
<td>88.9</td>
</tr>
<tr>
<td>Coconut Meal</td>
<td>83.5</td>
</tr>
<tr>
<td>Dried Beet Pulp</td>
<td>75.9</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>53.0</td>
</tr>
</tbody>
</table>

**FEEDING VALUE**

Coconut meal is a valuable source of digestible protein, carbohydrates, fat and mineral matter. Experiments at Florida (1909) showed that a unit of protein in coconut meal is very nearly equivalent to a unit of protein in cottonseed meal, while practical feeding experience on the Pacific Coast of the U.S.A. proved that apart from being a good dairy feed, it may also be used to advantage in swine and poultry rations, either mixed with other concentrates or
as a component of special commercial mixed feeds.

Hobbs, R.E.T. (1931) found that addition of coconut meal to Savannah grass had the effect of greatly raising the nutritive value of the latter, and further that a combined ration of Savannah grass and coconut meal fed at the rate of 40 lb of grass and 3 lb meal per head will provide a suitable maintenance ration for Zebu oxen and allow a surplus for production.

Horsekind are still widely used for draught purposes throughout the West Indies, and in this connection it is noteworthy that experience with work and Army Horses in continental Europe (2) indicated that as much as one-quarter of their grain ration may be composed of coconut meal without any ill effects as regards working capacity or general well-being. Rommel and Hammond (4) corroborated this.

PALATABILITY

In general, this product is very palatable to cattle, less so to swine and other farm animals. Dairy cows soon become accustomed to it. It should be noted, however, that owing to its high oil content it will turn rancid in prolonged storage and thereby become unpalatable, but if good quality meal is used it should keep easily for a couple of months.

(It appears that the increased fatty-acid content of rancid meal has no nutritional significance except perhaps with poultry.)

EFFECTS ON THE ANIMAL AND ITS PRODUCTS

BUTTER

When fed to milk cows, coconut meal will tend to produce a hard butter of excellent flavour, so that it may be mixed to advantage with those feeds such as linseed meal, rice residues, gluten meal, etc., which have the opposite influence on the butter. If fed too heavily, though, a hard butter of poor texture will result.

PORK

When fed to swine, the meal will produce a firm, good quality pork; hence it is of value in counteracting the effects of those feeds which produce a soft pork, like peanuts and those just mentioned.
MILK

Reports that coconut meal had a beneficial effect on the milk secretion of cows by causing an increase in the fat content, and also by retarding the natural decrease in milk production due to advancing lactation, were verified by Woll, F.W. (17) in California (1919 - 1920). Coconut meal is therefore among the few feeds that can do this, others being palm nut meal, molasses and malt sprouts.

COCONUT MEAL FOR OTHER CLASSES OF FARM ANIMALS

SWINE

Thompson and Voorhies (20) 1922, found that coconut meal proved to be a desirable supplement to barley in feeding market hogs if given in the proportion of one pound to three or four of barley.

Laxative effect was too marked when fed in higher proportions in conjunction with alfalfa pasture or cut green alfalfa.

POULTRY

Work done in California (17) up to 1921 indicated that coconut meal was not quite so palatable or beneficial physically to poultry as was soyabean meal or linseed meal, but was nevertheless a reasonably good high-protein feed and as valuable as other oil meals in proportion to protein content, so that it were best used as a component of commercial poultry feeds in mixtures with other concentrates.

SUMMARY AND CONCLUSIONS

Coconut meal has a high feeding value and forms a valuable source of digestible protein, carbohydrates, and fat, as well as mineral matter, for feeding farm stock. Although its feeding value is somewhat below that of cottonseed meal or linseed meal, it compares well with barley and other cereals, and is decidedly above wheat bran, dried beet pulp, or molasses in this respect, these feeds being of similar rank in feeding value.

This is appreciated in a general way in the West Indies but it is thought that perhaps better results might be obtained if a little more attention were paid to its exact place in livestock feeding.

Coconut meal has the advantage of being relatively cheap, costing 2½¢ per lb in Trinidad, so that by its wider inclusion in farm rations, a decrease in the cost of production may confidently be expected.
The by-products from sugar manufacture which are of value as feeds for livestock are:

a) Sugar cane tops  
b) Cane Molasses  
c) Rum Yeast

The first two of these have long been used in stock feeding in the West Indies, so that perhaps they do not strictly speaking come under the title of this discussion (as waste materials having possibilities in this direction). Yet they merit a certain degree of attention since as yet their actual feeding values are somewhat obscure to many stockmen in the area. Rum Yeast, on the other hand, is relatively new on the market.

**SUGAR CANE TOPS**

As mentioned above, this product has an established place in West Indian feeding practice on the whole. Indeed, in many of the islands it forms the only source of roughage during certain months of the year (June to August) until the short-term fodders come into a suitable stage for cutting.

In actual fact, it has been shown (Robinson, 1950) that cane tops do not make very suitable fodder for the high-yielding dairy cow. Again, Woodman, E., 1948, pointed out that their protein content, though average for tropical fodders, was appreciably lower than that of pasture roughages used in the temperate countries. Also, cane tops are especially high in dry matter content, and this serves only to aggravate the deficiency of protein, since the bulk intake is limited by the animal's capacity. Further, cane tops possess a very wide nutritional ratio - 1:22 for 13 week-old sugarcane as compared with 1:4.7 for extensively grazed U.K. pastures (Woodman 1948).

Bearing in mind that it has been proved in the temperate climates that a nutritive ratio of 1:6 is advisable when feeding dairy cows, the logical course has been pursued, namely affecting
a decrease in the Nutritive ratio of the ration by incorporating a concentrate having a high protein content. Robinson \(^{(21)}\) records that this does not appear to be an entirely satisfactory solution.

In India, inefficient utilization of cane tops led to an investigation into its nutritive value for stock. Das Gupta et alia \(^{(25)}\) 1949, found that cows (Bos taurus cows used) relished the tops when these were fed as the main source of dry matter. Tests done with over-ripe Co 312 canes yielded the following figures for digestible nutrients - calculated on a dry basis.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>3.21</td>
</tr>
<tr>
<td>T.D.N.</td>
<td>66.76</td>
</tr>
<tr>
<td>Other Ext</td>
<td>2.35</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>58.26</td>
</tr>
</tbody>
</table>

The digestibility of the fibre and of the nitrogen-free extract of cane tops were found to be higher than those of wheat straw, but digestibility of the protein was lower than that of linseed cake. The over-ripe canes proved nearly equal to maize in nutritive value and compared favourably with Elephant grass, Guinea grass and "Jowar".

Milk yield was quite satisfactory even when the amount of oil cake supplement necessary with wheat straw is halved when feeding with cane tops.

**NUTRITIVE VALUE OF CANE TOPS AS COMPARED WITH OTHER FODDERS**

*(ROBINSON\(^{(2)}\))*

<table>
<thead>
<tr>
<th>Fodder</th>
<th>D.M.</th>
<th>S.E.</th>
<th>D.C.P.</th>
<th>N.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cane tops</td>
<td>35.2</td>
<td>18.8</td>
<td>0.92</td>
<td>1.21</td>
</tr>
<tr>
<td>Do Silage</td>
<td>37.9</td>
<td>24.1</td>
<td>1.11</td>
<td>1.21</td>
</tr>
<tr>
<td>Elephant grass</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(26 weeks)</td>
<td>27.8</td>
<td>13.4</td>
<td>0.71</td>
<td>1.19</td>
</tr>
<tr>
<td>Maize Silage</td>
<td>15.7</td>
<td>9.0</td>
<td>0.5</td>
<td>1.15</td>
</tr>
</tbody>
</table>

**CANE MOLASSES**

This is the residue after the extraction of sucrose from cane juice, and is sufficiently well-known to render description unnecessary. It is produced in the proportion of 450 pounds of molasses to one ton of cane sugar on the average, so that it will
be readily seen that throughout the area as a whole quite a formidable quantity of this commodity will result annually from the activities of the sugar producers. As already mentioned, much of it has found its way into livestock rations chiefly in the role of an appetizer - so to speak - for poor quality fodders, but the problem of disposal still commands attention; indeed there is every indication that this problem will assume considerably greater proportions in time to come as production continues to be steadily increased.

FEEDING VALUE

Cane or "Blackstrap" Molasses is classified as a carbonaceous concentrate, and should therefore be considered as a substitute for feeds such as corn. In composition it differs from this feed in that whereas molasses contains 60 - 65% total digestible nutrients, practically all of which are carbohydrates, corn boasts about 82% T.D.N. with 7% of these being protein. This indicates that on the basis of T.D.N. content, molasses is worth approximately 75% as much as corn pound for pound, yet it must be remembered that in practical feeding, other considerations will enter, such as:

i) amount of nitrogenous feed which must be combined with molasses or corn to furnish the necessary protein

ii) palatability

iii) labour entailed in feeding

iv) price

so that although molasses may appear on face value to be inferior to corn, actual practice may show it up as equivalent or nearly so to the latter. This actually has been found to be the case for fattening poultry (Henry and Morrison (24) and for milk production and calf-feeding (Brintnall (26)). Henke (25) describes the work done with regard to molasses as a feed for dairy cows as presenting "neither a wholly favourable nor a wholly unfavourable picture."

Results obtained by some workers almost contradict the findings of others. Thus while Henke reports (27) that molasses is palatable to swine, and that, in amounts up to 20% of the con-
centrate ration it was worth about as much pound for pound as rolled barley when fed to fattening pigs (of initial weight of 50 - 100 lb), the view at the Missouri Agricultural Experimental Station (28) is that "hogs do not relish a sweet feed, hence the use of molasses in rations for fattening hogs is limited."

Other workers have shown molasses to be a good source of Vitamins B and E, and of value in preventing and curing nutritional anaemia.

**Cane Molasses for Cattle**

Perhaps the best utilizers of cane molasses are cattle. Its feeding value for fattening this type of stock has been shown to be approximately equal to shelled corn, pound for pound, when fed in small amounts. (28) As stated above, Brintnall (26) corroborated this view with regard to dairy cows and calves.

Ellison and Catala (29) working in Puerto Rico in 1928, supplemented the grain ration for one group of cows with cane molasses and for another, with corn chops (ground corn and by-products), the roughage for both groups consisting largely of cane tops. Whereas the chop-fed lot consumed more feed and produced more milk, greater economy in cost of milk production was obtained with addition of molasses to the ration.

**Effects on Animal and Its Products**

Woodward and Lee (30) encountered scouring after feeding molasses in amounts of 0.5 to 0.7 pounds to calves up to 7 months of age. Since the same effect was produced by an equivalent quantity of granulated sugar, the inference was that the laxative effect was brought on by the sugar content of the molasses rather than any other constituent.

Grisdale (30) in 1913 substituted cane molasses in varying percentages for a mixture of 6 pts bran, 3 pts gluten meal, 2 pts cottonseed meal and 2 pts dried brewers grains fed to dairy cows. His findings were as follows:
At a 10% level - molasses was quite satisfactory and showed better palatability.

At a 20% level - milk flow decreased, but weight and condition improved.

At a 30% level - there was marked decrease in milk flow, scours occurred and a loss in body weight resulted.

Thus for maximum beneficial effect without detrimental results, its use must be limited to small amounts in practical feeding.

Perhaps the most outstanding merit of molasses is the effect it has of increasing feed consumption of poor quality fodders by rendering these more palatable; it will also increase consumption of feeds already palatable in themselves.

MOLASSES FOR POULTRY

Winter\(^{(1)}\) reports that the laxative effect of molasses limits its use in rations for laying hens to a level of 10%. It increases the amount of water drunk by the birds, but has little or no influence on feed consumption, body weight or production. However, mortality tends to be lowered as it contributes toward better health and condition. It improves milkless rations for growing chicks.

In fattening trials, rations containing up to 10% of cane molasses gave slightly better gains with little more feed consumption than those without.

Experiments in Hawaii\(^{(1)}\) showed that when fed in amounts not exceeding 7% of the mash it was satisfactory for chicks, growing pullets, and cockerels, though it did not prevent coccidiosis in baby chicks.

MOLASSES FOR SWINE

Against the findings of Henke mentioned earlier, we have those from stations in the U.S.A.\(^{(1)}\) which demonstrated that when molasses was used as a partial substitute for fattening hogs, "gains were produced more slowly, more feed was required per unit gain, and in every case molasses was much less valuable than corn."

However, it was thought that growing or breeding hogs (not on full feed) might make better use of it, to the extent that it might replace...
The utilization of this product in animal feeding is relatively new, but its prospects of becoming accepted are good. One firm of distillers in Trinidad has recently released an appreciable quantity of this product on the market.
CEREAL RESIDUES

INTRODUCTION

The two chief cereals grown in the West Indian area are Rice and Corn. The latter figures prominently in animal rations in practically every island, the former is fed to stock in British Guiana and Trinidad as rice bran and broken rice. In many of the territories the requirements of corn are largely met, but not so in Trinidad where the high price of corn for human consumption is a hindrance to its use as livestock feed.

RICE RESIDUES

Rice is processed in Trinidad by some 300 mills each turning out a different product. There is no grading, so that there are consequently no reliable standards whereby rations may be efficiently compounded and kept stable. Moreover these products are never sufficient in quantity to be effectively utilized in this way.

FEEDING VALUE

The tendency in Trinidad is for the rice husk to be either used as a complete ration or as a diluent for coconut meal, both of which uses are inefficient, since it has been shown that rough rice needs nearly twice as much protein supplement (e.g. coconut meal) to balance the ration as does corn in a fattening ration. However, the Marketing Board Stock Feed Depot at St Joseph has undertaken the production of Rice Bran from husk purchased from the millers and processed to lower the fibre content as much as possible.

NUTRITIVE VALUE OF CEREAL RESIDUES

Most of the by-products from cereal grains have higher levels of protein, fat, and fibre than the original grains, and some contain a greater percentage of certain vitamins. Whilst the higher protein, fat and vitamin contents add to their value as feeds, the higher fibre content limits their use for swine and poultry.
Those maize residues which have potential value as livestock feeding stuffs are:

a) Hominy Feed
b) Germ oil/meal
c) Gluten Meal
d) Gluten Feed
e) Maize Straws and silage

The first four of these products have their common West Indian counterpart in Cornmeal but a brief consideration of each individually would not be out of place here.

HOMINY FEED

This is the residue from the processing of corn to produce degeminated cornmeal for human consumption. It contains some of the starchy protein, besides the germ and the corn bran (tip caps and outer layers of the kernels), and is generally used in the U.S.A. to replace part or all of the corn used in rations for livestock. It is useful too in poultry rations. (23)

GLUTEN MEAL AND FEED

Gluten meal differs from gluten feed in that whereas the former is mostly gluten, the latter contains both gluten and bran. Gluten meal is comparable to the oilseed meals in protein content, though the protein is generally inferior from the nutritional standpoint. However, it is superior in protein content to the Feed, although they are both widely used in the U.S.A. in livestock feeding - particularly for dairy cattle - and may both be regarded as useful protein supplements.

An added attraction of the meal prepared from yellow corn is its content of carotenoid pigments which impart the desirable yellow colour to the shanks and skin of poultry.

MAIZE STRAWS

No literature was available on the use of maize straws in livestock feeding beyond figures of analysis and nutrient content. These are included in Robinson's work. (21)

MAIZE SILAGE

Robinson (22) in 1950, carried out feeding trials to compare
the value of a supplement of molassed maize silage to dry cane
tops with dry cane tops alone. He noted that whereas a significant
increase in milk yield resulted, there was a decrease in the
percentage butterfat in milk, although the total yield of butterfat
per cow was not affected.

**RICE RESIDUES**

By-products in the milling of rice for human consumption
are:

1) Hulls
2) Rice Bran
3) Rice Polish

The hulls are removed first; the bran is the germ and
outer layers of the kernel; rice polish is derived from the polishing
of the kernels.

*Rice Polish* is much lower in fibre than the bran, whilst
neither of the two have been found to be as high in protein as are
the wheat by-products. Their fat content is high, though, hence
their tendency to go rancid readily.

Volcani(24) compared the suitability of rice for milk and
butterfat production in cows with barley-meal and found that

a) although the animals showed a preference
   for barley-meal they accepted rice polish
   willingly.

b) There was no difference in milk yield or
   butterfat content between groups.

He concluded that a considerable portion (58%) of rice polish may
safely be included in the concentrate ration.

*Rice bran* is fed to dairy and beef cattle, sheep, and
pigs, but only in limited amounts to the latter owing to its
tendency to produce scouring and soft-lard. It is worthy of mention
at this point that Tilman et alia(2) through experiments in
Louisiana found that solvent-extracted rice bran, owing to its
lower fat content did not have these faults.

Rice polish is higher in T.D.N. than the bran - a fact
worthy of note in general feeding. Also the high content shown by
these products of several of the B vitamins is noteworthy in the use
of the two feeds for swine.
COTTON RESIDUES

Cottonseed meal is well recognised as a valuable protein supplement for livestock feeding. In the northern islands where cotton is a major crop the meal is freely used in stock rations, and a certain amount is imported annually into most of the other islands from these areas, but the demand is not met, with the result that every year considerable quantities of linseed meal are imported into the West Indian area to supplement the use of this product. In this connection it is reported that St Vincent could supply its own total requirement of cottonseed meal as well as of coconut meal were it not for the use of these two valuable concentrates as manure.

FEEDING VALUE

Raw cottonseed meal contains several compounds which are toxic to non-ruminants in particular, gossypol being the most studied of these. However, proper heating during processing reduces toxicity to the extent that the meal can be used as the only protein supplement in diets for swine and growing poultry. Nevertheless, even the highest quality cottonseed meals are not recommended for laying hens, because the minute non-toxic levels of gossypol cause the egg yolks to develop a green colour in storage.

The proteins of cottonseed meal are considered somewhat inferior to those of properly heated soybean meal and animal-protein supplements, but this may be due to inadequate B12 in the diets used, and to deterioration of cottonseed protein resultant on the heat required for detoxification. (A recently developed process of solvant extractions has obviated the need for heat in detoxification and has resulted in a better quality meal.)

The high fibre content of the raw meal renders necessary a decorticating process which, unfortunately, is not generally employed in the West Indies, though the very small amounts of cottonseed meal available in Barbados at certain times of the year are subjected to this process before use.
The level of cultivation of Soy-Bean in the West Indies is not high. However, prior to the war the crop was reported as becoming increasingly popular in Barbados. It is a crop well worth encouraging throughout the area as the quality of its "seed-protein" is superior to that of cottonseed.

In the U.S.A. in recent years it has increased in supply by rapid strides until at present it leads all other protein supplements as a feed for all classes of stock, including poultry.

The proteins of soy-beans are peculiar in that they must be heated first for maximum value to non-ruminants. The heat may destroy anti-enzymes present or may render the protein more available or both.

Vines as well as whole beans will be eaten by stock, but better results have been obtained by use of the oil-meal extracted from the beans, as will be shown below.

SOY-BEAN VINES

Flint(35) observed that the crop could efficiently be fed to swine as forage, the animals being turned on to the field to consume the whole plant. He advocated the successive planting of early medium and late varieties to ensure a continuous supply of food. The crop is more upright in growth than cowpea, and in some respects a heavier yielder, so that it is more valuable as a hog feed.

SOY-BEANS

Sleeter Bull et alia(36) found soy-beans to be unpalatable to pigs, and also that they had deleterious effects on the pork of market hogs though this was not the case with sows.

He concluded that soy-beans were satisfactory as a feed for brood sows but not for market hogs. Flint(35) observed that when combined with corn it was especially good for growing-fattening swine.

SOY-BEAN OIL MEAL

This is low in vitamin B12 so that for non-ruminants it must be supplemented with this factor. Also it contains less riboflavin, calcium, and Phosphorus than do the animal-protein supplements.
Hence in compounding rations including soy-bean oil meal care must be taken to ensure the presence of adequate quantities of these nutrients. However, the oil meal was palatable and was superior to soy-beans in effect on rate of gain, and on the whole proved to be a promising protein supplement to growing and fattening hogs.
Groundnuts (peanuts) are grown as a crop in many of the West Indian islands, notably in St Vincent, Antigua, and Grenada. What use is made of the residues from this crop in these islands is not recorded in the available literature, but it is unlikely, with the standards of crop husbandry and animal feeding prevailing throughout the area as a whole, that their worth as feeds for livestock are fully exploited if recognised. In direct contrast to this concept is the situation in the U.S.A. where its use in rations for all classes of livestock is widespread.

The usable derivatives of the groundnut crop, the nutritive values of which have been investigated are the Hay and the Oilmeal.

**GROUNDNUT HAY**

Kuhlman and Cave (38) fed threshed peanut hay as a roughage to Dairy Cows and found that it proved equal to alfalfa hay in maintenance of bodyweight, milk yield, and amount needed to produce 100 pounds of milk.

Van Wyk and others (39) fed groundnut hay to five Priestland cows and concluded that it was satisfactory for use with dairy cows. The same conclusion was drawn concerning pigs, but if pods were included proportions should be reduced, since in the case of the farmer a tendency towards scouring resulted, whilst in the latter soft fat was produced.

Kraus (41) demonstrated that well-cured peanut hay, with or without nuts attached, when fed to work mules, milk cows, and hogs, is at least as high—if not higher—than the best grasses or legumes. Poultry will actively seek stray nuts left after threshing among the cured vines.

**GROUNDNUT OILMEAL**

This is the purely-ground product left by the pressure extraction of the oil from peanuts, and in general it has been shown (40) that groundnut oilmeal of the best grade is equal to the best grades of linseed, cottonseed, and soy-bean meals in feeding value, for all classes of livestock, and for swine in particular.
NUTRITIVE VALUE

Palatability of peanut oilmeal is in general good, and (on the basis of experiments in Iowa) more so than linseed oilmeal. Its composition varies considerably according to the grade of peanut, methods used in preparation, and efficiency of equipment, but it contains many of the important amino-acids that heighten its value as a source of vegetable protein. French specialists rank it among the best sources of legume protein for pigs.

Its oil is as readily digested as animal fats and is utilized as completely, a point of value in regard to milk and butterfat production.

Peanut meal is good for all types of poultry as well, though these animals, being omnivorous, must have a certain quantity of animal protein in their diet.

Morrison makes the straight-forward statement that it is "one of the best protein supplements for livestock feeding."

In swine feeding, the meal produces soft fat when fed at 40 - 50% levels in the ration, but enhanced flavour and appearance of the meat might offset this.

Peanut oilmeal is deficient in calcium so that this mineral should always be supplied when the meal is used as the only supplement for swine.
There is a thriving pineapple industry in Antigua and an increasing possibility of one being started in Trinidad. Should this latter event come to pass there will come with it the problem of the disposal of cull fruit and residues from the extraction of the juice. The answer is Pineapple bran, or the dried, finely-ground outer shell and core of the fruit.

Pineapple bran boasts a high sugar content and is therefore valuable as an energy producing feed. Henke (1) found it not as good as corn or barley for fattening swine, but useful nevertheless if finely ground. It is higher in calcium than corn, wheat, or oats, and lower in phosphorus than they are. It is probably 5-6 times as good as a source of vitamin A as these grains; its vitamin B content is slightly less than that of whole wheat.

In view of its energy-producing value it is widely used to feed work animals on Hawaiian plantations.
Whole sweet potatoes as well as the dried article can efficiently be utilized as stock feed, and this is a point of importance with regard to the problem of disposal of cull fruits, the proportion of which resulting from the widespread cultivation of the crop as a table vegetable is large enough to warrant attention.

FEEDING VALUE OF SWEET POTATOES

Seath, Rusuff, Miller, and Brenton (45) conducted trials with sweet potatoes on milking cows. They concluded that the product was a good carbohydrate feed for dairy animals, either dehydrated or in the freshly chopped state. Culled, bruised and sectioned potatoes were less palatable than whole potatoes, but the freshly chopped article was 2.5 times as valuable as silage in the dairy ration.

The high carotene content of Puerto Rico varieties increases the vitamin A content of the butterfat.

SWEET POTATO VINES

When these were used as a supplemental pasture for milking cows there was an increase of 19 percent in milk production over that from cows on permanent pasture. (45)

DRIED SWEET POTATOES

Briggs (44) et alia found dried sweet potatoes very palatable to steers and lambs, though for these animals the digestibility of its protein was less than that of corn. Percentage of nitrogen intake retained was taken as a measure of nitrogen utilization and showed that sweet potatoes were on par with corn in this respect.

On an air-dry basis the weighted average T.D.N. content of dried sweet potatoes was 72.9% whilst that for corn was 79% showing that the dried sweet potatoes had 92% of the value of corn in T.D.N. content.

Grimes (45) corroborated this in experiments where sweet potato meal was fed to steer calves in conjunction with corn. Fed with cottonseed meal and peanut hay it was 91% as efficient per unit of gain as corn meal.
He observed that dried sweet potato meal was not palatable to mules when fed alone, but that maximum utilization was achieved when it made up no more than 50% of the grain ration. He reports that dried sweet potatoes were unsatisfactory for pigs weighing 50 pounds.

Research now shows that yields considerably above those made when sweet potatoes are grown for human consumption can be attained through breeding of new varieties especially for livestock and development of cultivation methods adapted to their production.
OTHER RESIDUES

BREWERY WASTE

Three by-products of the brewing industry are important as feeds. These are:

- Brewers' dried grains
- Malt sprouts
- Brewers' dried yeast

BREWERS' DRIED GRAINS

These are the residue from the barley after digestion and extraction of most of the starch. They are predominantly a cattle feed to be used interchangeably with other feeds of similar type as to bulk, crude fibre, and protein contents. Sometimes they are used as a potential replacement for grains in rations for cattle, sheep and horses.

Rigor and Acatic (46) found dried brewers' grains could be fed in levels up to 80% of the ration to Holstein and Jersey cows with no change in butterfat or milk but an increase in bodyweight.

Tomme and Karavaeva (47) fed brewers' grains to pigs at levels up to 11% of the ration and observed no deleterious effects on meat colour, odour, or taste, or on lard.

MALT SPROUTS

These are the roots from the sprouting of the barley during the malting process. They have proved satisfactory in mixed feeds for cattle.

BREWERS' YEAST

This is separated from the mixture after fermentation, and is valued primarily as a source of riboflavin, niacin, pantothentic acid, and choline. It is best used for swine and poultry rations owing to its high protein content, but is also useful for cattle.

CASSAVA

Cassava meal is used in British Guiana with success. However, the only literature available on the subject dealt with investigations in Hawaii into the feeding value of the roots.
From these investigations, Henke\(^1\) concluded that these were valuable as a feed for swine and had a feeding value approaching that of barley.

A hindrance to Cassava utilization is its content of prussic acid but this is effectively removed by boiling.

**BANANAS**

Hernández and Hernández\(^2\) showed that the leaves are the best sources of digestible nutrients, calculated on a fresh weight basis. Owing to its very high water content (95%) the fresh plant is not a concentrated food.

**COCOA BEAN HUSK**

This is used in the U.K. for feeding to livestock, where it is a by-product of chocolate manufacture. Due to the high thio-bromine content precautions must be taken not to overfeed this material, the maximum allowance being about 2\% in cattle rations.
CONCLUSION

By-products play an immensely important part in animal-feeding policies in other parts of the world where the livestock industry is highly developed. The benefits to be gained by both stockmen and growers from utilizing in this way residues which would otherwise go to waste are in general well-appreciated. Thus in the U.S.A. by-products are reported to constitute about one-third of the poultry ration and about one-seventh of the ration for growing and fattening swine; the feeding of such otherwise worthless commodities as citrus pulp, beet pulp and the like has come to be standard practice. Indeed one would not be far wrong in stating that in these countries it would be an uncommonly inefficient planter who would not exploit as far as possible the financial gain to be made from all the by-products of his crop.

Hitherto this has not been the case in the West Indies. The reason has largely been an economic one. As pointed out earlier, livestock have been kept on a pitifully disorganised basis, with the result that attempts to employ crop residues for feeding - a practice more than not in the nature of a refinement - have been rendered unfeasible owing to the lack of attention paid to the more fundamental principles of management.

However, the West Indies, is today approaching political maturity, and closely bound in with this is economic development. One of the industries or pursuits which will of necessity have to be expanded is the livestock industry, and its development will be dependent in no little measure upon improvement in feeding standards and techniques.

The merits of the more important crop residues in this connection have been presented throughout this treatise, but it must be remembered that they can in no instance be more than supplementary to good pasture, though sometimes complementary to each other. Hence, in a long-term programme the first need will be pasture improvement, followed by feeding trials to prove those
potential concentrates with which pastures may most economically and efficiently be supplemented - the realm of the crop residues.

However, this does not exclude their use at present. Far from it. In fact, it is felt that application of a little foresight and education could not fail to "reap wondrous benefits" to the West Indian stockman, and here Government intervention in the proper collation and dissemination of information would be effective.

Finally, it is worth remembering that a variety of feeds such as is provided by the diversity of crops important to the area will not only be more likely to furnish all the animals' needs, but will, moreover, tend to maintain a keen appetite, and so indirectly lead to increased production.
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THE MORE IMPORTANT NUTRITIONAL COMPONENTS OF THE DISCUSSED
WEST INDIAN BY PRODUCTS
(AVERAGE OF MANY ANALYSES)

DIAGRAM 1
PERCENTAGE DRY MATTER & TOTAL DIGESTIBLE NUTRIENTS

DIAGRAM 2
PERCENTAGE CRUDE PROTEIN, CRUDE FIBRE & CRUDE FATS