

Pan American Health Organization

PAHO/ACMR 10/9  
Original: English

TENTH MEETING OF THE  
ADVISORY COMMITTEE ON MEDICAL RESEARCH

Washington, D.C.

14-18 June 1971

RESEARCH IN AGRICULTURAL AND FOOD SCIENCES

AT INCAP

The issue of this document does not constitute formal publication. It should not be reviewed, abstracted, or quoted without the consent of the Pan American Health Organization. The authors alone are responsible for statements expressed in signed papers.

## RESEARCH IN AGRICULTURAL AND FOOD SCIENCE AT INCAP\*

Ricardo Bressani\*\*

Institute of Nutrition of Central America and Panama (INCAP),  
Guatemala, C.A.

### INTRODUCTION

It is now well recognized that most nutritional deficiencies of public health significance observed in the Latin American area and other regions of similar ecological conditions, constitute an extremely complex problem. To improve the situation, a multidisciplinary coordinated approach is needed. The different responsible factors that must be corrected, although closely interrelated, can be classified schematically as shown in Figure 1.

The factors affecting food availability such as production and conservation in relation to the nutritional needs of the population are of primary importance. Food consumption depends on factors such as education, socio-economic status, marketing and distribution. Furthermore, as indicated in the diagram, factors which are either limiting the consumption of foods, or interfering with the utilization

---

\* Presented at the Tenth Meeting of the Pan American Health Organization Advisory Committee on Medical Research, held in Washington, from June 14 to 18, 1971

\*\* Head of the Division of Agricultural and Food Science,  
INCAP

of the nutrients provided by the ingested foods, must also be corrected in order to improve the nutritional status of the population. There are at least two groups of factors affecting nutrient utilization, those related to the food itself and in its preparation for consumption, and those having to do with the individual. The results of the reaction of these and various other components determines the nutritional condition of the population. Relatively little can be achieved until the basic problem of insufficient and inadequate food supply is solved. Inefficient food production and the high rate of population growth are creating a situation in Latin America which requires immediate attention. INCAP has been well aware of this situation for many years, as evidenced by the creation of its Division of Agriculture and Food Science for the purpose of contributing to the solution of this problem through the application of science and technology.

Among the important factors responsible for the present state of affairs, is the situation created by previous national economical policies which accorded more attention to cash than to food crops. The probable reason for such an arbitrary emphasis is that the need for food was not as pressing at that time as it is today.

At present, there is more awareness of the problem and a greater interest in its solution. Practical answers to

daily food and agricultural problems based on scientific investigation are urgently needed. This need is felt by private enterprise and university and government agencies, particularly those working in the fields of agriculture, food technology and animal science. Nevertheless, the activities of private and public organizations do not yet include research, primarily because of the scarcity of adequately trained personnel.

The research activities of the Division of Agricultural and food Sciences are therefore, concerned with the efficient utilization of vegetable and animal resources for man.

The research interests and activities of the Division are described schematically in Figure 2. Raw materials and by-products in these scheme represent any material with a potential value as food or feed, which may come either from agriculture or from industry. Therefore, it is necessary in many instances to study the effect of the agronomic, genetic and environmental factors affecting the chemical composition of agricultural products or to study the conditions used in the production of industrial by-products. At this point, these materials have only a potential value, as food or feed, and it becomes necessary to study their nutritional value, their improvement in nutritional quality, the effect of processing and conservation to transform them

into an stable and edible form and to learn of the effects these materials have on the performance of the animal. Once this has been achieved, they can be classified as food or feed and utilized in the nutrition of animal or man.

PRESENT ACTIVITIES OF THE DIVISION OF AGRICULTURE AND FOOD  
SCIENCE

During the past few years the Division of Agriculture and Food Science has been actively engaged in four areas of research indicated in Figure 3: a) Food Science; b) Animal Nutrition; c) Nutritional Biochemistry, and d) Agricultural and industrial by-product utilization.

Each area of research includes three to four programs as shown in the Figure, with the common objectives of increasing the availability of better quality foods for humans. Each program is, in turn, made up of research projects which develop as results become available and the original objectives are reached.

a) FOOD SCIENCE

a.1 Basic Food Crops

Cereal grains and leguminous seeds are by far, the foods consumed in largest amounts by people in low income groups in developing countries. In the Central American countries, corn and beans provide practically all of the

protein and a large amount of the calories and other nutrients needed per person daily. It is therefore, obvious that any improvement obtained in the nutritive value of such foods will have an impact upon the nutritional condition of people in the area.

Although work has been carried out on both corn and beans, most of it has been done with corn, and includes studies concerned with varietal and environmental effects on nutritive value, effects of various fertilizers on amino acid content and protein quality, changes in the chemical composition, protein distribution and amino acid content during maturation of the kernel, studies on the relationship between total protein, zein concentration and protein value, distribution and chemical composition of physical components of corn kernels and the effect of fungi on the chemical composition and nutritive value of corn. Other cereal grains, such as sorghum, rice and wheat, have been studied but to a lesser degree. Research on corn continues with studies dealing with the synthesis of corn protein fractions of the grain and amino acid content during development of the kernel, with the objective of learning whether it is possible to alter the distribution of proteins in corn endosperm to give better quality products, as is the case with opaque-2 corn. The work on cereal grains also includes studies on the nutritive

value of individual protein fractions of the endosperm, which should be of value to geneticists in their breeding programs.

As indicated, emphasis was given to corn, however, recently more intensive study has been given to leguminous seeds such as beans, cowpeas, and chick peas. Some work has been accomplished, mainly to establish the existence of differences in chemical composition and nutritive value between species, varieties and effects of environment. The results of these studies indicate some leguminous species to be superior to others; the same result, to a lower degree is also true between varieties. Of greater interest were the studies on the use of minor elements fertilizers with nitrogen fixing bacteria on protein quality of beans, indicating some improvements in nutritive value. These should be studied further so that recommendations can be made to growers of these foods.

Bean consumption has been stable over the last few years, a situation which is peculiar and suggests that there is a maximum tolerance to the consumption of beans. The reasons for this, if it is true, are not known, since a higher intake would improve the quality of the complete diet. If on the other hand the limitation is due to the availability of beans, it would be interesting to ascertain the variability

on protein content of beans. Preliminary studies have indicated that protein content can vary from as low as 16% to a value as high as 40%. If the quality of the protein is the same and the amount consumed per day remains constant, it is obvious that consumption of varieties with greater protein concentration will have a greater impact on the quality of the diet and thus, on the nutritional condition of the people.

Studies have also been carried out to some extent with the fractionation of the proteins in beans to learn which of the fractions is sulfur amino acid deficient, and which is a good source of lysine, so as to have a better basis for a bean quality selection program.

#### a.2 Studies on non-conventional sources of protein

The studies dealing with the utilization of cottonseed flour in the formulation of protein-rich foods such as INCAPARINA is already well known, therefore, it will not be described here.

During the past few years the possibility of developing and utilizing new protein sources has been investigated. Several examples can be cited: the seed known as quinoa, grown in South America, has been used by people to a limited extent and there are reports indicating the high quality of its protein. Therefore, seed collected in Bolivia was planted



at the INCAP farm to learn whether it would grow or not. It was found that it prospered and produced seed satisfactorily at 5000 ft above sea level. It was also found that the plant has a potential for high yields. The effect of fertilizers on yield and adaptability were also studied and the results again gave evidence of the potential of this plant in the highlands of Guatemala or similar areas.

The seed from the rubber tree, available in very large quantities but not utilized, is another possible source of protein. Chemical analysis of the seed indicated the presence of about 22% fat and about 30% protein on a fat-free, moisture-free basis. Biological tests in animals, carried out with the seed indicated that poor growth was obtained due to a limited food intake. The reasons for this poor acceptance are organoleptic, as the seed apparently contains no toxic factors. The oil extracted is being characterized chemically and nutritionally and the meal is being studied as a source of protein for animal feeding. If such studies prove the protein to be of value, further studies will be undertaken to learn of its use as such, or as protein concentrate in human foods.

Another possible source is the coconut. Although copra is produced at present in limited quantities, coconut plantations are being increased in several areas

Owing to the problems that are presently besetting cotton production, it is believed that coconuts will supply at least part of the oil obtained now from this source. Screw press and solvent extracted copra has been the subject of some studies. The large amounts of fiber contained by copra make it difficult to use it without further processing. Either the protein has to be extracted or the coconut should be processed at earlier physiological ages. There is a definite need to investigate the changes taking place during the development and maturation of the coconut.

The results of certain studies are already available at INCAP.

The nuts from the African palm and the corozo, are both further possible sources of protein. These products have been studied to a limited extent in the past, but not as protein sources for human or animal feeding. The availability of these two sources is increasing in the Central American area, therefore, it is necessary to increase the knowledge of their use. One disadvantage is the presence of high levels of crude fiber which if easily eliminated could double protein content. There is need to know their essential amino acid content, how to use them in feeds, what the quality of their protein is, and the possibility of extracting the

protein fraction to produce protein concentrates.

There are other possible sources such as the "jícaro seed" and "aceituno meal", but available knowledge of these sources is practically non-existent.

Needless to say there is much that still remains to be done in the production of the ingredients of vegetable mixtures, in their formulation, evaluation and increased use.

With respect to industrial processing of oil seeds two lines of research are still needed. One involves the development and improvement of present processing methods to increase yield of edible oilseed flours meeting nutritional specifications; and the second, the production of materials with a higher protein concentration. After sufficient progress is achieved in both of these endeavors, new formulations more practical than those now in use, could be developed.

The preparation of protein isolates from vegetable protein concentrates means a further step toward the formulation of foods with greater acceptability. Liquid formulations or powders that are easily soluble in water, would then be feasible. Preliminary studies have been conducted with the use of acid and enzymatic hydrolysis of oilseed meals to produce hydrolyzates of the protein, free of fiber and other non-desirable materials.

If practical-economical methods are developed, the products will be used in formulations which could find use in human as well as in young animal nutrition.

In addition to the above, certain studies on the processing of ingredients used in formulations for the purpose of improving flavor, texture, and physical characteristics are in progress. As such process involves high temperatures which could alter amino acid availability, it is essential to test such a possibility by biological assays.

As part of the testing of presently available formulas, studies have been conducted on the importance of the quality and quantity of the protein in these mixtures as supplements to poor quality diets. The results of this work should be significant in the preparation of recommendations for efficient use of the mixtures and possible improvement of their formulation.

a.3 Effect of processing and storage on nutritive value

Several studies have been carried out in the past, under this program. One of the processes which was studied more intensively was that of converting corn into tortilla, which included changes in gross chemical composition, in vitamin, mineral, and amino acid content and protein quality. The development of a process to convert corn into tortilla flour, was not carried out because of the lack of facilities;

in any event, it served for the development of other processes now in use. Several studies have been carried out with immature corn to produce a drink with very pleasant flavor and high nutritive value.

Processing of beans has also been studied. It was found that cooking under pressure (16 lbs) for 20 minutes was enough to destroy toxic factors in beans and improve protein quality at the same time. This finding is useful and will probably become more important in the near future since home cooking of beans is becoming an expensive operation because of fuel cost. In this connection, cooked bean powders have been prepared and their stability and nutritive value under various kinds of storage conditions is being studied. This preparation could be the base for highly nutritive soups and it could be very useful as a vehicle for other nutrients deficient in rural diets. In this respect studies are underway to increase the protein quantity and quality of cooked bean powder.

Amino acid supplementation is becoming of practical importance as a means to improve protein quality. Studies have been carried out on the stability of the added amino acids to various food products, including protein-rich foods supplemented with amino acid which are processed before

consumption. Since these added amino acids are in the free form, they can easily react with sugars present in the food when processed or kept under storage. Therefore, studies are underway to determine the stability of the added amino acids to various food products, including protein-rich food supplemented with amino acids which are processed before consumption. Fast analytical methods for free amino acids have been developed to help in assessing the stability of these nutrients in foods.

#### a.4 IMPROVEMENT OF NUTRITIVE VALUE

It is known that cereal grains have a poor protein quality due to specific amino acid deficiencies. Various cereal grains as well as other protein sources have been studied in this respect, and information is available on how to improve the situation. Cereal gruels are common food items in Central America. Therefore, supplementation studies indicated that small amounts of milk, soybean flour, cottonseed flour, their various combinations or with amino acids, could significantly improve their protein quality.

One problem which is now receiving some attention is the practical supplementation of the corn to be made into tortillas. Results of various experiments indicated that 8% soybean flour with 0.10% lysine could bring the quality of

the enriched corn to that of casein and also increase total protein content. The supplements have been shaped to resemble corn kernels and it is hoped that these could be added at the time corn is being milled before tortilla preparation. Meanwhile this supplement can be added at the industrial level to lime-treated corn flour, food already produced in some Latin American countries.

Although additional studies are needed to solve specific problems, the biggest gap between laboratory findings and application is the lack of facilities to prepare such enriched foods to show possible producers. Similar approaches are being followed for other foods. For example, a high protein containing black bean kernel is being developed and tested, since it has been found that such a material could significantly increase the quality of corn-bean diets.

## b. ANIMAL NUTRITION

### b.1 Feed Composition

Animal production depends to a large extent on the nutrient content of feeds used singly or combined. Tables of feed composition are not available in Latin America, therefore, it is essential to analyze all possible products for better feed formulations. A table for use in Central America, containing 153 different feedstuffs was recently published, however,

chemical analysis is just one aspect in evaluating a feed.

b.2 The evaluation of the nutritive quality of ingredients  
for animal feeds

Very little information is available in the area particularly for products produced locally with technologies which are not too well developed or controlled. Work in this area will be well related to the investigations outlined in the previous section.

The evaluation is to be obtained from growth studies and conversion values of feed into edible portions and related to cost. It also includes studies on digestibility trials and reproductive performance as well as other methods used in animal nutrition.

b.3 Use of local resources in feeds for poultry, swine and  
cattle

While it is a fact that animal rations used in some areas could serve as well in others, it is often not possible to prepare them because of the lack of raw materials, or if these are available, their cost is too high in relation to the cost of the product derived from the animal consuming such feeds.

There is therefore, an urgent need to use local sources which would be available at all times at a low cost,



whose need would stimulate areas of production. In order to be able to use these products, it is necessary to know as much as possible about them in terms of their chemical composition, amino acid content and acceptability by the animal, to allow their incorporation in balanced rations.

There are many examples such as various plants which could be used instead of alfalfa leaf meal; the yuca or cassava root could replace corn as a source of energy; sugar cane molasses could also replace part or all of the corn, thus reducing the competition between humans and animals. The meals from corozo and African palm could serve as sources of protein to replace soybean meal. In order to attain success, however, it is necessary to carry out a detailed study of these products so that the expected results may be obtained.

#### a.4 Preservation of Forages

The availability of green forages in the Central American countries is determined by the rainy season which starts in May and ends in late October. During the summer months or dry season, forage availability decreases significantly to the point where there are many losses of cattle.

Interest has developed in preserving forage during the rainy season, however, silage preparation has not been successful, probably due to the lack of knowledge on how

it should be done. There are various reasons for this such as high moisture content in the forage when cut, low sugar concentration, high temperatures and relatively humidity and that the material to be ensilaged is grass rather than the most common crop used for this purpose, which is corn or sorghum.

The problem is of significance in all Latin America and studies should be conducted to solve it. At the INCAP farm, small experimental silos which have been used to a limited extent, to carry out this type of work are available. In some cases, good silage has been possible when the grass is placed in the silos with reduced moisture content (65-70%) and molasses added to help in the fermentation. Other materials have also been ensilaged, such as coffee pulp, showing ways in which it is possible to accumulate feed for periods of low availability of such foods.

### c. NUTRITIONAL BIOCHEMISTRY

During the past few years, experience with different projects has made evident that there is a need to study specific problems in more detail and under more controlled conditions. The information collected from this type of investigations is more basic and allows for a better understanding and use of foods or raw materials.

c.1 Evaluation of protein quality and protein utilization

New biological methods for testing protein nutritive value in animals are also being studied and evaluated for the purpose of developing methods which could correlate better with results obtained in humans and those now available. Such an accomplishment would greatly simplify the testing of new products, permitting a more direct association of results with those derived from work with humans.

Similarly, methods are also being developed to measure the protein quality of foods with protein levels below 10%. These methods for example, have allowed the separation of various rice varieties according to quality, a procedure which was not possible using the common PER or NPU methods.

Studies are also underway on the factors controlling utilization of vegetable proteins, mainly amino acid balance and digestibility of the protein, to allow the identification of fractions which are not digested and which make the bulk of fecal nitrogen when vegetable proteins are fed.

Finally, methods are being studied to permit the measurement of the supplementary value of protein supplements, since with available methods, the effects measured are not necessarily due to better quality only, but to a higher

quantity of protein.

In the field of food supplements, the significance of the quality and quantity of protein supplements to the regular diet consumed by the population of the area, is being investigated. The importance of amino acid balance and the effect of non-protein nitrogen sources is also being studied in the hope of finding the conditions for better utilization of foods consumed.

c.2 Relationships between nutrients and/or non-nutritive substances and animal performance

A better utilization of materials depends to a large extent on knowledge of the interaction between the various components of the food. Studies have been carried out on the mechanism of gossypol toxicity and the importance of certain vitamins and minerals on protein utilization and amino acid imbalance.

D. AGRICULTURAL AND INDUSTRIAL BY-PRODUCT UTILIZATION, UTILIZATION OF INDUSTRIAL AND AGRICULTURAL WASTES AS FOODS

The low availability of forage as indicated above, has indicated the need to look for materials which could be used as animal feed. During the last two years work has been done with cottonseed hulls, molasses and coffee pulp. Formulations which have given good results in ruminant feeding have been developed with the first two, and some of them are

already in practical use. Some work has been done with coffee pulp, but so far, the results indicate that it contains factors which cause poor performance in young ruminants. In order to determine which factors are responsible and how to eliminate them various studies have been undertaken in rats and chicks. Results suggest that the animal shows an increased tolerance with time, that storage decreases the levels of toxic factors, permitting levels as high as 50% of pulp in the feed. Various treatments have been studied but none have resulted in an elimination of the factors responsible for the poor animal performance. Studies are also underway to identify such factors.

Other wastes are also under consideration such as sugar cane bagasse, citronella and lemon grass bagasse, corn stalks and cobs and sawdust.

It should be indicated that there are facilities available at the INCAP farm for working with poultry, swine and ruminants, animals which have frequently been used in various types of studies. Studies on the development of milk replacers for calf feeding using vegetable proteins and non-specific nitrogen sources, such as urea, ammonium citrate and other, have been developed and are already in use in Central America. Likewise, diets for cattle at different stage of growth have been developed.

EDUCATION

The Division of Agricultural and Food Science has been active also in the education programs of INCAP. During the last 10 years, approximately 30 university students and other professionals have helped in carrying out the research activities of the Division. In most cases the work accomplished was used by the students for their thesis requirement before obtaining their respective degrees from the faculties of Chemical Engineering, Agronomy, Veterinary Medicine, Chemistry and Pharmacy.

The students and professionals have come from the Central American countries as well as from various countries in South America.

FIGURE 1  
FACTORS RESPONSIBLE FOR NUTRITIONAL DEFICIENCIES

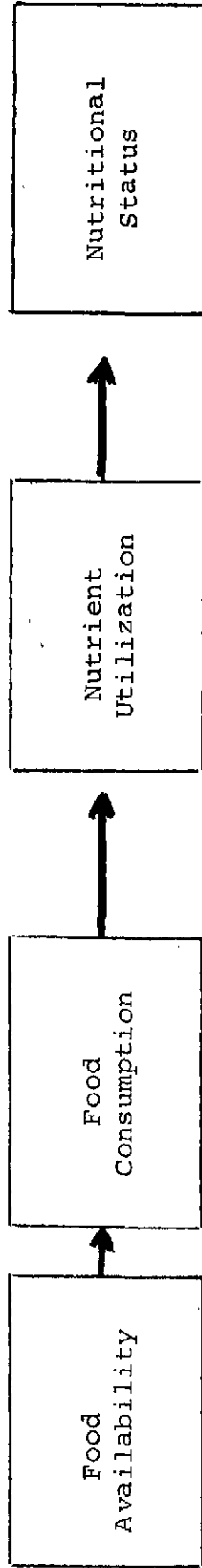


FIGURE 2 SCHEMATIC REPRESENTATION OF THE RESEARCH ACTIVITIES OF THE DIVISION  
OF AGRICULTURAL AND FOOD SCIENCE

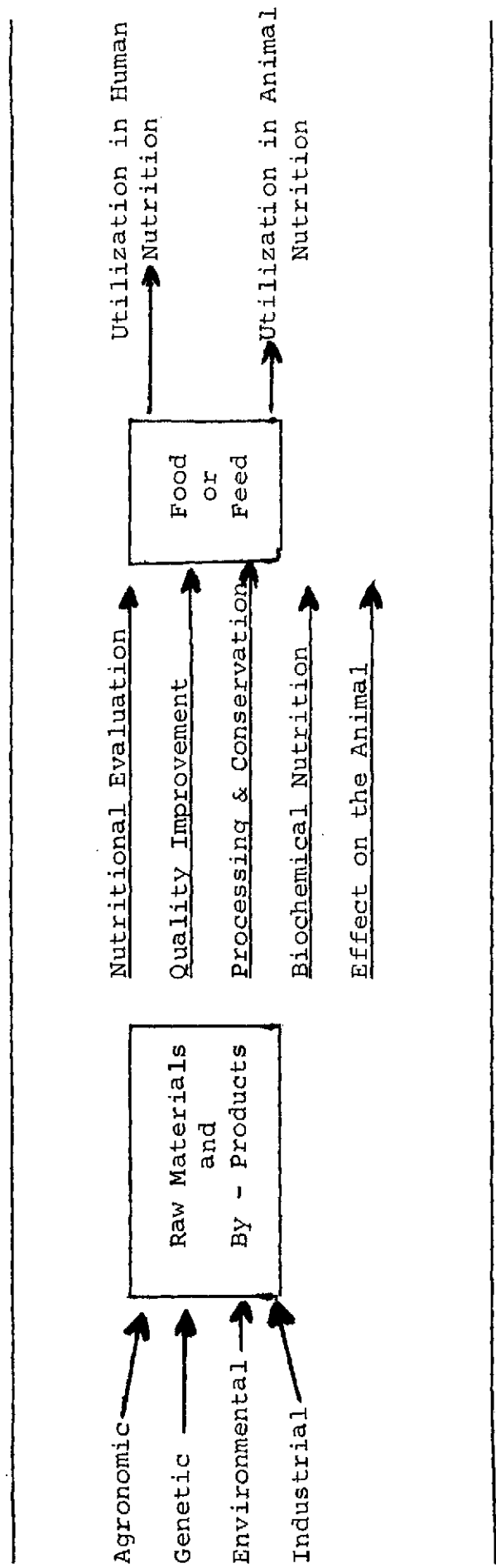




FIGURE 3 AREAS AND PROGRAMS OF RESEARCH OF THE DIVISION OF  
 AGRICULTURAL AND FOOD SCIENCES

Area of Research	Programs
FOOD SCIENCE	Basic Food crops Non-conventional sources of protein Improvement in Nutritional value Processing and Storage
ANIMAL NUTRITION	Feed Composition Evaluation of Nutritive value Use of local resources in feeds Forage Preservation
NUTRITIONAL BIOCHEMISTRY	Methodology for Evaluation of Protein Quality Relationships between Nutrients Physiological effects of naturally occurring toxic substances Interaction between diet and animal performance
AGRICULTURAL AND INDUSTRIAL BY-PRODUCT UTILIZATION	Chemical analysis Evaluation of Nutritive value