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WASTE RECYCLING IN THE FOOD CHAIN

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searching here and there for food and other supplies and ocassionally changing his abode as the fortune of his chase dictated. He was free-ranging.

He remained dependent on intact, natural plant and animal systems for his food and other life needs until he began learning how to modify his environment. The historical events that lessened his free-range method of feeding are not easily traced, but it is certain that, with the beginning of agricultural inovation, the man-nature complex was profoundly altered. It was not until he learnt something about the cultivation of plants and the domestication and care of animals, roughly ten thousand years ago, that man became capable of altering the life-support system of the biosphere. A greatly improved food supply favoured increases in the rate of human population growth. In turn, increases in man's numbers, and the resultant stress on food production practices compel flourishing human societies to make increasing use of the natural resources available to them. While technology has contributed immensely to our standard of living and is now permitting more people to live in crowded urban communities than ever before, we are also exploiting our available resources and producing wastes as never before.

WHAT IS WASTE?

Wastes occur when man fails to utilize with equitable, prudent and maximum effectiveness the means made available by nature for the satisfaction of his wants. Man's activities in extracting, harvesting, manufacturing, and eating would result, in part, in outputs not considered useful to him. These he has termed waste. Even the outputs considered useful have a limit to their usefulness and when that limit is reached, the further unutilized parts too are termed waste. A good example is the process of eating banana. Man considers

he needs only the banana pulp which he then consumes while he immediately discards the peel as waste. After digestion, he further discards the unabsorbed portion of the pulp through his faeces as waste. Is the banana peel a real waste? In making palm oil, the kernel is left behind; in making flour, bran is left over; in obtaining vegetable oils, we have oil cake or meal; in getting sugar, there is bagasse and sugar beet pulp apart from molasses; in making cheese, there is whey. Are these real wastes? No, they are not. We speak of them respectively as by-products because they are utilizable wastes. Thus, whether a by-product is a waste or not is a question of its current value. The soap industry may consider the banana peel a basic material for soap making while the pharmaceutical industry finds molasses very useful for making syrup. Whey has been quite handy in the production of baby foods. Similarly, the building industry has found the bagasse very useful for the manufacture of particle boards. What appears as waste to one producer could be a useful material to another producer of a different product. The by-products that are not being put into any use at all are the real wastes. They are of great concern. They are even detrimental to our environment.

It should be obvious by now that the most appropriate definition of waste is "materials with disposal cost, or products with a negative price." This implies a stimulus, in fact a challenge, to transform the negative price to a positive one as one searches for utilization possibilities.

Types of Wastes

In general, two classes of wastes are generated by the activities of man on earth. These are the inorganic wastes and the organic wastes. The inorganic wastes include cans used for different packaging, emptied liquor and drug bottles, all sorts of scrap metal dumped as litters in the cities. Automobile and indsutrial gases, plastic wrappings, car wrecks and old tyres of various types as well as radioactive wastes belong here. This class of waste cannot be directly recycled into the food chain and hence would not be our focus of discussion.

The organic waste, on the other hand, could be partitioned into three broad areas: industrial, urban and agricultural wastes.

Industrial waste

Industrial wastes include solid residue, liquid solutions and gaseous discharge. These are effluent from factories e.g. rubber factory producing residual ammonia and dissolved carbohydrate, sterilizer condensates from mills, supernatant liquids from fermentation processes and effluent discharge from chemical, starch and sugar factories. Gaseous wastes in the form of highly corrosive fumes, chimney exhausts from boilers and incinerators are a feature of most industries that use fired boilers.

Urban waste

In the urban centres, wastes are generated throughout the processing industry. For example, the meat processing and utilization system produces waste at the stockyard, abattoir, packing plant and at the supermarket as trimmings. Discards from household and institutions as well as garbage and human faeces contribute substantially to urban wastes.

Agricultural waste

Agriculture produces mainly one form or the other of solid wastes which are either burnt or left to decompose on the land very much like the urban rubbish heap. In this region, cocoa produces the cocoa husk, coffee generates the pulp, rice produces the straw and paddy husk, the maize, cassava, beans and most farm crops produce the primary residues after harvest and their secondary left-overs during processing as food. The forest products industry generates waste in the form of branches, leaves and needles during wood harvesting; sawdust, chips, shavings and barks during wood dressing and pulp fibre during wood processing. The livestock sector of agriculture produces wastes in the form of manure and litter, dead animals, feathers, blood, offals, rejected eggs, egg shells and hatchery waste.

THE FOOD CHAIN

While recognizing wastes as defined by man, it is pertinent to remind ourselves that in nature, the term waste does not exist. This is because the law of conservation of mass does not permit matter to be created or destroyed. Any material that is discarded will be reincorporated into the system for reuse. The products or effects of any deciduous tree, either its fallen leaves, fruits or branches, contain the nutrients for future growth of some other plants. The shed shell of lobster provides a local supply of calcium for the skeletal needs of other animals. In whatever form the dropping leaves or the egg shell is reused, it cannot be wasted. It only enters into the food chain. Nature's tendency to re-utilize everything as completely as possible accounts for the fact that over many millions of years, despite enormous continuous production of waste on the land and in the sea, relatively little waste has accumulated for any length of time. Most of it has entered into the food chain.

In its most simplified form, the food chain is made up of the soil, plant and animal systems. Plants grow on the soil and animals eat the plants. The animal in turn defecates and eventually dies only to replenish the soil with nutrients for further plant growth. In the sea, the story is the same as marine animals thrive on sea weeds for their survival.

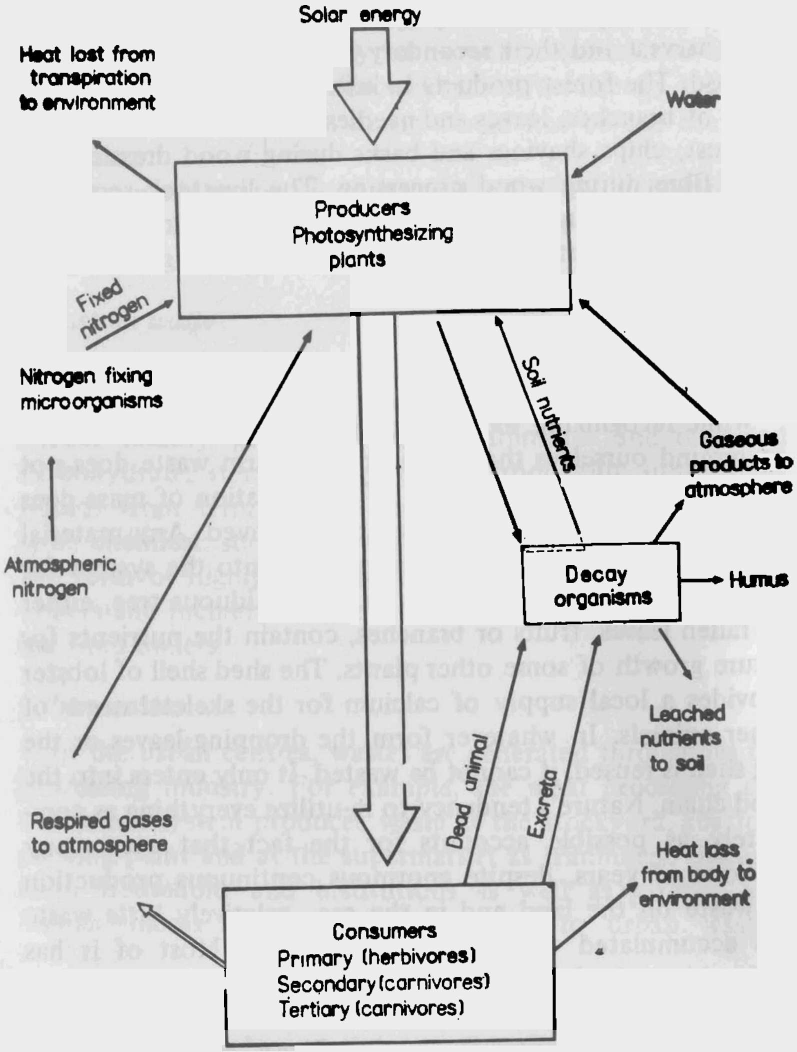

Fig. 1: The Food Chain

The animals eventually die and decay on sea beds to produce nutrients that enable the sea plants to grow and serve for feeding other sea animals. This represents a simple cycle. The complete cycle includes not only the recyling of chemical elements present in the faecal and urinary excretion of animals, but also those in the end product of the respiratory processes of all living organisms and those in the products that are produced from the decomposition of dead organic matter by microorganisms. Balance, or more accurately stated, approximate equilibrum is attained when the production of organic matter and its consumption within a system of interacting plant, animal, and microbial life are nearly equal, so that displacements in the cyclic flow of energy from producers to consumers, and subsequently to decay agents are minimized. Obvious exceptions must be made for those chemical elements that are in dynamic exchange in the cycle of production and consumption of organic matter and in their transformation from one form to another in the present biosphere. During the earth's long geological past, vast quantities of carbon in the form of dead organic matter, now represented by the fossil fuel – coal, oil, and petroleum – were accumulated beneath the earth's surface. Our increased utilization of fossil fuel in the present century has added much carbon dioxide to the biospheric circulation of carbon, the ultimate consequances of which still remain to be determined (Fig. 1).

JUSTIFICATION FOR WASTE UTILIZATION

The natural food chain, that takes care of all we consider as waste, is unfortunately slow and rather inefficient. A substantial amount of nutrient from dead leaves, dead animals and other wastes are not available to further support plant. growth. They are either lost in erosion to areas where they are unsuable for such purposes, or they are lost to the ground water through leaching. The question that arises is should man stand by and wait patiently for nature to recycle its own misplaced resources in its own very inefficient manner? The answer must be in the negative. Man cannot afford to wait for the following various reasons.

1. Volume of Waste

The amount of wastes produced by man and its animals is enormous. During a lifetime an average adult man who lives up to sixty years will use and discard total solid material exceeding 600 times his adult weight. The situation is worse in the developed countries like U.S.A. or Canada where per capita production of solid waste has increased steadily to a daily rate of 10 1b or 4½ kg per person. Similarly, a cattle farmer that keeps a herd of 1·00 animals must be ready to dispose of 20 tons of faeces every week.

2. Pollution Problem

Yet, another reason why we must go ahead is the need to reduce the problem of pollution in our cities and villages. Pollution is the contamination of the environment by misplaced materials. Most often, such materials are either by-products, residues or wastes. Complete utilization of these pollutants will provide a better environment for man.

3. Economics of Waste Utilization

A third reason concerns the economics of waste utilization. The world population pressure leads to increasing food demand and for certain communities, imminent starvation. In Nigeria today we can rightly say that there is acute shortage of practically every food commodity. We are compelled to provide ways and means of increasing food production through the use of substitutes and unconventional resources.

From the economic point of view, organic material with disposal cost can be regarded as resources out of place. However, if their utilization is to have a role in the overall management systems and if successful adoption of safe technology is to come about, decisions for waste recycling must be based on appropriate economic feasibility criteria of which three factors are important. These are:

(a) the value or market potential for the products derived from the process;
(b) the cost and economies of scale of a waste-recovery utilization system and
(c) the cost of alternatives.

When wastes take on value, they become part of the economic incentive system. They constitute a resource subject to business principles. When the powerful forces and attractions of the market system are imposed on them, then the reduction of environmental pollution automatically takes place.

CURRENT USES OF WASTES

Urban Wastes

In California, sewage is processed and recycled as drinking water. It is by far cheaper to treat sewage water for drinking than to desalinate water from the Pacific ocean which forms the coastal line of that state. Lagos has once made an attempt in this direction. A commercial plant which processes solid urban watste is in operation in Rome. Edible protein is recovered from the vegetable matter component of the waste and used as food. In Germany, a 200-ton a year pilot plant produces algal protein from sewage. Another algal protein pilot plant also based on sewage is in operation in Jerusalem, Israel. Urban sewage is now actively converted into single cell protein in Canada.

Agricultural Wastes

In a similar manner, agricultural wastes consisting of animal manure and other fibrous wastes are now being utilized to some extent.

Manure

In the USA, some cattle feedlots have constructed plants to convert cattle manure and other wastes to methane, carbon dioxide and fertilizer. Sufficient methane is obtained to run the plant with enough surplus to heat 10,000 homes in each case. The methane, of course, is also convertible to single cell protein. In Taiwan, cooperative farms compost rice straw and use the compost to grow mushrooms. That country makes over ₦120 million annually, just from exporting mushroom made through this means.

Under intensive poultry keeping, handling of poultry manure has become quite a big concern in the overall management of the poultry business. A small poultry keeper with a thousand birds must be ready to move one ton of manure every week. The ruminant animals like cattle can use dried poultry, swine and cattle manure incorporated in their growth diets. For example in Denmark, cattle has been fed rations containing 40% dried poultry manure and they produced a daily body weight gain of 2.75 1b per day. This is quite an outstanding growth rate by any standard. In Africa, animal manure is used to fertilize the soil by composting the faeces and spreading on the land while municipal and farm wastes are also being used as land-fills on excavated sites. It may however prove more economic were such resources diverted to increasing food production in home gardens and arable farms.

Fibrous wastes

Examples of instances where fibrous wastes have been

converted to food resources also abound.

A food yeast that is very highly nutritious may be produced rapidly and in good yields from carbohydrate contained in waste wood. Wood wastes may be converted into sugar that is suitable for yeast production in yields of 45% to 50% of the wood substance. This technique of producing high protein yeast from wood waste has been well established in Western Germany for over thirty years.

Woodshavings, emanating from wood dressing, also contain a substantial amount of useful resources. Cellophane and rayon have been produced from this waste. Cellulose which makes up wood fibre is probably the most important chemical produced from wood waste since it is used to make paper. However, some of the shavings have been rescued to produce such other chemicals like turpentine and formaldehyde which have a lot of industrial uses. Woodshaving is more commonly used as animal bedding on which livestock sleeps and excretes. The bedding is further used as fertilizer to replenish the soil for plant growth.

USES OF WASTES AS ANIMAL FEED

Available information from analysis of waste utilization under different conditions suggest that while best uses will vary in each case, organic wastes used as fertilizer or as fuel appear as a feasible alternative in some situations. In a great many circumstances, highest use value of waste appear to be animal feed. The present world demand for grain for direct consumption and industrial uses rather than for feeding animal which has resulted in escalated animal feed costs makes this position truer today than ever before. Our main challenge then becomes the recycling of waste as animal feed.

RESULTS AT IFE

I have in the past fifteen years examined different kinds of wastes: low fiber, high fiber and faecal wastes for their recycle potentials. My main effort in this regard has been geared towards recycling these wastes to provide an alternative feed ingredient for the monogastric livestock. These animals require conventional ingredients like grains, tuber and protein foods for their maintenance and production. Thus, in real terms, the production of pigs, poultry and rabbits is in direct competition with man for food. The feed cost for raising these animals amount to about 75% of their total cost of production.

Cocoa Wastes

In 1968, the Ministry of Agriculture and Natural Resources of the Western Nigeria recorded a total cocoa production of about 300,000 tons. Based on an unexportable fraction of total production of four percent by the Cocoa Research Institute of Nigeria, we have an average of 12,000 metric tons of cocoa beans declared unfit for export annually because they are either smoky, velvety, slaty, mouldy or broken beans. These quantities are burnt to prevent their being used to adultrate the exportable ones. My first project was a post graduate study designed to find a valuable use as livestock feed for these vast quantities of discarded cocoa beans. This project was supervised by Professor A.A. Adegbola. Investigation regarding the nutrient value of the waste revealed that it contains a substantial amount of all amino acids, except methionine and arginine. It is also rich in vitamins, especially vitamin A, the B-complex and vitamin D which are vital to our existence.

In spite of its high content of amino acids and vitamins, the bean also contains a physiologically active substance called theobromine which is toxic to animal when fed continuously in a normal diet, making the beans unsuitable for feeding livestock. Our primary concern was then the removal of this deliterous alkaloid. After series of experimentation, we evolved a technique that eliminated virtually all of the harmful theobromine. Our technique is very simple, inexpensive and efficient. It is also easily adaptable for a large-scale application without loss in nutrient quality of the final product. The contents of critical amino acids including lysine, methionine and cysteic acid were actually elevated by our process of detheobrominization. Feeding trials conducted with the detoxified discarded cocoa-bean-meal demonstrated that pigs will grow very well when up to 25% and not more than 50% of its diet is made up of the cocoa bean.

Cassava Peel

The low yield of maize and its high demand as human food have compelled us to continue to look for alternate sources of dietary energy for monogastric animals for meat and egg production purposes in this country. Of all the tropical farm crops, cassava is the most productive in terms of energy yield, producing about 13 times more energy per hectare than maize or guinea corn. It is actually the highest known producer of starch and it is in the top rank of crop biomass producer.

In 1974, we embarked on an intensive study to evaluate cassava as animal feed. The approach was multidisciplinary involving the Departments of Chemistry and Agricultural Economics, and the project which was based in Animal Science was financed by the International Development Research Centre (IDRC) of Canada. While our feeding responses indicated that cassava could be manipulated to successfully replace 55% in pigs' diet, 40% in broilers', 30% in those of the laying birds and 45% in the diets of rabbits, the economic signals in terms of demand and pricing of cassava left us very uncomfortable about feeding cassava to animals. Within five years that the project was begun, we observed that while cassava production did not increase substantially in this country, all the various income groups have increased their appetite for 'gari' or some other forms of cassava meal. In southern Nigeria, the price of gari went up about 250% during the second-half of the seventies. However, cassava peel which forms 10 to 18% of total root, depending on variety, is not used in any form at all. It is wasted. My emphasis at this point of the cassava study was shifted to utilization of its peel. The peel is higher than the tuber in its content of protein, fat and ash. However, it also contains on the average, ten times more of the toxic substances, the cyanogenic glucosides, than the tuber, which is the main reason the peel is considered unsuitable for consumption either by man or animal. The principal cyanogenic glucosides in cassava are linamarin and lotaustralin. Linamarin in the human is predominantly converted to thiocyanate, a well known goitrogenic agent (i.e. goitre promoting agent). Other problems associated with thiocyanate include nervous syndrome described as tropical ataxic neuropathy in Nigeria (Osuntokun 1971), renal and hepatic carcinoma and other non-specific ailments. The toxicity of cassava, even the cassava pulp (i.e. tuber without the peel), is well recognized by African population where various methods of preparation of cassava into the traditional meals have been employed to make cassava safe for consumption. In southern Nigeria, the use of high dry heat in the process of frying cassava pulp into gari inactivates the enzyme linamarase which is responsible for the hydrolysis of linamarin to hydrocyanic acid that releases cyanide to the body. The use of palm oil to colour gari in Bendel and Eastern States further eliminates the effect of whatever cyanide might be left behind. There is a sound scientific basis for this procedure, and a graduate student in Animal Science of this University recently elucidated the probable mechanism of action of palm oil in cyanide detoxication as part of her doctoral thesis (Fomunyam 1982).

In collaboration with colleagues in Animal Science and Professor Oke from the Department of Chemistry we employed available knowledge to modify the peel in a way acceptable as animal feed. I must say that the original work in this respect was done by Dr. Sonaiya and myself. We utilized a comibation of fat and synthetic amino acid methionine; both of which are conventional nutrients, to improve the feeding value of cassava peel and also completely detoxify it. We can now compose the pig diet to contain 15% of the peel while 30% of rabbit pellet could be supplied by cassava peel without any adverse effects in growth and meat quality. For poultry, the problem of white yolk in eggs associated with feeding cassava flour is eliminated where the peel makes up about 15% of the mash. This is because the peel is higher in lipid and contains more carotene than the flour. Egg yolk normally becomes progressively yellow as carotene content of the diet increases.

Fibrous Residue of Vegetables

Here in the tropics, there is an all-year round production of green crops and herbage. Some of these are used as fodder, some as food and some others are not used at all. An effective way of maximizing the use of these crops is by fractionation. Based on this idea, I have undertaken studies on the production of protein form green leaves for use by man and livestock. This process is carried out mechanically using a screw press of a pulper whereby about 50% of the fresh weight of the greens is recovered as juice which can be fed directly to animals. In the alternative, the protein is coagulated by heat to obtain a curd called leaf protein which has been used as protein supplement for kwashiokor patients in rehabilitation centres or as animal feed. I do not intend to discuss the protein aspect of my research in this lecture. Rather, I will like to draw attention to the 50% non-juice residue from the fractionation process. This is the fibrous residue or chaff that was believed to be completely unsuitable for feeding monogastric animals and which is considered unattractive for recyling through the soil as fertilizer. Some of this residue have been tried as silage, but most are regarded as pollutants. The chaff of vegetables including carrot leaves and those of Amaranthus sp. (*tete* vegetable) have been examined for their replacement value for corn in a project partly financed by the Christian Aid of the United Kingdom. The results indicate that, on the average, the chaff will replace 10% of yellow corn in the rations of rabbits without deleterious effects on growth and carcass parameters. This process constitutes the most effective known means of recycling the residue.

Brewery Wastes

A lot of wastes occur in agro-allied industries. Production of distilled liquors and alcohol from cereal grains has been on an unprecedented increase in Nigeria within the past decade. Right now, about ninety four breweries and distilleries carrying over a hundred liquor labels have been established in this country in recent years. Most of them are already in the production phase. Within 20 km of this institution, there are three of such companies and one of them is in active operation.

After grinding and cooking, α and β amylase enzymes are added to cereal grains to hydrolyze its starch to simple sugars and yeast is added to cause fermentation. The resulting alcohol is removed. But the residue has been put to little industrial use. Even when separated into several components or used as complete mixture called distillery slop, the coarse

particle of the slop is usually discarded. This coarse residue is termed the wet distillers' grains or brewers' dried grains when dehydrated. Chemical analyses have revealed that this bulky low-energy material contains an average of 92% dry matter, 26% crude protein, 6% ether extract and 4% ash. It is also fairly rich in essential amino acids. However, it contains 17% crude fibre which is considered high for monogastric livestock. We have found that when fed to pigs and rabbits at 15%, the brewery waste actually improved the utilization of corn. These classes of animals will grow well on 30% of the brewers waste without loss in meat quality.

Sawdust

Another 'waste' that has been of interest to me is sawdust. This material is well known to most people as a product of the sawmilling industry. Sawmilling is one of the commonest small-scale industries in the forest zone of Nigeria. Around Ife town alone, there are over twenty sawmilling industries producing different qualities of wood. As far as we know today, sawdust constitutes a serious pollution problem and the conventional way of disposing it is by burning on site. Sawdust is mainly ground wood containing cellulose, hemicellulose, lignin and various other chemicals like tanins generally found in wood.

We had two major constraints at the beginning of the project on sawmill. The first was palatability. In what form can animals eat sawdust? It was felt that if one added enough salt and incorporated the sawdust with other ingredients, the taste problem might be overcome. My second problem was digestion and utilization of sawdust by animals. In order for cellulose to be utilized as a source of food, it must be broken down into its component glucose monomers. In the ruminants, this action is carried out by enzymes produced in the rumen. In monogastric animals, the ones I am interested in, this action has to be accomplished outside the digestive system since this class of animals are not endowed with cellulose digesting organism. From our knowledge of rumen digestion, we are aware that for cellulose to be digested in the rumen, the enzyme must be able to establish physical contact with the cellulose and although little is known about the size and structure of the enzyme cellulase, the approximate diameter is established and the mechanism of digestion does not exclude pulverization. The first step was to treat the sawdust with alkali. This procedure is not new as it had been used by other scientists for preparing high fibre diets for ruminant animals. What is new in my approach is the attempt to prepare sawdust as feed for rabbit using alkali solution. We identified the proper concentration of sodium hydroxide required to make a good feed for livestock. The animals that were fed the sawdust treated with varying levels of alkali confirmed that the concentration of either 4% or 5% sodium hydroxide selected through chemical investigation was biologically the best. It was encouraging to observe that animals fed sawdust did not die, but actually grew well. I was, however, still not satisfied with the technique as the use of alkali or any reagent for that matter for the treatment of feed ingredients has attendant health risks to non-experts. Alkali treatment of the sawdust can however be practised under large scale commercial production. The moment small-scale producers, the average Nigerian farmer and the backyard operators i.e. the groups that produce more than seventy percent of the meat we eat are involved, the procedure requiring the use of alkali, becomes completely out of reach.

The second phase of this study was designed to achieve the quality of alkali-treated sawdust without using alkali. Following carefully laid out experiments, we discovered that gradual steaming of sawdust provided the kind of product that was desired. The steamed sawdust was incorporated

directly into the feed without further treatment. While satisfactory, this technique was labour intensive and appeared to be energy consuming. We therefore continued with further experimentation. Results of the third phase of our search showed that we improved the crude protein and ash while reducing the crude fibre and lignin content by incubating the raw sawdust with poultry excreta at a ratio of 85:15 of sawdust to excreta. Reducing lignin content of the final product was particularly fascinating to us, because unlike cellulose and hemicellulose, lignin is generally resistant to enzyme action and is therefore indigestible. Consequently, its presence and distribution are of prime importance in determining the overall digestibility of whatever cellulosic material in which it occurs.

The use of poultry excreta with sawdust led me into another series of studies with feacal material as animal feed. I will discuss that aspect briefly later on. It was however noted that the sawdust-excreta mixture was more acceptable to the animals. Rabbits readily consumed pellets containing 25% of the sawdust-excreta mixture. The results also showed that animals prefer sawdust emanating from hardwood like mahogany and *Iroko* trees to those collected from soft wood like *arere* etc.

Animal Excreta

During the past two decades, there has been a steady growth in this country of confined feeding of poultry, especially the laying birds in battery cages. This situation makes large quantities of poultry excreta available, resulting in pollution and disposal concern. When excreta is dried, the problem of objectionable odour is eliminated. For ease of collection of poultry manure referred to above, I have worked mainly with poultry excreta. It is now possible to formulate rabbit pellets to contain 12% of poultry excreta without any loss in growth advantage by the animals and the efficiency of conversion of such excreta to meat has been quite impressive. It is also pertinent to state that the quality of meat produced from animals fed excreta was just as good as that produced from those fed mainly fishmeal or groundnut cake supplements.

There are problems that can arise from feeding faeces to animals. Coliform bacteria, anaerobic spore formers and other pathogenic organisms contained in excreta could pose health problems, especially in the breeding stock. In a series of studies in the area of mineral metabolism, an extensive area of research in which I have been involved, but which I do not intend to discuss in this lecture, I have established, amongst a host of other facts, that supplemental dietary copper at a level of 200 ppm was capable of suppressing the build-up of harmful microorganisms in the feed, and of parasites in animals. Using this information, I was able to improve live performance in animals fed excreta, when between 200 and 250 ppm of supplementary copper was included in their diet. Under this dispensation, pregnant rabbits could be fed 10% of faeces in their diet without any fears for the mother or the offspring.

IMPLICATIONS

The implications of these studies are as follows. Using either pigs or rabbits as the machine for waste recycling and from the average of values of efficiency of conversion of feed formula to dressed carcass weight, 11 kg of sawdust could be transformed into 2 kg of meat, 15 kg of dry poultry excreta is convertible into 2 kg of meat, 4 kg of cassava peel could now become 1 kg of flesh while 3½ kg of brewery waste could provide 1 kg meat. Specific dry weights of city rubbish, banana and plantain peels, vegetable chaff,

farm stovers and various grades of organic wastes are convertible into various quantities of meat, lard or bacon.

CONCLUSION

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From the foregoing, it must be obvious and overwhelming that a rational society should immediately demand that waste recycling be prosecuted not only as an urgent goal, but as a matter of top priority. The question of course is who should be responsible for making it a priority. Is it the scientist, the ecologist, the engineer, the city planner, the private individual/entrepreneur or the government? Who makes use of recommendations that have accumulated for waste recycling? Who needs them? Recommendations emanating from various research efforts geared to benefit the lives of our people are locked up in several libraries. While municipal governments are worried about how to rid their cities of waste, and farmers are making no profit on their by-product, we in the universities are equipped with the know-how to utilize wastes. As usual, everybody is doing his own thing, there is neither effective communication nor coordination of effort.

RECOMMENDATION

Cooperative Effort

For our results to have any practical value, there is a need for an organization that will effect the collection, processing, distribution and sales of various waste materials for use as new feed resource. For example, the Saw-millers Association could oversee the production of sawdust feed, while the Cocoa Producer Association and the Poultry Farmers' Association takes care of cocoa waste meal and poultry manure meal respectively. This kind of organisational set-up could be achieved at the cooperative level without necessarily involving financial input from government.

Goverment Effort

On its own part, government should make a deliberate effort to recycle waste. An important step will be for governments at both the State and Federal levels to set up Waste Management Boards instead of Waste Disposal Boards. Such Boards should involve experts in the various areas of waste management and utilization and should sponsor studies in the mode and economics of waste collection, waste transportation, waste treatment and waste utilization. The results obtained by the Board along with those available in research institutions will assist in shaping the guidelines for waste recycling in this country. Technology for waste utilization cannot be directly imported from other countries the way we import most of our daily needs. They must be developed here because the way we accumulate our wastes and the kind of wastes we accumulate are somehow different from those of other countries.

University Effort

On our part in the university, our research effort must continue. We should try harder to examine all aspects of waste recycling. Such interdisciplinary approach will require the input of more departments than are presently involved in the project.

Mr. Vice-Chancellor Sir, in my considered opinion, waste recycling is an effective means of improving food production and simultaneously reducing environmental pollution. We can achieve it and we must continue to try.

Thank you.

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