ANALYSIS OF SOME ANIMAL FEEDING STUFFS

BY

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D E C L A R A T I O N

I hereby declare that this thesis "Analysis of Some Animal Feeding Stuffs" has been written by me and that it is a record of my own research work. It has not been presented in any previous application for higher degree. All quotations are indicated and the sources of information are specially acknowledged by means of references.

V. I. E. AJIWE

Date: 27/6/1983

D E D I C A T I O N

To my Dearest Wife,

My friends and to the

animal world

A C K N O W L E D G E M E N T S

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A B S T R A.C_T

Importance of quality control through chemical analysis has long been established in most developed countries. Quality control of animal feedstuffs have been given little attention in Nigeria. Based on this, methods for carrying out effective quality control of animal feedstuffs have been outlined using some feed stuffs as examples. National Animal Production Research Institute broiler starter rations showed a good scientific formulation even though there were some high and low results obtained especially for the mineral contents. Variations of the proximate and toxic factor results of the Pfizer poultry products from established standards proved better than the mineral content results. For the National Animal Production Research Institute dairy cattle rations and lamb concentrate feed, the results for the proximate factor were in order while there appeared short-comings in the mineral nutrients and thioglucoside contents.

TABLE OF CONTENTS

		Page
Title Of Thesis		i
Declaration		ii
Dedication		iii
Acknowledgements		iv
Abstract		v
Table Of Contents		vi
List of Tables		ix
List of Figures		x
CHAPTER 1:	INTRODUCTION	1
1.1	Quality Control Of Animal Feeding Stuffs In General	1
1.2	Quality Control In Developed And Developing Countries	4
1.3	A Review Of Work Done On Chemical Composition And Quality Control Of Nigerian Animal Feedstuffs	6
1.4	Factors Normally Analysed In Feedstuffs	9
1.5	Important Notes On Factors Being Determined.	10
1.6	Aim Of The Project	16
CHAPTER 2:	EXPERIMENTALS	17
2.1	Sampling Of The Feeding Stuffs	17
2.11	Sampling	17
2.12	Sample Preparation	18
2.2	Proximate Analysis Of The Feeding Stuffs	18
2.21	Moisture Determination	18
2.22	Crude Protein Determination	19
2.23	Crude Fat Determination	20
2.24	Determination Of Total Ash	22
2.25	Acid Soluble And Insoluble Ash	23

		Page
2.26	Crude Fibre Determination	23
2.27	Nitrogen Free Extract	25
2.3	Toxic/Endogenous Factors	25
2.31	Urease Activity In Soyabean Meals	25
2.32	Thioglocoside Determination	29
2.4	Determination Of Essential Minerals And Microelements	30
2.41	Sodium Chloride Determination	30
2.42	Determination Of Phosphorus	31
2.5	Flame Photometric Determination Of Sodium And Potassium	34
2.51	Determination Of Potassium	34
2.52	Determination Of Sodium	36
2.53	Determination Of Calcium And Other Mineral Elements By Atomic Absorption Spectrometry ..	38
2.54	Determination Of Iodine	54
CHAPTER 3:	RESULTS AND DISCUSSION	60
3.1	Results And Discussion On 0-3 Calf Concentrate And The Milking Cow Concentrate	60
3.11	Proximate And Toxic Factors	60
3.119	Mineral Composition	63
3.2	Results And Discussion On National Animal Production Research Institute Broiler Starter Rations	73
3.21	Proximate And Toxic Factors	73
3.22	Mineral Composition	75
3.3	Results And Discussion On Pfizer Poultry Feed-stuffs	83
3.31	Proximate And Toxic Factors	83
3.319	Mineral Composition	85
3.4	Results And Discission On The National Animal Production Research Institute Lamb Concentrate	94
3.41	Proximate And Toxic Factor	94

Page

3.42 Mineral Composition 101

3.5 CONCLUSION 102

REFERENCES 103

LIST OF TABLES

		Page
CHAPTER 2:	Table 2.1: Wave Lengths For Metal Analysis.	43
CHAPTER 3:	Table 3.1: Proximate Composition Including Thioglucoside Content Of National Animal Production Research Institute Cattle Feed	69
	Table 3.2: Proximate Composition Including Thioglucoside Content Of National Animal Production Research Institute Milking Cow Cattle Feed.	70
	Table 3.3: Mineral Composition Of National Animal Production Research Institute Cattle Feed.	71
	Table 3.4: Mineral Composition Of National Animal Production Research Institute 0-3 Calf Concentrate Feed.	72
	Table 3.5: Proximate Composition Including Thioglucoside And Urease Activity Of National Animal Production Research Institute Broiler Starter Rations.	81
	Table 3.6: Mineral Composition Of National Animal Production Research Institute Broiler Starter Rations.	82
	Table 3.7: Proximate Composition Including Thioglucoside Content Of Pfizer Poultry Feeds.	90
	Table 3.8: Proximate Composition Including Thioglucoside Content Of Pfizer Growers Mash.	91
	Table 3.9: Mineral Composition Of Pfizer Poultry Feeds.	92
	Table 3.10: Mineral Composition Of Pfizer Growers Mash.	93
	Table 3.11: Proximate Composition Including Thioglucoside Content Of National Animal Production Research Institute Lamb Feed.	100
	Table 3.12: Mineral Composition Of National Animal Production Research Institute Lamb Feed.	101

L I S T O F F I G U R E S

		Page
Figure 2.1:	Calibration Curve For Urease Activity Determination.	28
Figure 2.2:	Calibration Curve For Phosphorus Determination.	33
Figure 2.3:	Calibration Curve For Potassium Determination.	37
Figure 2.4:	Calibration Curve For Sodium Determination.	39
Figure 2.5:	Calibration Curve For Calcium Determination.	46
Figure 2.6:	Calibration Curve For Cobalt Determination.	47
Figure 2.7:	Calibration Curve For Copper Determination.	48
Figure 2.8:	Calibration Curve For Iron Determination.	49
Figure 2.9:	Calibration Curve For Magnesium Determination.	50
Figure 2.10:	Calibration Curve For Manganese Determination.	51
Figure 2.11:	Calibration Curve For Zinc Determination.	52
Figure 2.12:	Calibration Curve For Determination Of Selenium.	53
Figure 2.13:	Calibration Curve For Iodine Determination.	59

CHAPTER 1

INTRODUCTION

1.1 QUALITY CONTROL OF ANIMAL FEEDING STUFFS IN GENERAL

The economic production of animal products is dependent upon meeting total nutritional requirements of the animal (1). To do this, it is necessary to know the nutritional value of the feeds as well as the nutritional requirements of animals. The knowledge of these is achieved by quality control through chemical analysis of the animal feeds.

Quality control of manufactured and formulated animal feeding stuffs is desirable in order to know that a feed possesses the required nutritional values which have been designed into the formula. There are two main ways of achieving this, and they are as given below:

(a) One way is to monitor the nutritional values of the raw materials and the operation of weighing at the proportionating stage to see that the finished product will have the designed nutritional values within a defined and calculable variance.

(b) The second method is to sample the finished product and compare the results of the assay with those

stated on the Control Chart [Control Chart is a method of stating what values are desired and what variations above and below this are permitted and this normally tallies with the legislative formula or specifications] to see if the nutritional values are within acceptable limits previously calculated (2).

(c) A third factor that is important in quality control is the physical quality. For a particular feed, it is necessary to state the physical specification in terms of particle size range with permissive tolerance. Control is exercised in choice of raw materials and degree of particle size reduction in the grinder. For formed feed the spefication will outline the physical dimensions together with a permissive tolerance and also a measure of durability of the formed feed.

In the industry the first two procedures provide information for the day to day running of feed mills. Analysis and visual inspection of raw materials and products help in assessing trends in production efficiency and raw material quality. Quality control data (through chemical analysis) allows a check to be made on the value of purchased raw materials and to know whether they meet contract specifications in terms of nutrient levels if laid down. This is particularly important for the purchasing department and such records should show price, composition by analyses and comments on other factors (3).

The first method outline above is preferred to the second because the analysis here does not help in

reformulation of the already formed feed. But on the other hand, it may be useful for a check in new formulations. Again, if the consumer has an analytical laboratory, this stage of analysis will help in demand of the standard specifications from the manufacturer. Likewise, if feeds are imported, analysis of feeds by consumer country will help check that the overseas manufacturers meet contract specifications. Apart from the nutritional values, quality control is necessary in determining the level of toxic substances normally present in raw materials - for example aflatoxin in groundnut cake, thioglucosides in all feed-stuffs and gossypol in cotton seed cake (4). Analysis of raw materials (feeding stuffs) will enable the manufacturer prepare mixed feeds of the required nutritive value. Raw material or feeding stuffs chemical analysis by the consumer or farmer (at least the government farmer) will help in formulation of standard rations for particular type, breed and age of animal - from the knowledge of the compounds, vitamins, mineral and toxic compositions of such feeding stuffs. Equally if the consumer performs it on commercially purchased feeds, will help to safeguard against the mortality of his animals by knowing which feed contains high quantity of toxic substance.

Analysis for toxic substances in feed raw materials will enable the manufacturer to estimate the length of time materials can be stored without risk of spoilage. From the foregoing discussion, one may say that quality control increases cost of production but on the other hand it saves the manufacturer, the wastage of raw materials in

terms of determination of length of storage.

1.2 QUALITY CONTROL IN DEVELOPED AND DEVELOPING COUNTRIES

Feed enterprises in developed countries in general operate on a much larger scale than their counter parts in the developing world. They normally maintain small laboratories at individual feed mills to carry out simpler routine tests, while the more difficult analysis and formulation work are undertaken by a larger central laboratory which also controls the technical performance of the mill laboratories (5). Small mills in developed countries depend on their operation by relying on obtaining their raw materials from suppliers of good repute. They also make use of the quality control of their suppliers of premix materials to investigate specific problems which may arise.

Through analytical data for quality control, developed countries have come out with a qualitative description of the animal feed product as to its (a) origin or parent material, (b) species, variety, or kind, (c) the part actually eaten, (d) the process and treatments to which it has been subjected, (e) stage of maturity, (f) cutting or crop, (g) grade or quality designations and classiiication (5) also complete chemical composition. The scheme for such a description was proposed by Harris (1963) (6). This is the National Research Council assigned nomenclature and is found in the Joint United States and Canadian table of feeds. In like

manner, United Kingdom Ministry of Agriculture, Fisheries and Food have come out with Standard tables of composition and nutritive value of feeding stuffs (7), also there are tables of numeral composition. Equally, composition of concentrate By-product Feeding stuffs have been Compiled by Committee on Feed Composition Agricultural Board of National Research Council (1956) (8). This gives the class of feeding stuff, proximate, mineral, vitamin amino acid, energy and carbohydrate compositions. A specific table of feed composition for sheep has been published by National Research Council (1968) (9), (10a,b). This table, contains data on proximate, mineral, vitamin and amino acid contents of energy feeds, protein supplements, dry and succulent roughages and miscellaneous additives. Also, composition of feeds commonly used in poultry rations have been published by National Research Council (10), (11). Similarly, a table of composition of feeds and nutrient requirements of dairy cattle have been compiled through analytical data by National Research Council (1978) (12).

For the developing countries, quality control facility is needed for all feed manufacturing companies or enterprises, no matter how small, in order to operate efficiently. In the absence of quality control analytical laboratories, there is need for such enterprises to use the Government or University advisory service/analytical laboratories. So far, it is only few developed countries that have come out with standard tables and quality control methods for their feed manufacture and formulation. One of such countries is India (13).

One set back in most developing countries is the absence of legislation on feed description and quality. Whereas most developed countries have comprehensive legislation controlling the composition, description and marketing of animal feeds, only few developing countries have enacted legislative laws on animal feeding stuffs. Some of the developed countries having such legislation on manufacture and sale of animal feeds are United Kingdom (14), Switzerland (15), etcetera. The developing countries that have regulations for manufacture and marketing of animal feeds are India, Jamaica, Cyprus, Malta, Peru, Republic of South Africa (16, 17, 18, 19, 20, 21, 22).

It is obvious that compliance with regulations on feed composition or effective participation in standardisation schemes cannot be achieved unless proper quality control is carried out through analytical methods. Cockerell, et al (1975) (23), have outlined how legislations may be enacted.

1.3 A REVIEW OF WORK DONE ON CHEMICAL COMPOSITION AND QUALITY CONTROL OF NIGERIAN ANIMAL FEEDSTUFFS

So far, much work has not been done on the chemical composition and quality control of Nigerian feeding stuffs, both compounded and the raw materials. The importance of chemical analysis to quality control and in helping the farmer who formulates his own feeds cannot be over-emphasized. Ema (1977) (24) has worked on sheep and cotton seed supplement and came out with the conclusion that sheep diet consisting of 37.5% groundnut cake and 2.5% cotton

seed provided adequate nutrients for sheep and that feeding of cotton seed to sheep was not related to the so-called spontaneous fracture as observed in sheep (i.e. the free gossypol was not dangerous to sheep). He also came out with the required percentage protein, calcium, phosphorus and free gossypol. But work by Smith and Clawson (1965) (25), Wilde (1944) (26), have shown that monogastric animals are readily intoxicated by gossypol while Gallup (1927) (27), Reiser and Fu, (1962) (28) have shown that ruminants are more tolerant. Again work by Sherrod and Tilman, 1964 (29), Dankae et al (1965) (30), Nelson and Watkins, (1968) (31), Parsons, (1974) (32) and Rogers et al (1975) (33), show that sheep can exhibit toxic symptoms due to gossypol.

Oyenuga (1958) (34), has carried out the proximate analysis of some possible browse trees and shrubs in the Middle Belt. Oyenuga (1958) (35) has also found the proximate composition of some feeding stuffs available in the middle belt. But so far there is no analysis covering the mineral composition or vitamin composition of such feeding stuffs. Bello (1977) (36) worked on feeding trials and chemical analysis of some commercial poultry feeds in Zaria. He came to the conclusion that mortalities, poor growth and performance occurred among chicks placed on feeds from one of the manufacturing industries, and that the quality of poultry feeds in Nigeria leaves much to be desired because of the lack of any established standards.

Olayiwole (1968) (37) has outlined the proximate composition of concentrate mixture for dairy cows,

digitaria grass, maize silage and elephant grass silage.

Njike (1978) (38), has worked on the proximate, mineral and vitamin composition of cotton seed meal while Dafwang et al, (1979) (39) have given the proximate composition of blood meal. Proximate analysis of palm kernel meal, soya bean meal, cotton seed meal and rap seed meal have been carried out by Nwokolo et al (1966) (40). Nwokolo et al (1976) (41) also analysed the amino acid and mineral composition of palm kernel and soya bean meals.

Ademosun and Bikovich (1971) (42) worked on the proximate analysis of Local Yellow maize, Opaceue maize and guinea corn. So far, the analysis done in Nigeria has rested on the rat materials and most have been incomplete. Olomu (1979) (43) has outlined that the trace elements contents of these ingredients for commercial and formulated feeds have not been analysed due to lack of facility to determine them. Even though the trace elements play less important role in the formulation of animal feeds, it is necessary to know their level to safeguard against the outbreak of disease of the animals due to deficiency of such elements. In other words, there is need to know if the specified level of trace elements is incorporated in the commercial or formulated feeds. It is in pursuit of quality of poultry feedstuff that Federal Government of Nigeria did set up an expert panel on feed standards in 1979 (44). The panel reviewed research work on nutrient requirements of chickens in Nigeria and have come out with recommendations for proximate and mineral compositions of

the Broiler starter, finisher and layers rations. These recommendations are similar to those of National Research Council (1971).

1.4 FACTORS NORMALLY ANALYSED IN FEEDSTUFFS

In quality control through chemical analysis, Wende's proximate analysis is often carried out which comparises (a) moisture, (b) crude protein, (c) crude fibre, (d) total ash (mineral matter), (e) nitrogen extract (NFE), (f) insoluble ash and (g) crude fat determinations. Reason for these determinations is that they indicate possible constraints on usage due to the presence of excessive content of cellulosic material, oil or mineral matter. Also, the insoluble ash is determined to know the amount of sand and or other dirt which may be present. The major mineral contents of formulated mixed feeds such as calcium, potassium, sodium, magnesium and phosphorus are usually tested to know if they satisfy the level required for a particular group or age of animal.

The toxic factors, thioglucoside content and Urease activity of samples of the commercial and formulated feedstuffs are also determined. Urease test is carried out on soya bean feedstuffs because they usually contain proteins which may adversely affect feed conversion efficiency. The analysis for toxic factors is important so as to obtain some idea of the normal levels of toxicity which may be expected. It is also noteworthy that toxic factors test is most important when feeds concerned are

those of the poultry, calf, pig and lamb feeds. Because of the importance of some microelements in mixed or manufactured feeds in terms of growth, maintenance and disease in the animals, the level of the microelements zinc, manganese, copper, iron, cobalt, selenium and iodine are often analysed.

1.5 IMPORTANT NOTES ON FACTORS BEING DETERMINED

1.51 Protein: Protein contains carbon, hydrogen, oxygen and nitrogen and sometimes it contains iron, phosphorus and sulphur. Protein is the only macronutrient which contains nitrogen except for small amounts in lignin. Feedstuff proteins on the average contain 16% nitrogen. Various proteins exist. They are formed by different combinations of amino acids of which there are over 25 to be found in proteins (45).

Its functions to the animal are very essential. Protein forms the basic structural material from which all body tissues are formed. It is essential for growth, development of the animal as well as the faetal development. Apart from these it is useful for maintenance and milk production. Protein is not replaceable by any other feed nutrient, for this reason there is a certain minimum level of dietary protein recommended for each class of animals. This level varies for animals of different classes depending on the physiological age and type of production.

The dietary protein is determined as crude protein by Kjeldahl procedure. This determination is based on

the fact that most nitrogen containing macromaterials in most feedstuffs are proteins and proteins on the average contain approximately 16% nitrogen. This means that result obtained in nitrogen determination is multiplied by 6.25, since 6.25 x 16% gives 100% protein in the sample.

1.52 Crude Fibre: Crude fibre is the fraction of the nutrient designed to include those materials in a feedstuff which are of low digestibility. Crude fibre precludes cellulose, certain hemicelluloses and some of the lignin - these are essential for energy requirements of the livestock.

1.53 Crude Fat: This includes all of that portion of a feedstuff soluble in ether. Hence, crude fat is commonly referred to as ether extract. While the crude fat in most feedstuffs is usually mostly true fats, it may also include varying amounts of other ether-soluble materials such as the fat-soluble vitamines, carotene, and sterols. But this part of other ether-soluble materials constitute a very small percentage of the overall feedstuff, therefore no sizeable error is made in assuming that the ether-soluble fraction is mostly true fat.

Fats (lipids) combined with structural protein form the membranes essential to life in all cells. Mobilization of body fat during prolonged under feeding is a well known phenomenon. Lipid metabolism changes with and partially

controls, the various productive functions such as lactation, fattening, work and growth (as outlined by Hafez and Dyer, 1969).

1.54 Nitrogen Free Extract: This is the carbohydrate part of the feedstuff. It includes mostly sugars, starches, hemicelluloses and some more soluble lignin. Nitrogen free extract is the primary source of energy in livestock feedstuffs.

1.55 Moisture Content: If feedstuffs are to be stored safely, it is very necessary that they be at a "safe" moisture content level and free from pests infestation. The term "safe" is the moisture content at which it is not possible for moulds to grow. The relationship of moisture content to pest activity is best expressed in terms of the atmospheric relative humidity with which the moisture in the feedstuff is in equilibrium and with 10^{o} rise in temperature decreases by 0.6-0.7% for oil free materials.

The relationship between moisture content and possible biological activity for an oil-free feedstuff at temperatures of 20-30°C has been outlined by Cockerell et al (1975) as given below.

1. Up to 8% moisture (30% relative humidity): no significant biological activity.
2. 8-14% moisture (30-70% relative humidity): insect infestation possible.
3. 14-20% moisture (70-90% relative humidity): insect infestation and mould growth possible.
4. 20-25% moisture (90-95% relative humidity): insect infestation, mould and bacterial growth possible.

If one allows a safety margin, moisture content of 13% for oil-free feedstuffs is appropriate. This figure is reduced by 1% for a feedstuff containing up to 5% oil.

1.56 Mineral Matter Or Ash: This fraction of the animal feedstuff nutrient includes for the most part the inorganic or mineral components. There are 16 mineral elements which function in animal nutrition. Of these elements, seven are macro and nine are micro. The micro-elements include calcium phosphorus, potassium, sodium, sulphur, chlorine and magnesium. The trace elements are iron, iodine, copper, cobalt, fluorine, manganese, zinc, molybdenum and selenium.

The role of the most essential mineral elements in the animal body are as outlined below.

(a) Sodium and chlorine: These two minerals are considered together due to their biochemical relationship and are provided as sodium chloride. They are necessary for formation of digestive joices, control of body fluid concentration, control of body pH and nerve and muscle activity. Deficiency of calcium is slow in developing. Excess of sodium causes hypertension.

(b) Phosphorus: It is essential for bone and teeth formation; as a component of protein in the soft tissues; milk and egg production and in various metabolic process. Deficiency causes rickets, osteomatacia, osteoporosis, poor apetite, lowered milk production and general

unthriftiness.

(c) Magnesium: It is necessary for many enzyme systems; helps in carbohydrate metabolism and is necessary for the function of nervous system. Magnesium deficiency results to hypo-magnesia associated with toxic symptoms and frequently death. Excess of it causes depression of cardio vascular system and the central nervous system.

(d) Potassium: Potassium is required by livestock for a variety of body functions such as osmotic regulation, acid-base balance and digestion. Symptoms of a potassium deficiency are rather non-specific such as decreased feed consumption, lowered feed efficiency, slow growth, stiffness and emaciation. Excess leads to hyperkalemia.

(e) Iron: Iron is necessary for hemoglobin formation. Its deficiency brings about anemia, fatigue, depressed growth and reduced resistance to infection.

(f) Iodine: Iodine is important for the production of thyroxin by the thyroid gland. Its deficiency leads to goiter and reduced rate of cellular oxidation.

(g) Cobalt: Cobalt functions as a component of vitamin B_{12} molecule and is necessary in the rumen synthesis of vitamin B_{12}. Cobalt deficiency leads to loss of appetite, emaciation, listlessness, macrocytic amenia and inco-ordination.

(h) Copper: Copper is necessary in iron absorption, in hemoglobin formation, in various enzyme systems and in

synthesis of Keratin for hair and wool growth. Copper deficiency leads to anemia, depressed growth of hair and wool depigmentation and reduced reproductive efficiency. Excess of it causes jaundice, haemolysis and death.

(i) Manganese: Manganese is essential in enzyme systems influencing estrus, ovulation, fetal development, udder development, milk production, growth and skeletal development. Its deficiency causes defective ovulation, testicular degeneration, congenital deformity, perosis in birds, abortions, resorptions, poor growth, lowered serum alkaline phosphatase and 'knuckling' over in calves.

(j) Selenium: Selenium is useful in vitamin E absorption and utilization, and is an essential component of the enzyme glutathione peroxidase. Deficiency of selenium leads to nutritional muscular dystrophy (white muscle disease) in lambs and calves; retained placenta in cows; heart failure; paralysis; low fertility; poor growth; liver necrosis and pancreatic fibrosis in chicks. Excess of selenium results to loss of hair; soreness of feet and sloughing of hoofs; incordination; atrophy of heart; cirrhosis of liver and excess salivation.

(k) Zinc: Zinc prevents parakeratosis, promotes general thriftiness and growth of body and hair. Its deficiency causes parakeratosis, unthriftiness and poor general growth.

1.6 AIM OF THE PROJECT

The aims of this project are

i. To explain why quality control is essential for feed manufacturing, formulating and marketing enterprises.

and ii. To describe the method by which quality control is achieved through chemical analysis.

CHAPTER 2

E X P E R I M E N T A L S

2.1 SAMPLING OF THE FEEDING STUFFS

2.11 SAMPLING

Samples of manufactured and formulated animal feedstuffs were collected by scooping a small portion of the feedstuff from about 10-20% of the bags supplied to consumer as a consignment (45). The samples of formulated feeds were collected from National Animal Production Research Institute, Shika, Zaria, while Pfizer poultry feeds were collected from School of Agriculture, Ahmadu Bello University, Zaria. All samples were stored in covered plastic buckets at room temperature.

The samples that were collected are some Pfizer product - broiler starter, chick starter, broiler finisher and growers mashes. Also National Animal Production Research Institute broiler starter formulated rations 1, 3, 7, 9 and 13 were collected. Other samples collected included O-3 calf concentrate for cattle, milking cow concentrate ration and lamb concentrate - all from National Animal Production Research Institute.

2.12 SAMPLE PREPARATION

Prior to analysis of samples, the samples were ground to pass sieve with circular openings of 1mm diameter and were mixed thoroughly (46). Pestle and motar were used for grinding hard samples while an electric grinder was used for the easier samples.

2.2 PROXIMATE ANALYSIS OF THE FEEDING STUFFS

2.21 MOISTURE DETERMINATION (47)

For moisture determination of each sample, a metallic dish was dried in an oven at 80°C for about 20 minutes, then was cooled in a desiccator and weighed as W_1. Then, few grams of the sample, say 5.0g was poured into the dish and the weight W_2 was noted. Now, the dish with the sample was dried in an oven at 105°C for 24 hours or more. After 24 hours, the dish was transferred to a desiccator and was allowed to cool. It was then weighed quickly with minimum exposure to atmosphere as W_3. The loss in weight of the sample during drying is the moisture content. The moisture content percentage was calculated as

$$\frac{W_2 - W_3 \times 100}{W_2 - W_1}$$

$$\text{Or Moisture Content (\%)} = \frac{\text{Wt of fresh sample - Wt of dry Sample} \times 100}{\text{Wt of fresh sample}}$$

2.22 CRUDE PROTEIN DETERMINATION

The total nitrogen was determined by a modified Kjeldahl method (48) and the result was multiplied by 6.25 to give crude protein.

Reagents

Sulphuric acid 98%, Nitrogen free. Potassium Sulphate, reagent grade. Mercuric Oxide, reagent grade. Paraffin Wax. Sodium Sulphide, 40% solution. Sodium Sulphide, 4% solution Pumice Chips. Boric acid/indicator solution. This is made by adding $5cm^3$ of indicator solution (0.1% methyl red and 0.2% bromocresol green in alcohol) to $1dm^3$ saturated boric acid solution. Hydrochloric acid standard solution (0.1M).

Apparatus

Macro Kjeldahl digestion and distillation units (make shift type). Kjeldahl flask ($100cm^3$ capacity) Conical flasks, $250cm^3$. Heating mantle.

Method

One gramme of each sample was weighed into Kjeldahl digestion flask and 10g of potassium sulphate, 0.7g mercuric oxide and $20cm^3$ sulphuric acid (98%) are added. The flask was heated gently at an inclined angle until frothing subsided and was boiled until the solution cleared. The boiling was continued for a further half hour. Excessive frothing was checked by addition of a small amount of paraffin wax. The digested sample was allowed to cool and

$90cm^3$ of distilled water was added. It was then recooled and $25cm^3$ of 4% sodium sulphide solution was added with mixing. After this, a small piece of pumice chips was added to prevent bumping, followed by addition of $80cm^3$ of 40% sodium hydroxide solution with the flask at an inclined position so that two layers are visible. The flask was connected rapidly to the make shift steam distillation system. It was then heated by steam and the distillate Ammonia was collected in $50cm^3$ boric acid/indicator solution. Excatly $50cm^3$ distillate was collected. At the end of distillation, the condenser tip was washed and the distillate was titrated against standard acid solution (0.1M HCl).

Calculation

The calculation was done as given below.

Percentage nitrogen content of sample is given by

$$\frac{Cm^3 \text{ acid} \times \text{Molarity of Standard Acid} \times 0.014}{\text{Wt of Sample (g)}} \times \frac{100}{1}$$

Therefore crude protein content (%) is
Nitrogen content % x 6.25

2.23 CRUDE FAT DETERMINATION (49a)

Reagents and Equipment

Petroleum ether (b.p 40-60°C) or in place of it anhydrous diethyl ether. Extraction thimbles, Round bottom flask, soxhlet extraction apparatus and regulated water bath.

Method

About 5.0g of each moisture free sample was put into a thimble of known weight W_1. Its weight W_2 was measured. The thimble with the sample was placed inside a soxhlet extractor. About 300cm^3 of diethyl ether was poured into a 500cm^3 round bottom ground joint flask. The soxhlet extractor with the thimble plus sample was fixed into the round bottom flask, which was already fitted in an electricically heated and regulated water bath. The top of the soxhlet extractor was then connected to a condenser. The water bath was then switched on and the heating rate was adjusted to give a condensation rate of four to five drops per second. The extraction was done for 24 hours. At the end of 24 hours the thimble was removed and the ether was reclaimed by connecting the round bottom flask to a condenser and a receiver apparatus. The remaining ether was removed by immersion on a boiling water bath and the flask was dried at 105^{o}C for 30 minutes. The flask was cooled in a desiccator and weighed to get the weight of the lipid content. From the weighing of the thimble (W_3) and its contents after extraction and drying in oven for 24 hours at 80^{o}C or by knowing the weight of the lipid extracted, the percentage fat content was obtained.

Calculation

Crude fat (% Dry Mater) is given by

$$\frac{\text{Weight of fat}}{\text{Weight of Sample}} \times \frac{100}{1}$$

$$\text{Or Percentage Fat} = \frac{100\ (W_2 - W_3)}{W_2 - W_1}$$

For the purpose of accuracy, the Ministry of Agriculture, Fisheries and Food's (1973) method (49b), first alternative calculation above was used.

2.24 DETERMINATION OF TOTAL ASH (49c)

Apparatus

Desiccator, Bunsen burner, Crucibles, Muffle furnace.

Method

For each of the samples, a clean crucible was dried in an oven at 100°C for about an hour. Then it was transferred to a desiccator and was allowed to cool. After cooling, the weight W_1 was noted. Exactly 2.0g of the feeding stuff was then weighed into the crucible giving the weight of crucible and feeding stuff as W_2. This meant that the weight of the sample was $(W_2 - W_1)$. The crucible containing the sample was heated gently on a bunsen burner in fume cupboard until smoking ceased. It was then transferred to a muffle furnace heated at 600°C. The heating was continued until all the carbon has been burnt away (within a period of 10 - 48 hours). The furnace was switched off, the crucible was taken out and placed inside a desiccator. It was allowed to cool and the weight of the ash and crucible (W_3) was measured.

Calculation

The Ash % was given as

$$\frac{\text{Weight of Ash}}{\text{Weight of Sample}} \times \frac{100}{1} \text{ or } \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1}$$

2.25 ACID SOLUBLE AND INSOLUBLE ASH (49c)

Reagents And Apparatus

Hydrochloric acid (1 to 2.5 V/V). Filter paper (ashless)Crucible dishes.

Method

The residue obtained from ash determination above was used. The ash was boiled with $25cm^3$ hydrochloric acid, taking care to avoid spattering. The solution with its residue was filtered through asheless filter paper and washed with hot water until acid free. Then, the filter paper with residue was placed into a dry, tared crucible dish and was placed in a muffled furnace at $600^{\circ}C$ for upwards of two hours or until carbon free.

Calculation

$$\frac{\text{Weight of acid treated Ash}}{\text{Weight of Sample}} \times \frac{100}{1}$$

2.26 CRUDE FIBRE DETERMINATION

The crude fibre was determined as that fraction remaining after digestion with standard solutions of sulphuric acid and sodium hydroxide under carefully controlled

conditions as specified by Association of Official Analytical Chemists, (1970) (50a,b,c).

Reagents

Sulphuric acid solution (0.1275M). Sodium hydroxide solution (0.313M). Antifoam reagent (Octyl alcohol). Ethyl Alcohol. Hydrochloric acid 1% V/V.

Apparatus

Beakers, 600cm^3 tall-sided. Round-bottom flask-Condenser unit. Buchner flask 1dm^3. Buchner funnels, Crucibles. Ashless filter papers (dried at 100°C). Heating Mantle, Oven, Muffled furnace.

Method

2.0g of the dried, fat-free sample was weighed into a 600ml beaker. (The residue from fat determination was used). To this, 200cm^3 of hot 0.1275M sulphuric acid was added. The contents were carefully transferred to a round bottom flask which was later placed quickly under condenser, and brought to boil within 1 minute. The solution was boiled gently for exactly 30 minutes, using distilled water to maintain volume and to wash down particles adhering to the sides. Execessive foaming was checked with antifoam where necessary. The contents of the flask were then filtered through Whatman No. 541 paper in Buchner funnel using suction. The residue was washed well with boiling water. The residue was transferred back to the round-bottom flask and to it was added 200cm^3 hot 0.313M sodium hydroxide. The flask was replaced under the condenser and again brought to boil within

one minute. After it had been boiled for exactly 30 minutes, it was filtered through ashless filter paper Whatman No. 541 placed in a funnel. The residue was washed first with boiling water, 1% hydrochloric acid and then with boiling water. Finally it was washed twice with alcohol, dried overnight at 100°C in an oven, cooled and weighed. The weighed sample and filter paper were then placed in a tared crucible and was ashed in a muffled furnace at 500°C for 3 hours or till carbon free. After switching off the furnace, the crucible with the ash was quickly transferred to a desiccator, cooled and was weighed.

Calculation

The crude fibre (%) of fat-free dry matter was given as

$$\frac{\text{Wt of Crucible + dried residue - Wt Crucible + ashed residue}}{\text{Wt of Sample}} \times 100$$

2.27 NITROGEN-FREE EXTRACT (50d)

The Nitrogen-free extract is a calculated proximate factor based on dry matter (DM). It is calculated as

100% - % Crude protein - % Crude fat - % Ash.

2.3 TOXIC/ENDOGENOUS FACTORS

2.31 UREASE ACTIVITY IN SOYABEAN MEALS

This was determined by method of Schram and Aines . (1959) (51).

Reagents

Dimethylaminobenzaldehyde solution (DMAB):16.0g of DMAB was dissolved in 1dm^3 of 95% ethanol and to this was added 100cm^3 concentrated hydrochloric acid. (This solution is stable for one month).

Pyrophosphate buffer: 23.3g $Na_4P_2O_7 10H_2O$ was dissolved in approximately 980cm^3 distilled water. To this was added 3cm^3 of concentrated HCl and then dropwise further HCl was added until pH of the buffer came between 7.7 to 7.8. The solution was then diluted to 1dm^3. Buffered urea solution: 0.4g urea was dissolved in 1dm^3 pyrophosphate buffer. (This solution is stable for one week).

Zinc acetate solution: 22.0g zinc acetate dihydrate was dissolved in distilled water, to it was added 3cm^3 of glacial acetic acid and the volume was made up to 100cm^3 in a 100cm^3 volumetric flask.

Potassium ferrocyanide solution: 10.6g $K_4Fe(CN)_6 3H_2O$ was dissolved in a distilled water and made up to 100cm^3 in a 100cm^3 volumetric flask.

Apparatus

Water bath at 40°C, capable of maintaining temperature within ± 1°C, with a shaking device. Conical flasks, 125cm^3. Volumetric flasks, 25cm^3. Spectrophotometer (Spectronic 20).

Method

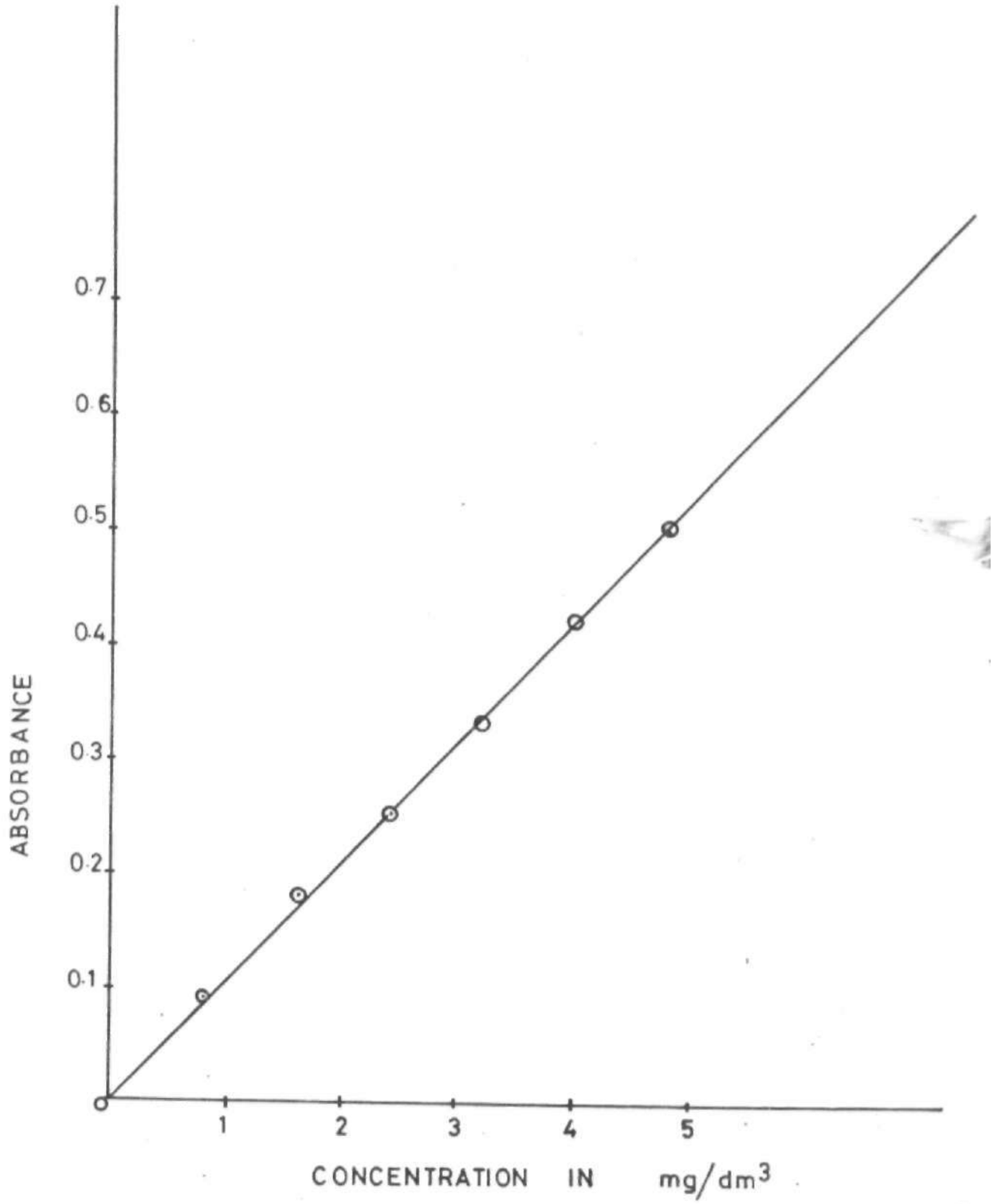
1.0g of each National Animal Production Research Institute broiler sample was weighed accurately into a

conical flask and to it was added 50cm^3 of the buffered urea solution. The flask and its contents were incubated in water bath for 30 minutes exactly at 40°C with shaking. It was then removed from the water bath with quick addition of 0.5cm^3 each of concentrated HCl, ferrocyanide solution, zinc acetate solution and 0.1g of charcoal. This was shaken for 15 minutes and then filtered. Filterate was discarded if coloured and the procedure was repeated using more charcoal. 10cm^3 aliquots of a clear filterate and 10cm^3 of DMAB Solution were pipetted into a 25cm^3 volumetric flask and was made up to 25cm^3 with distilled water. Also a reagent blank (10cm^3 DMAB made up to 25cm^3 with water) and a urea blank (10cm^3 buffered urea solution and 10cm^3 DMAB made up to 25cm^3 with water) were made up. A standard curve (see Figure 2.1 on page 28) was prepared by pipetting aliquots of buffered urea solution from 2 to 12cm^3 into 25cm^3 volumetric flasks with addition of 10cm^3 of DMAB and making up to the mark. The flasks were well mixed, stood in water bath at 25°C for 10 minutes and the absorbance was read at 430mμ.

Calculation

The urease activity was calculated as mg/dm^3 urea in urea blank minus mg/dm^3 urea in sample. This was further calculated in percentage, taking into consideration grammes of feed used.

Fig. 2.1 CALIBRATION CURVE FOR UREASE ACTIVITY DETERMINATION



2.32 THIOGLUCOSIDE DETERMINATION

The method described below will give the approximate thioglucoside content. The method is that of McGhee et al (1965) (52).

Reagents And Apparatus

Barium Chloride (5% solution). Volumetric flasks, 500cm^3. Steam bath. Round-bottom flasks. Ashless filter paper.

Method

To a measured 5-10.0g of each of the Samples previously defatted by soxhlet extraction, 250cm^3 of distilled water was added in a round bottom flask. The flask was then fitted with a condenser and the content was hydrolysed at 54°C for one hour. After this, it was boiled for two hours keeping volume constant by the addition of distilled water. The content of the flask was filtered, retaining filterate while the residue was washed three times with 50cm^3 hot water. The washings were added to the initial filterate and the volume was made up to 500cm^3 in a volumetric flask.

Barium sulphate was precipitated by heating the filterate and adding excess barium chloride solution. The precipitate was digested and aged on the steam bath for a few hours and was then filtered using an ashless filter paper. The residue was put into a tared crucible and was

ashed in a muffled furnace at 500°C until carbon free. The weight of the barium sulphate was taken after coooling in a desiccator.

Calculation

Approximate thioglucoside content is calculated as

$$\% \text{ thioglucoside} = \frac{(\text{Mass of thioglucoside})\ (\text{Mass of } BaSO_4)}{(\text{Mass of } BaSO_4)\ (\text{Sample Mass})} \times 100$$

2.4 DETERMINATION OF ESSENTIAL MINERALS AND TRACE METALS

2.41 SODIUM CHLORIDE DETERMINATION (53a,b)

Reagents And Apparatus

Volumetric flasks, Pipettes. Conical flasks. Burettes. Standard 0.1M silver nitrate solution. Standard 0.1M ammonium thiocyanate solution. Ferric indicator - Saturated aqueous solution of ferric alum. Potassium permanganate solution - 6% W/V. Urea solution - 5% W/V Acetone (Analytical Reagent grade).

Method

For each sample, 2.0g was weighed into a 250cm^3 Conical flask. The sample was moistened with 20cm^3 of distilled water and 15cm^3 of 0.1M silver nitrate solution was added by way of pipette. The content of the flask was well mixed and then 20cm^3 concentrated nitric acid and 10cm^3

potassium permanganate solution were added with mixing. The mixture was continuously heated until liquid was cleared and nitrous fumes were evolved. The mixture was cooled. After which $10cm^3$ of uren solution was added and allowed to stand for 10 minutes. Then $10cm^3$ acetone was added followed by addition of ferric indicator. The excess silver nitrate in the solution was then back titrated with the 0.1M thiocyanate solution to a red brown end point.

Calculation

The Sodium Chloride % is given as

$$\% \text{ NaCl} = \frac{(15.00cm^3 - cm^3 \text{ of } 0.1M\ NH_4CNS) \times 0.585}{\text{Mass of (g) Sample taken}}$$

2.42 DETERMINATION OF PHOSPHORUS

The method used is that of AOAC (1970), (1980) (54a,b,c).

Reagents

Molybdovanadate reagent: 40g Ammonium molybdate $4H_2O$ was dissolved in $400cm^3$ hot water and cooled. Then 2.0g ammonium metavanadate was dissolved in $250cm^3$ hot distilled water, cooled and $450cm^3$ of 70% perchloric acid was added. The molybdate solution was then added gradually to the vanadate solution with stirring - after which the solution was diluted to $2.0dm^3$.

Phosphorous Standards: A 1000ppm stock solution of phosphorus was prepared by dissolving 8.788g potassium dihydrogen orthophosphate in deionised distilled water and

the solution was made up to one dm^3 in a $1dm^3$ volumetric flask. The working solution was prepared by diluting the stock solution 1 in 20 to give a working solution of $0.1mgP/dm^3$ concentration.

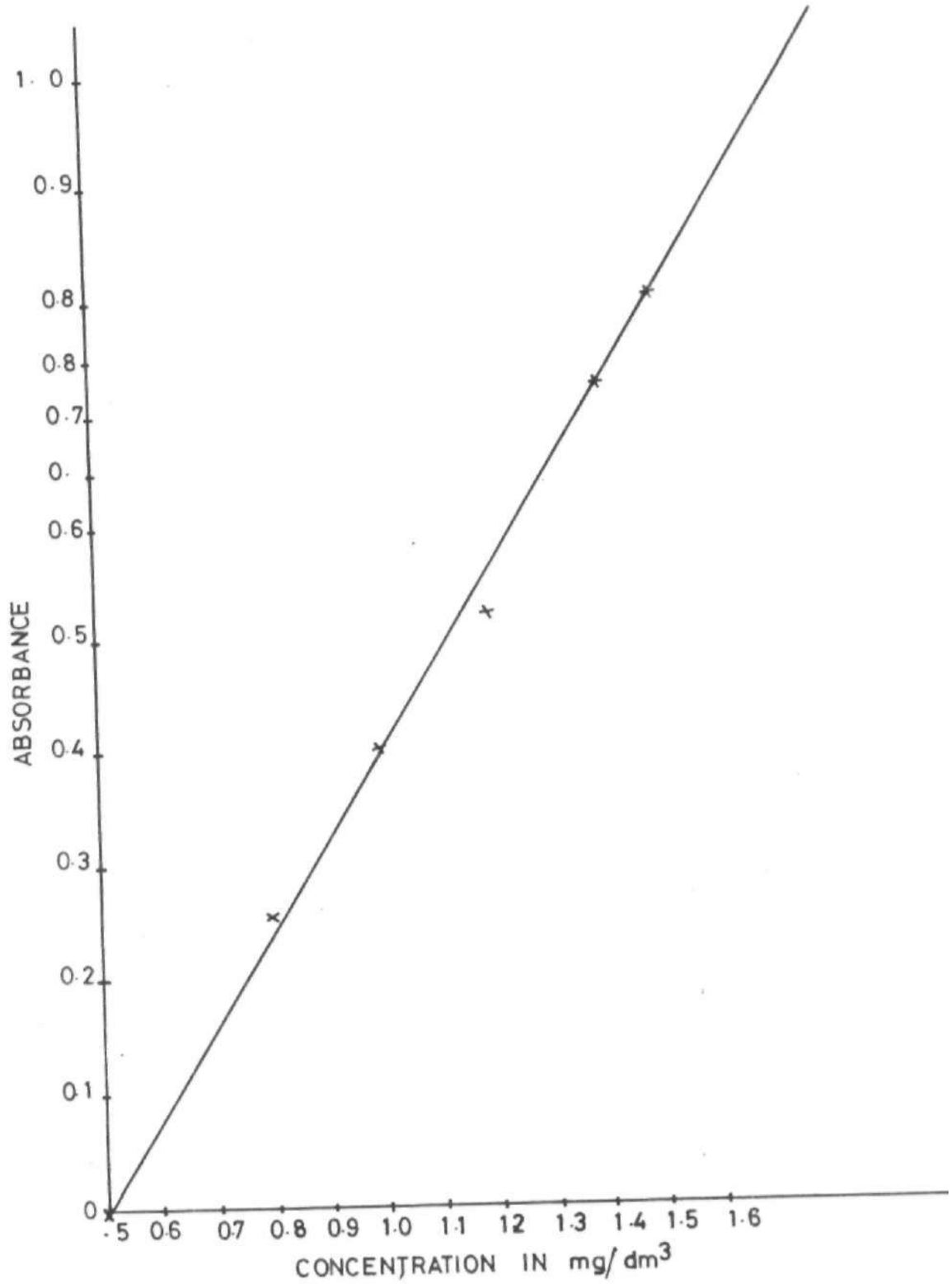
Apparatus

Spectrophotometer (Spectronic 20) to read at 400mu. Graduated flasks, $100cm^3$. Crucibles. Muffle furnace.

Method

2.0g of each finely ground sample was weighed into a crucible and was ashed as described under ash determination. To the ash was added $40cm^3$ HCl acid and a few drops of nitric acid, this was cooled and transferred to a $250cm^3$ volumetric flask. This was diluted to the mark and mixed. Aliquots of the sample solution ranging from $10cm^3$ to $25cm^3$ were pipetted into $100cm^3$ flask with addition of $20cm^3$ of the molybdovandate reagent and were made up to the mark. They were then mixed and allowed to stand for 10 minutes, after which their absorbance were read at 400mu. In like manner aliquots of the working standard containing 0.5, 0.8, 1.0 and 1.5mg phosphorus were transferred to $100cm^3$ flasks and were treated as above. The standard and samples were read at 400mu, setting the 0.5mg standard at 100% transmission. The amount of phosphorus in each sample aliquot was determined from a standard curve (see Figure 2.2 on page 33).

Fig.2.2 CALIBRATION CURVE FOR PHOSPHORUS DETERMINATION



2.5 FLAME PHOTOMETRIC DETERMINATION OF SODIUM AND POTASSIUM

2.51 DETERMINATION OF POTASSIUM

Reagents and Equipment

Potassium Standard: stock standard potassium was prepared by drying analar potassium chloride and from this 1.912g was weighed out - this was dissolved in deionised distilled water in a $1dm^3$ volumetric flask. Then the volume was made up to $1dm^3$ with deionised distilled water. This solution contained 1000ppmK. Flame photometer-Corning-EEL Model. Muffled furnace.

Method

2.0g of each moisture free sample was put in a crucible and was treated as in ash determination. To the ash was added $2cm^3$ concentrated hydrochloric acid to dissolve it. The solution was made up to $100cm^3$ in $100cm^3$ volumetric flask. From this stock sample solution aliquots were taken and diluted further to $100cm^3$ in volumetric flasks. The working potassium standard solutions for calibration curve were made by diluting $0.2cm^3$, $0.4cm^3$, $0.6cm^3$, $0.8cm^3$ and $1.0cm^3$ of the stock standard potassium solution to get concentrations of 2ppm, 4ppm, 6ppm, 8ppm and 10ppm respectively.

To measure the potassium standard solutions for a calibration curve and to measure the concentration of the sample solutions, photometrically, the instrument was allowed to stabilize for at least five minutes before use.

After this, a beaker of deionionized distilled water was inserted into the sample recess and the gas knob was adjusted to produce a flame with one large central blue cone. With the deionised distilled water sample still in position the gas control was slowly closed until ten separate blue cones had formed. The galvanometer was then set at zero by using the zero control against the reagent blank (deionised distilled water). After the reagent blank was replaced by a standard potassium solution of the highest concentration (10ppm). The sensitivity reading of the direct reading flame photometer was set at 100% transmittance with the 10ppm standard solution. The zero was again reset against the blank and then each standard and working sample solutions were aspirated in turn, flushing with deionised distilled water after each measurement. The intensity of emission was read from the galvanometer read out of the photometer in each case.

Calculation

The emission intensity of the standard potassium

solutions (KCl) were plotted against their concentrations to obtain a calibration curve. From the calibration curve (see Figure 2.3 on page 37), the concentrations of the samples were read out and the exact concentration of the sample solution was obtained by multiplying the dilution factor.

2.52 DETERMINATION OF SODIUM

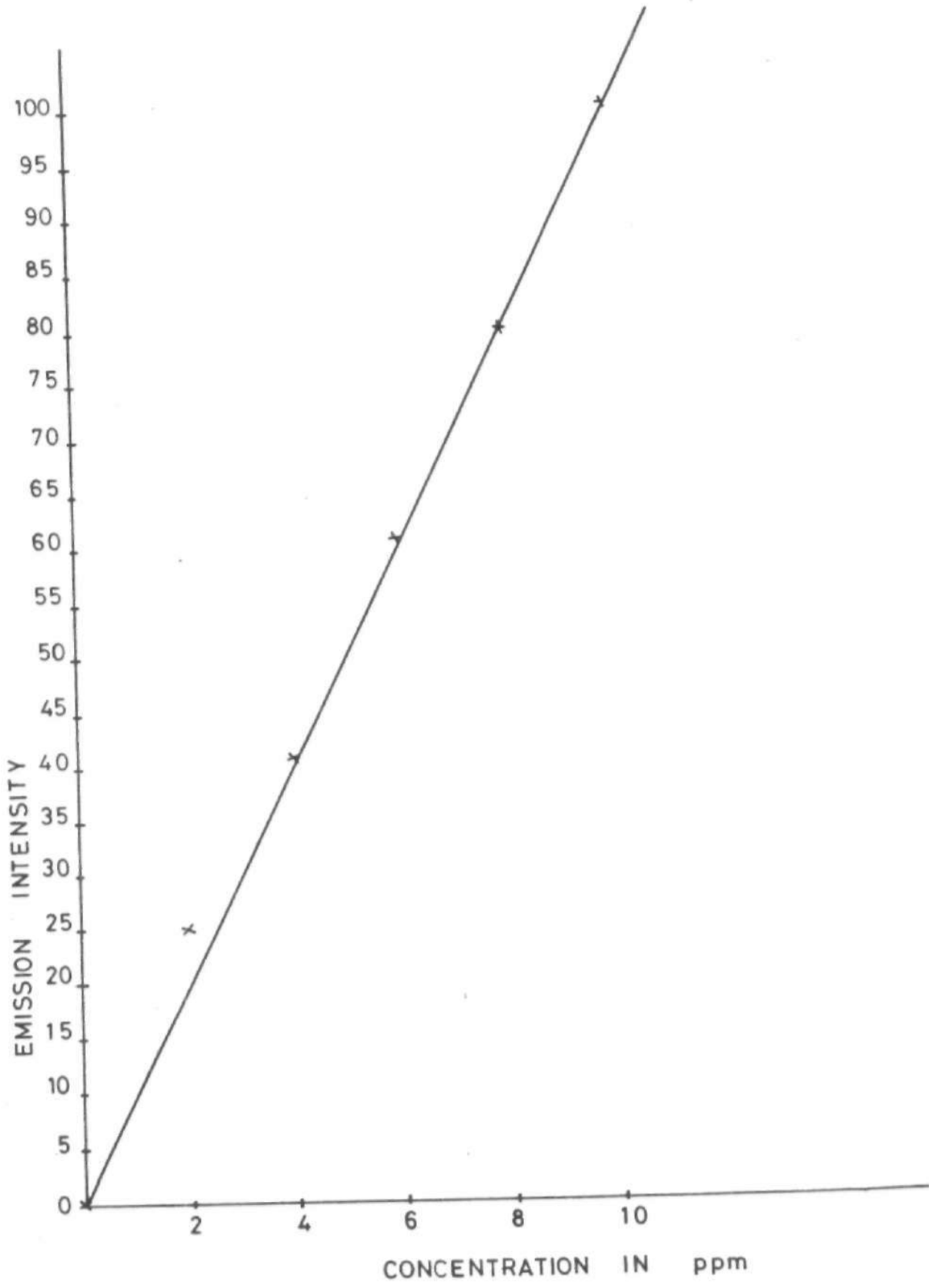
Reagents And Equipment

Concentrated hydrochloric acid. Sodium standard: stock standard sodium chloride of 1000ppm was prepared by drying some analar sodium chloride at $120^{o}C$ for one hour and cooled for 30 minutes. From this, 2.54g was taken out and weighed. The weighed salt was dissolved in $1dm^3$ flask and made up to the mark with deionised distilled water. This solution was stored in a plastic bottle. Flame photometer - Corning-Keel Model. Muffle furnace. $100cm^3$ volumetric flasks.

Method

The sample ash and solutions were prepared as specified under potassium determination above. From the stock sample solutions, aliquots were taken and diluted further to $100cm^3$ (with deionised distilled water) in a $100cm^3$ volumetric flasks. The working standard sodium solutions for calibration curve were made by diluting $0.1cm^3$, $0.2cm^3$, $0.3cm^3$, $0.4cm^3$ and $0.5cm^3$ of the stock standard sodium solution to obtain concentrations of

Fig.2.3 CALIBRATION CURVE FOR POTASSIUM DETERMINATION



1, 2, 3, 4 and 5ppm respectively.

The procedure for taking photometric readings of the standard solutions and sample solutions is the same as described under potassium determination. The flame photometer was set to give a reading of 100% intensity with the 5ppm standard. After this, other standard solutions and sample solutions were aspirated in turn, flushing with deionised distilled water after reading the intensity of emission of each on the photometer galvanometer.

Calculation

The emission intensity was then plotted for the standard readings against their concentrations (see page 39 for Figure 2.4). From the calibration curve obtained, the concentration of the sample solutions were extrapolated, finding the actual concentration of the sample solution by multipying by the dilution factor.

2.53 DETERMINATION OF CALCIUM AND OTHER MINERAL ELEMENTS BY ATOMIC ABSORPTION SPECTROMETRY (55, 56)

Apparatus

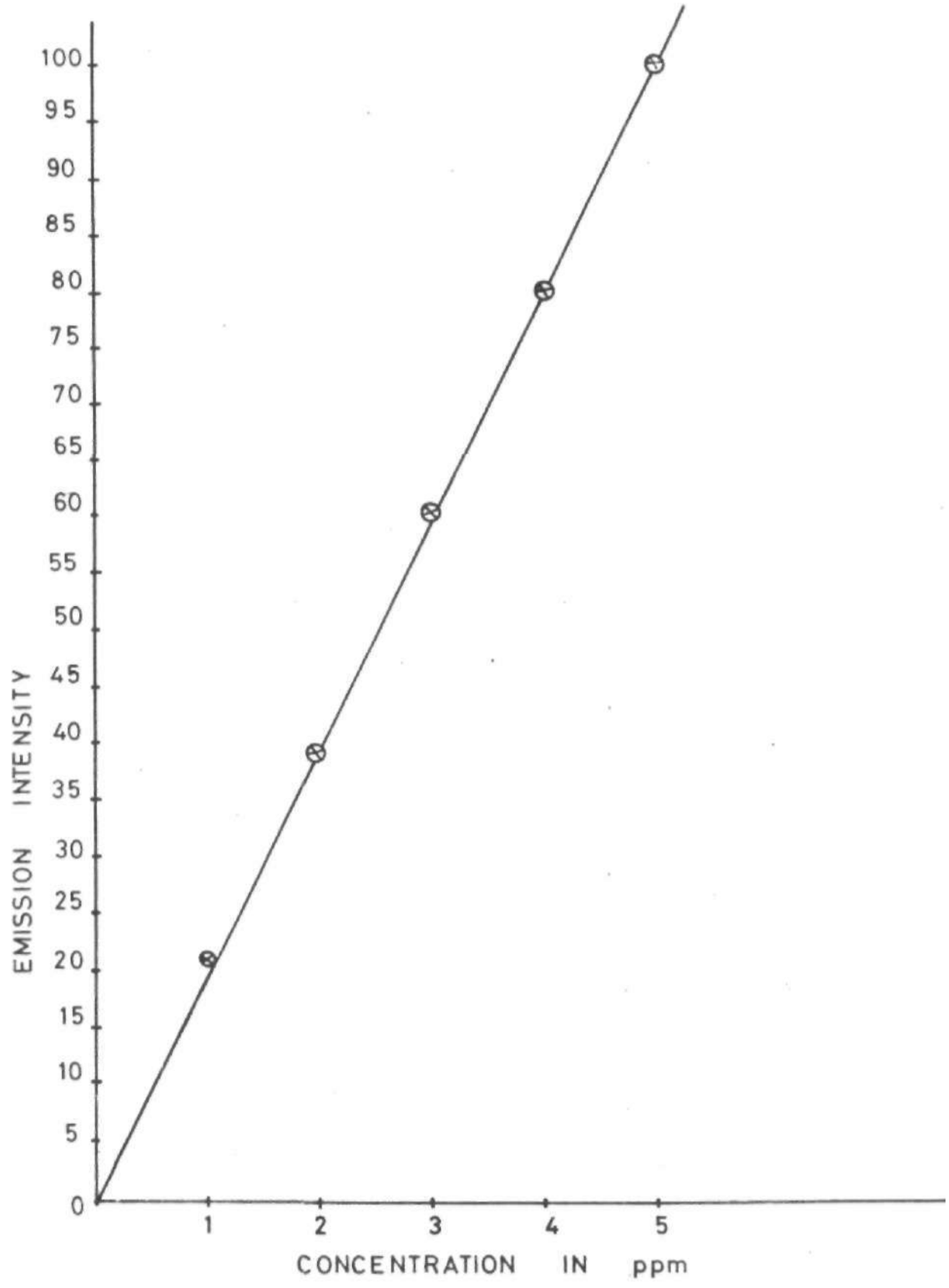
Atomic Absorption spectrophotometer Model Pye Unicam SP1900.

Reagents

Air: produced by a Compressor. Acetylene - standard commercial grade.

Fig. 2·4

CALIBRATION CURVE FOR SODIUM DETERMINATION



Calcium Solution: 630mg of calcium carbonate, $CaCO_3$ (analar grade) was dissolved in $10cm^3$ concentrated HCl. To this was added $200cm^3$ of deionised distilled water and was heated to obtain a complete solution. The solution was cooled and diluted to $1000cm^3$ with deionised distilled water in a $1dm^3$ volumetric flask. Deionized distilled water was used for the preparation of all reagents calibration standards and as dilution water.

Hydrochloric Acid (0.1M HCl).

Lanthanum Solution: 10g of lanthanum nitrate was dissolved in deionized distilled water and was diluted to $1000cm^3$ in a dm^3 volumetric flask.

Concentrated HNO_3.

Standard Metal Solutions: A series of standard metal solutions containing 0.1 to 5ppm were prepared by appropriate dilution of the following stock metal solutions with 0.1M HCl solution.

2.531 Calcium: To 2.4972g calcium carbonate (Analytical Reagent grade), $CaCO_3$ deionized distilled water was added, followed by dropwise addition of a minimum volume of concentrated HCl (about $10cm^3$) to effect complete dissolution. The solution was diluted to $1000cm^3$ in a $1dm^3$ volumetric flask with deionized distilled water. This solution was of 1000ppmCa concentration.

2.532 Cobalt: 4.7630g of cobalt sulphate $7H_2O$ was dissolved with deionized distilled water and made up to

to 1000cm^3 in a dm^3 volumetric flask - giving a concentration of 1000ppm Co.

2.533 Copper: 3.7980g of copper nitrate trihydrate (Analytical Reagent Grade) was dissolved with deionized water and was made up to 1000cm^3 in a 1dm^3 volumetric flask. The solution was standardized with 0.1M sodium thiosulphate using starch solution as indicator. The solution was of 1000ppmCu.

2.534 Iron: 27.801g of ferrous sulphate heptahydrate $FeSO_4.7H_2O$ (Analytical Reagent Grade) was dissolved in deionized distilled water containing 50cm^3 of concentrated sulphuric acid to give a solution of 5585ppm after making up to 1dm^3. The solution was standardized with 0.01M potassium dichromate solution using N-phenylanthranilic acid as indicator. Then 0.1M solution of ferrous salt was diluted to 1dm^3 with deionised distilled water to get a 1000ppm solution.

2.535 Magnesium: 10.0135g magnesium sulphate heptahydrate, $MgSO_4.7H_2O$ was dissolved in 200cm^3 deionised distilled water. To this was added 1.5cm^3 concentrated nitric acid and the solution was made up to 1000cm^3 with deionized distilled water. The solution was then standardized with 0.1M EDTA solution using erichrome black-T as indicator. The solution obtained was found to contain a concentration of 1000ppmMg.

2.536 Manganese: 3.076% manganous sulphate monohydrate, $MnSO_4.H_2O$ (Analytical Reagent Grade) was dissolved in 200cm^3 deionized distilled water. To the solution was added 1.5cm^3 concentrated nitric acid, and was made up to 1000cm^3 with deionized distilled water in a 1dm^3 volumetric flask. The solution was standardised with 0.1M EDTA solution usingerichrome black-T as indicator. The concentration was found to be 1000ppmMn.

2.537 Zinc: 4.3980g zinc sulphate heptahydrate, $ZnSO_4.7H_2O$ (Analytical Reagent Grade) was dissolved in deionized distilled water and was made up to 1000cm^3. The solution was standardized with 0.1M EDTA using erichrome black-T as indicator. The solution was of 1000ppm concentration.

2.538 Selenium: 1.00g of selenium powder (Analytical Reagent Grade) was dissoved in 15cm^3 concentrated hydrochloric acid plus 5cm^3 concentrated nitric acid. This was made up to 1dm^3 in a 1000cm^3 volumetric flask. The solution was later stored in a polyethylene bottle. The concentration of the solution was 1000ppm.

Method

(a) Preparation of sample/sample solutions: 2.00g of each moisture free sample was ashed in glazed crucible after pre-burning over a burnsen flame in a fume chamber. The ashing was done at 550^{o}C in a muffled furnace. After cooling in a desiccator, 10cm^3 3M HCl was added and the solution was covered with watch glass and boiled

gently for 10 minutes. The solution was then cooled, filtered into 100cm^3 volumetric flask and was diluted to the mark with deionized distilled water. Subsequent dilutions of the sample solutions to bring them into analytical range was done with 0.1M HCl.

(b) Instrument Operation: The hollow cathode lamp of the desired metal was installed in the instrument. The wavelength dial was set according to the Table 2.1 below. The lamp was then aligned in accordance with the manufacturer's instructions.

Table 2.1

Wavelengths For Metals Analysis

Metal	Wavelength in nm
Calcium	422.7
Cobalt	240.7
Copper	324.7
Iron	248.3
Magnesium	285.2
Manganese	279.5
Zinc	213.9
Selenium	196.03

The slit width was then set according to the manufacturers suggested setting for the element being measured. The instrument was turned on and the amount of current suggested by the manufacturer was applied to the

hollow cathod lamp. The instrument was allowed to warm up until the energy source stabilized, this process usually requires 10 to 20 minutes. The current was readjusted as necessary after warm up. The burner heads were then installed. The air (compressor) was turned on and the flow rate was adjusted to suit the specified maximum sensitivity for the metal being measured. The acetylene gas was then turned on, its flow rate was adjusted to the specified value - the flame was then ignited.

Deionized distilled water was atomized and the aspiration rate over one minute was checked. The rate, if necessary, was adjusted between 3 and 5cm^3/minute, and the instrument was zeroed. A standard solution was now atomized and the burner was adjusted both up and down and sideways until a maximum response was obtained. The instrument was now ready for analysis of both samples and standards.

(c) Standardization: At least five concentration of each stock standard metal solution was prepared by diluting aliquots of stock solution with 0.1M HCl so as to bracket the expected metal concentration of the samples. Each standard was aspirated in turn into the flame and the absorbance was recorded. For each standard four to six absorbance readings were taken and their average reading was made use of.

For calcium and magnesium calibration, 100cm^3 of standard was mixed with 25cm^3 of lanthanum solution (see lanthanum solution above) before aspirating.

For iron and manganese calibration, 100cm^3 of standard was mixed with 25cm^3 of calcium solution (see calcium solution above) before aspirating.

A calibration curve for each metal being determined was obtained by plotting on linear graph paper, the absorbance of standards versus their concentrations in ppm. Calibration curves for iron and manganese were plotted based on the original concentrations of standards before dilution with calcium solution (see Figures 2.8 and 2.10 respectively). In like manner, calibration curves for calcium and magnesium were plotted, based on the original concentration of standards before dilution with lanthanum solution (see Figures 2.5 and 2.9 respectively). The calibration curve was rechecked by aspirating at least one standard after the completion of the analysis of a group of samples. The calibration curve for cobalt is given in Figure 2.6; copper calibration curve is found in Figure 2.7; zinc curve is depicted in Figure 2.11 while selenium curve is shown in Figure 2.12.

(d) Analysis of Samples: The atomizer was rinsed by aspirating deionized distilled water and the instrument was zeroed. Each sample was atomized and the absorbance was read. Four to six readings were taken and the average was taken as the sample absorbance. For calcium and magnesium determination, 100cm^3 of sample solution was diluted and

Fig. 2.5 CALIBRATION CURVE FOR CALCIUM DETERMINATION

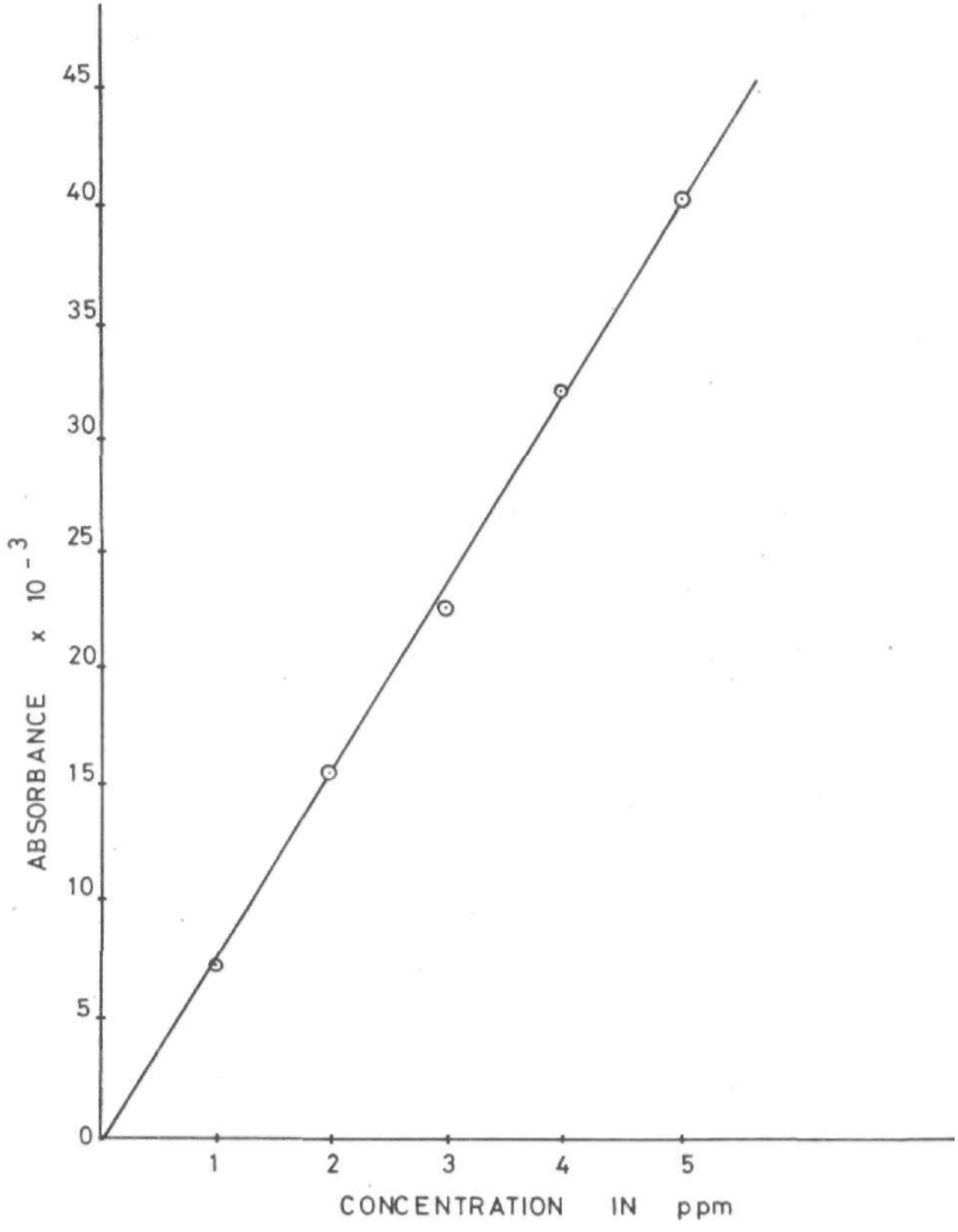


Fig. 2.6

CALIBRATION CURVE FOR COBALT DETERMINATION

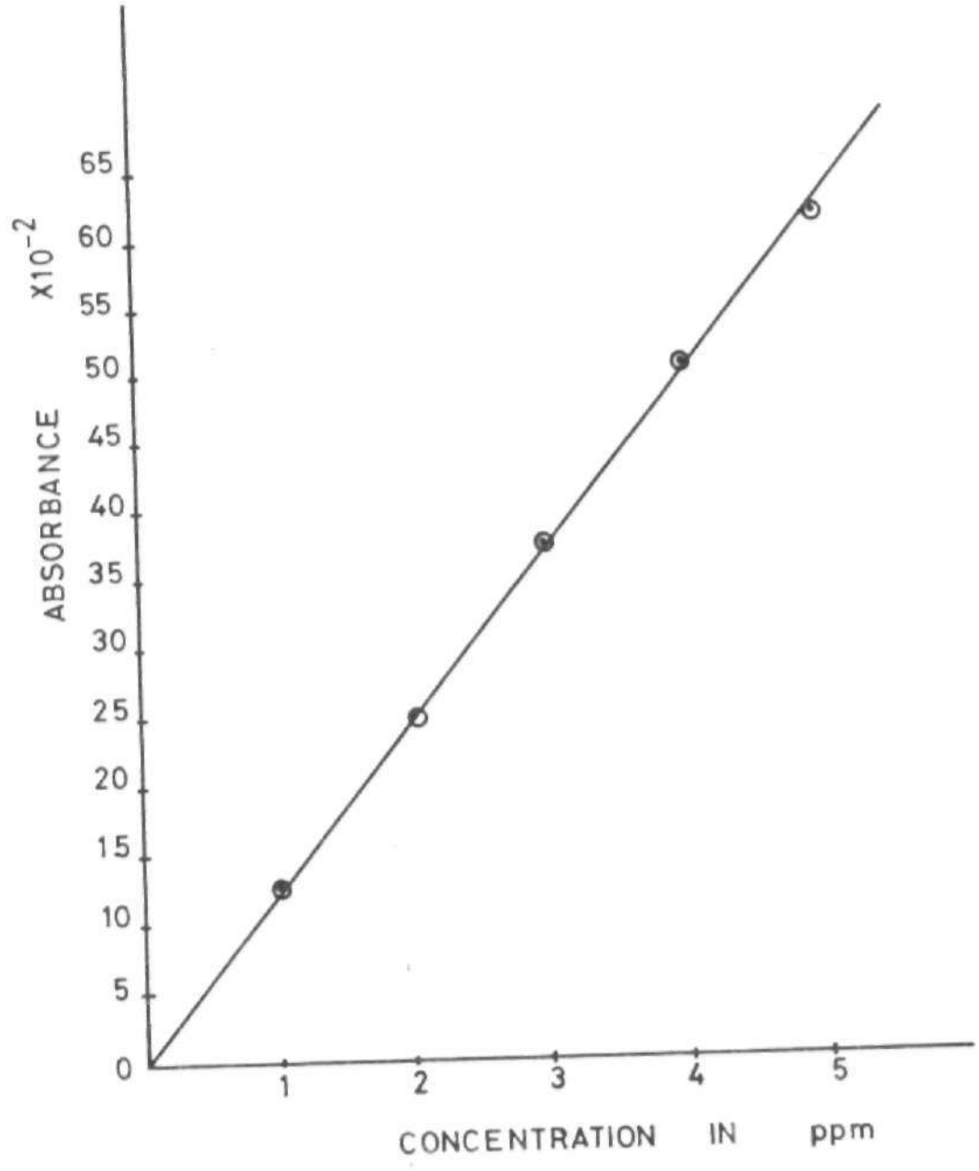


Fig. 2.7 CALIBRATION CURVE FOR COPPER DETERMINATION

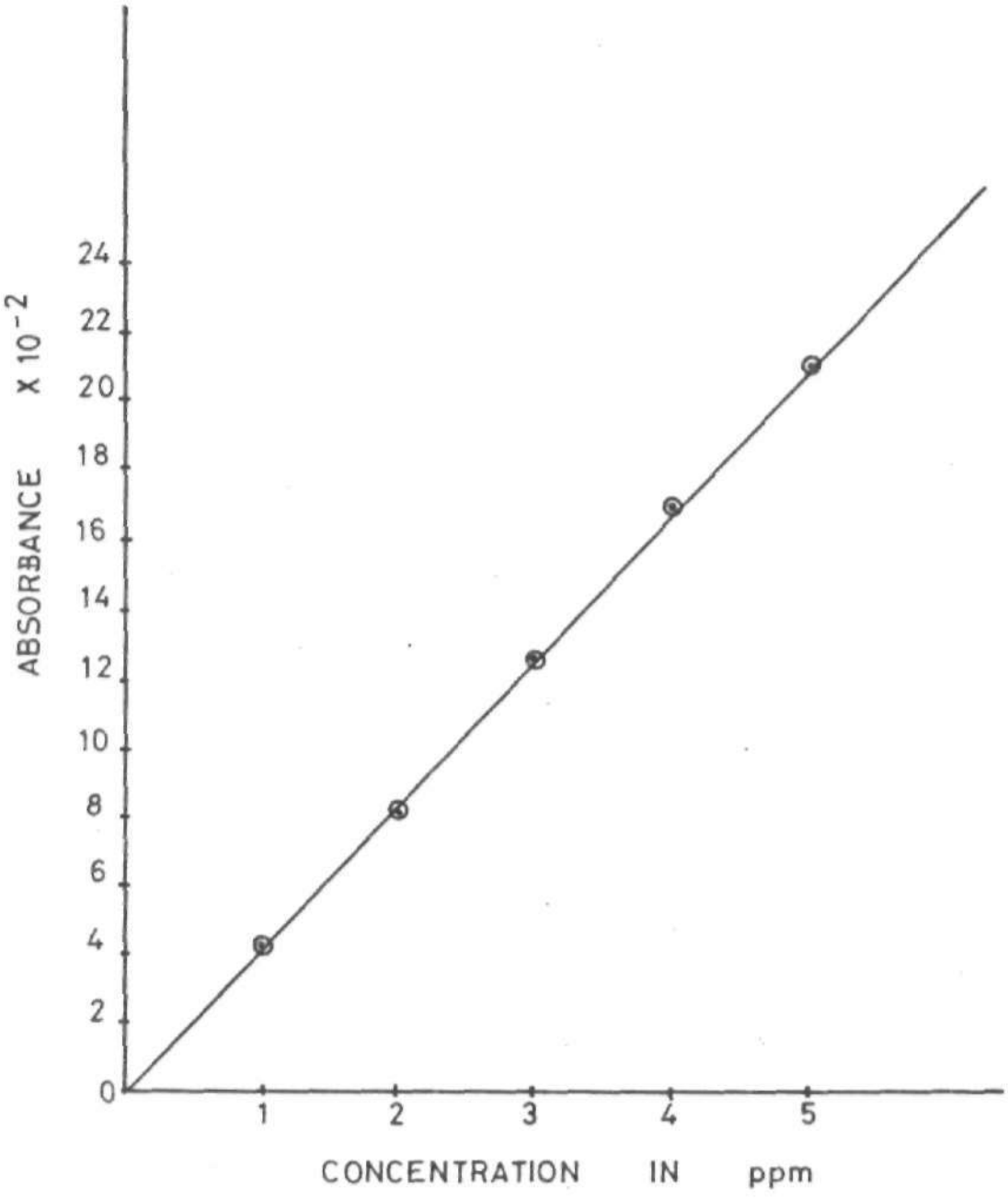


Fig. 2.8
CALIBRATION CURVE FOR IRON DETERMINATION

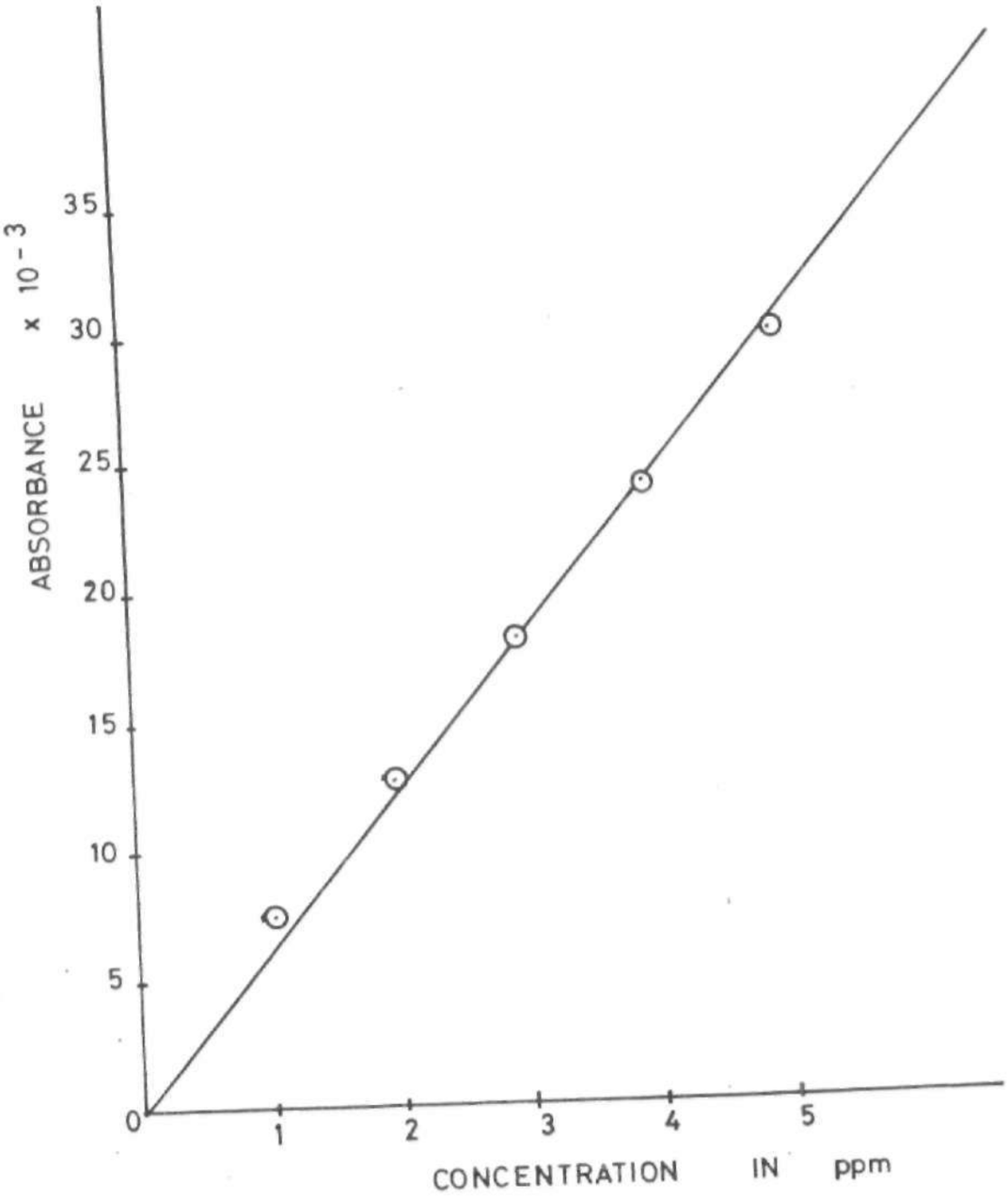


Fig. 2·9
CALIBRATION CURVE FOR MAGNESIUM DETERMINATION

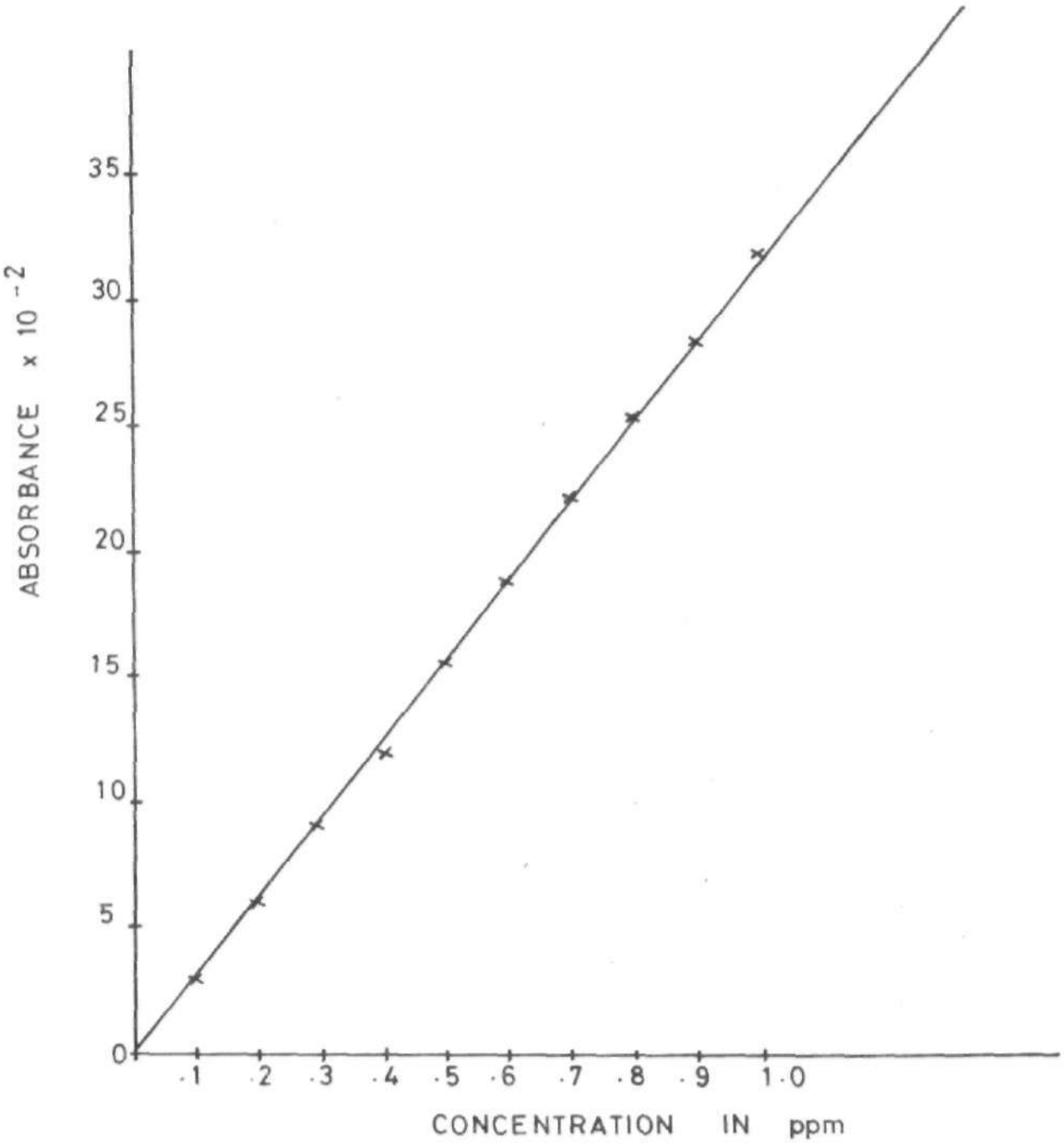


Fig. 2.10 CALIBRATION CURVE FOR MANGANESE DETERMINATION

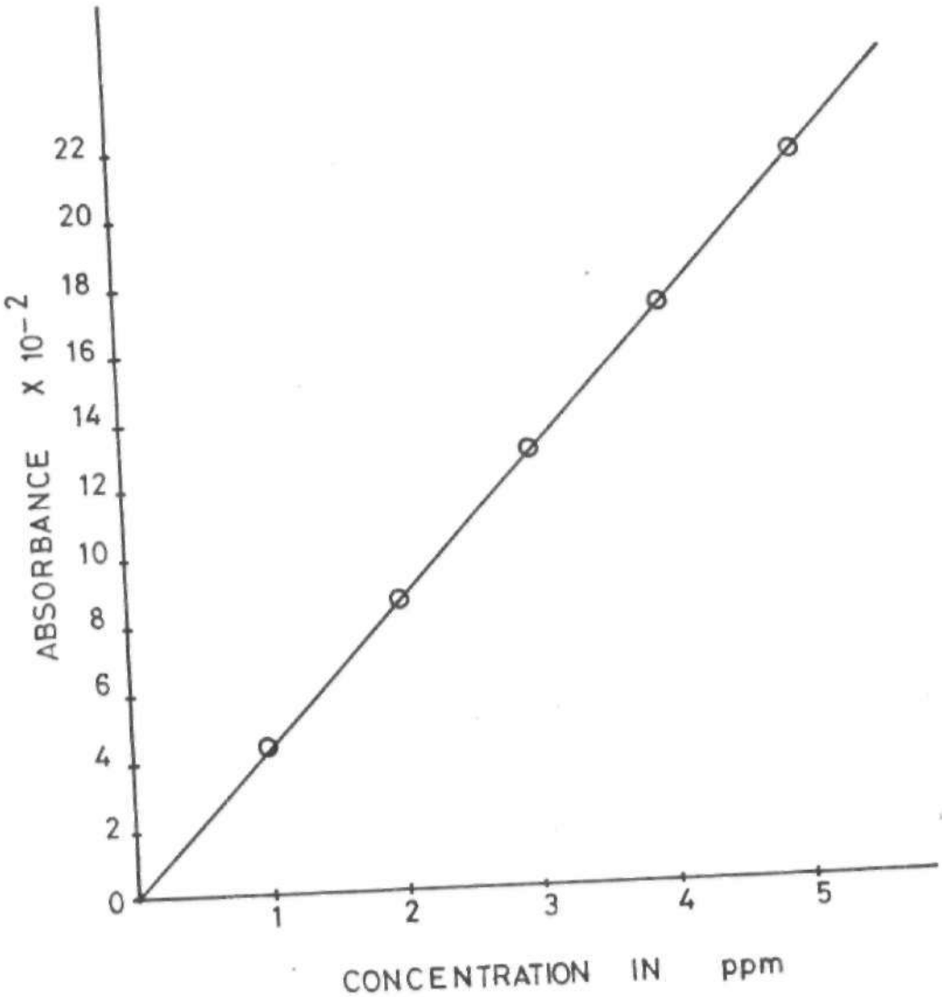


Fig. 2.11

CALIBRATION CURVE FOR ZINC DETERMINATION

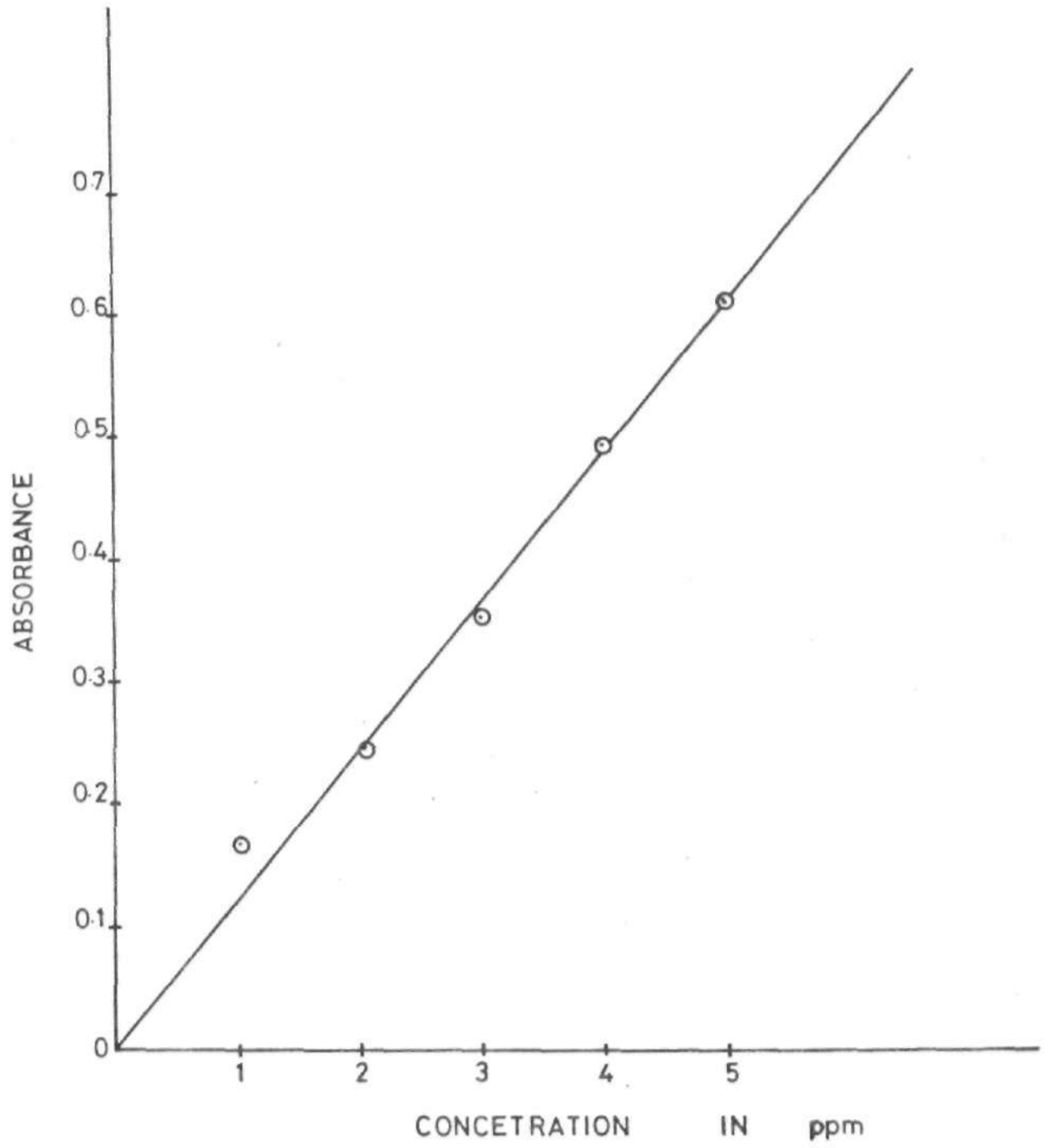
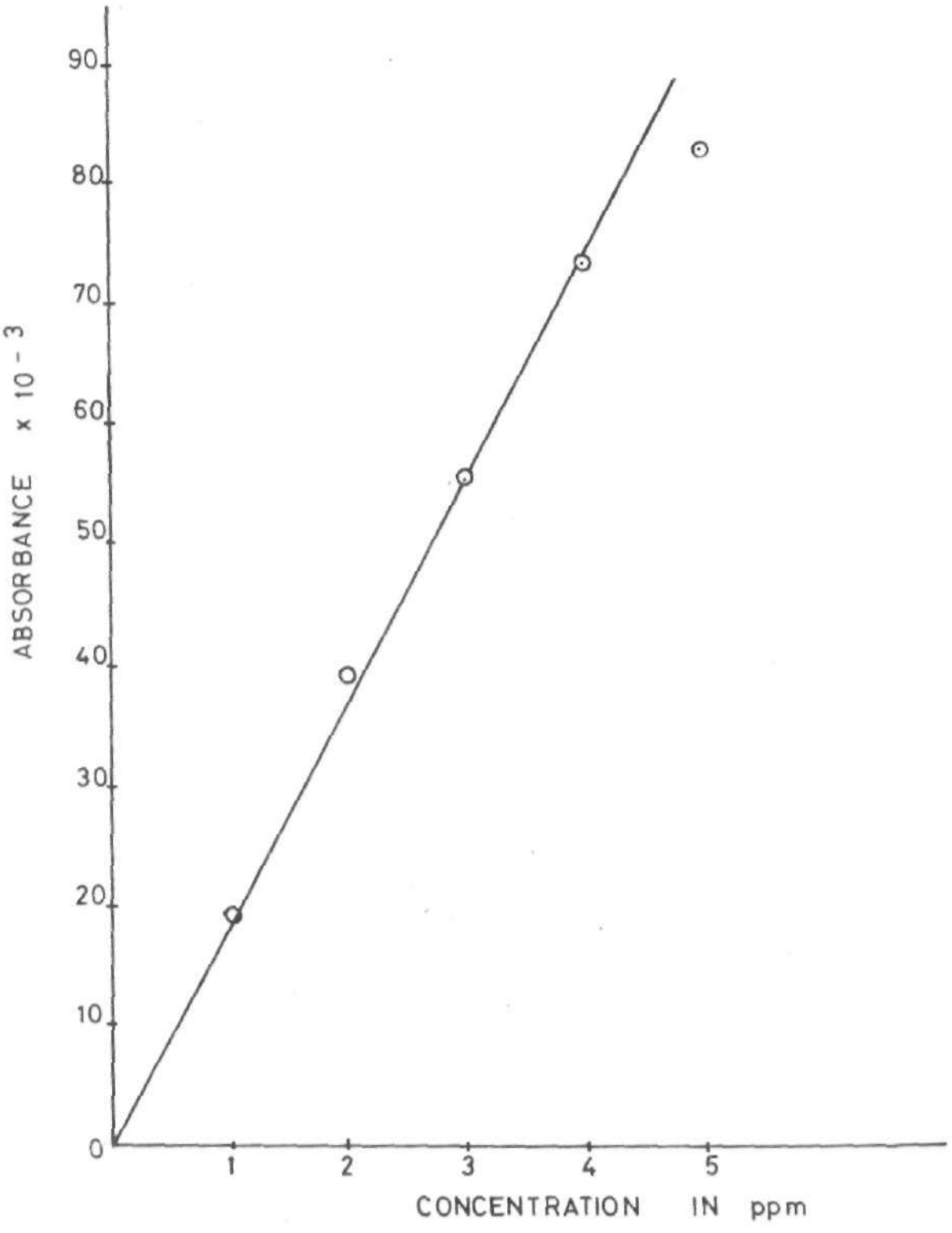


Fig.2.12
CALIBRATION CURVE FOR DETERMINATION OF SELENIUM



mixed with 25cm^3 calcium solution before atomization.

Calculation

The concentration of each metal ion in ppm, was calculated by referring to the appropriate calibration curve (see Figures 2.5 to 2.12 on pages 46-53. Further calculation to obtain percentage or mg/kg of metal ion in sample was carried out.

2.54 DETERMINATION OF IODINE

In this determination, part of Elmslie-Caldwell Method (57) for determination of iodine in mineral mixed feeds was combined with photometric determination of iodine in water (58, 59a,b).

Apparatus

Nickel dishes. Water bath, capable of temperature control to 30 $\pm$ 0.5^{o}C. Colorimetric equipment - Spectrophotometer EEL Model, for use at wavelengths of 525 nm and providing a lightining path of 1cm. 10.00cm^3 pipettes. 100cm^3 volumetric flasks. Stop watch. Furnace (muffled). 600cm^3 beakers.

Reagents

Sodium carbonate (solid). 1:1 sodium hydroxide solution (50%W/V). 96% Alcohol.

The following stock solutions were stored in tightly stoppered containers in a dark locker.

(a) Deionized distilled water, containing less than

0.3µg/dm^3 iodine.

(b) Sodium Chloride Solution: 200g NaCl was dissolved in deionized distilled water and diluted to 1dm^3.

(c) Arsenious Acid: 0.1M : 4.946g As_2O_3 was dissolved in deionized distilled water. To this solution was added 4.946g of potassium hydroxide and the solution was made up to 1000cm^3 in a 1dm^3 volumetric flask.

(d) Sulphuric Acid, H_2SO_4, concentrated.

(e) Ceric Ammonium sulphate,(0.02M),13.38g $Ce(NH_4)_4(SO_4)_4.4H_2O$ was dissolved in deionized distilled water and 44cm^3 concentrated sulphuric acid and this solution was made up to 1dm^3.

(f) Ferrous Ammonium Sulphate Reagent: 1.50g $Fe(NH_4)_2(SO_4)_2.6H_2O$ was dissolved in 100cm^3 deionized distilled water containing 0.6cm^3 of concentrated sulphuric acid. This solution was prepared daily.

(g) Potassium Thiocyanate Solution: 4.00g potassium thiocyanate, KSCN was dissolved in 100cm^3 of deionized distilled water.

(h) Stock Iodide Solution: 0.2616g anhydrous potassium iodide was dissolved in deionized distilled water and was diluted to 1000cm^3 in 1dm^3 volumetric flask. 1cm^3 of this solution was equivalent to 200ug/dm^3.

(i) Intermediate Iodide Solution: 20cm^3 stock iodide solution was diluted to 1000cm^3 with deionized

distilled water. The concentration of this solution gave $1cm^3 \equiv 4.00\mu g/dm^3$.

(j) Standard Iodide Solution: $25cm^3$ of intermediate iodide solution was diluted to $1000cm^3$ in a $1dm^3$ volumetric flask with deionized distilled water. The concentration of this solution gave $1cm^3 \equiv 0.100\mu g/dm^3$.

Method

5.00g of each sample (moisture free) was placed in a nickel dish. To this was added about 5.0g sodium carbonate (solid), $5cm^3$ sodium hydroxide solution (1:1 solution) and $10cm^3$ of 96% alcohol, taking care that the entire sample was moist. The contents were then dried at about 100^oC to prevent spattering upon subsequent heating. The nickel dish with its content was preburned over a bunsen flame in fume cupboard until smoking ceased. Then, the dish was heated in muffled furnace at 500^oC for 15 minutes. The dish was brought out and cooled in a desiccator. After which $25cm^3$ deionized distilled water was added, the dish was covered with a watch glass and boiled for 10 minutes. The contents of dish were then filtered through 18cm filter paper into a $600cm^3$ beaker and was washed several times with boiling deionized distilled water till about $230cm^3$ of filterate was collected. The solution was allowed to cool and was made up to $250cm^3$ in a $250cm^3$ volumetric flask.

Photometric Method: For the photometric measurement,

$10cm^3$ of the above sample solution or aliquots of it made up to $10cm^3$ with iodine free deionized distilled water was pipetted into a $100cm^3$ volumetric flask. Reagents were added to sample solution in the following order: $1.00cm^3$ sodium chloride solution, $0.50cm^3$ arsenous acid solution, and $0.50cm^3$ concentrated sulphuric acid.

The reaction mixture and ceric ammonium sulphate solution were placed in the 30^oC water bath and allowed to come to temperature equilibrium. Then, $10cm^3$ of ceric ammonium sulphate was added to the mixture and the contents were mixed by inversion of the flask and the stop watch was started to time the reaction. After 15 ± 0.1 minutes, the sample was removed from the water bath and $1.00cm^3$ ferrous ammonium sulphate reagent was added immediately with mixing, where upon the yellow ceric ion colour disappeared. Then, $1.00cm^3$ potassium thiocyanate solution was added with mixing. The sample was now replaced in the water bath. Within 1 hour after the thiocyanate addition, the red colour was read as percentage transmittance in the Spectrophotometer.

Calibration Standards: Standards containing 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 and 0.8 $\mu g/dm^3/10cm^3$ of solution were treated as in sample solutions above. Then, a calibration curve was obtained by plotting the absorbance of standards against their concentrations (see Figures 2.13 on page 59)..

Calculation

From the calibration curve, the sample concentrations in $\mu g/dm^3$ were read. Then the concentration was converted to mg/kg by further conversion taking into consideration the original sample weight taken.

CHAPTER 3

R E S U L T S A N D D I S C U S I O N

3.1 RESULTS AND DISCUSSION ON 0-3 CALF CONCENTRATE AND THE MILKING COW CONCENTRATE

3.11 PROXIMATE AND TOXIC FACTORS

3.111 Protein

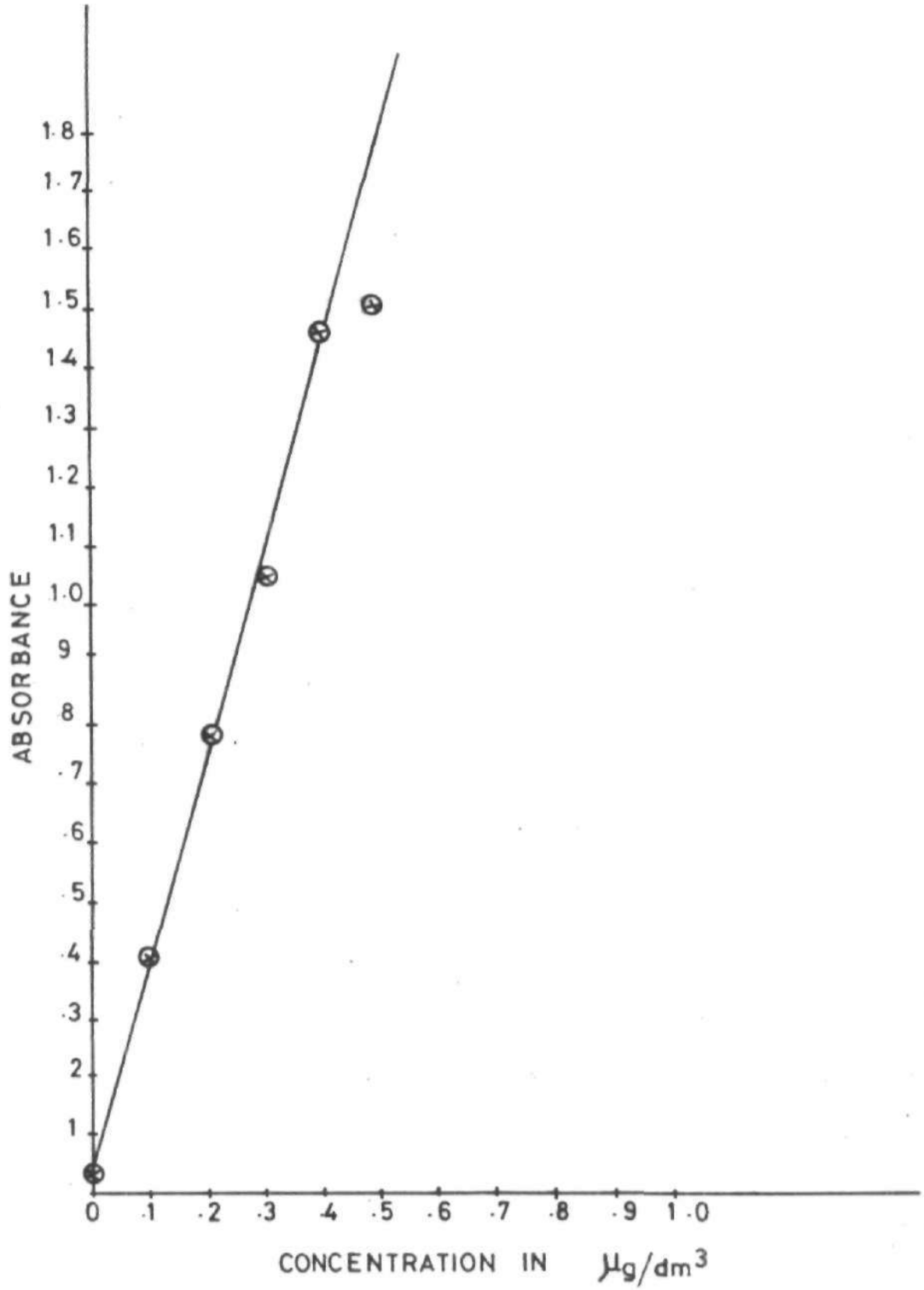
From the Tables 3.1 and 3.2 on pages 69 and 70, the protein results 17.806 and 18.068% of 0-3 calf and milking cow concentrates respectively are adequate when compared with National Research Council (1978) (60) standard. The National Research Council Table is consistent with many studies on milk production (61, 62, 63, 64, 65, 66, 67). On practical basis 16% protein in the dry matter is adequate for most lact ting cows; high-producing cows in early lactation need a higher percentage of protein - say about 20% (68, 69, 70).

For the growing calves, usually 16% crude protein is adequate and under some circumstances levels as low as 12% seem satisfactory. These values have been confirmed by investigators (71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81).

3.112 Crude Fibre

The values 15,363 and 21.425% shown in Tables 3.1 and 3.2 for 0-3 calf concentrate and milking cow

Fig 2.13 CALIBRATION CURVE FOR IODINE DETERMINATION



concentrate feeds respectively, are approximately in the range of 17% crude fibre recommended by National Research Council (1978). According to National Research Council Report, 17% crude fibre, on dry basis, in most situations is enough to prevent adverse effects of deficiency for lactating cows. Except for lack of energy or other nutrients, there are no known metabolic abnormalities associated with excessive fibre consumption.

3.113 Crude Fat

Typical dairy cattle rations will contain around 2-4 per cent fat. The addition of 2-5 per cent, depending on the amount already present, may be utilized quite efficiently. However, more than this may have adverse effects including interferences with rumen microbial action such as reducing fibre digestion and nitrogen metabolism (82). This goes to suggest that the result 5.655% obtained for milking cow as shown in Table 3.2 is only slightly above standard even though the National Research Council Table (1978) stipulates 2.0% fat. On the other hand, 5.280% for the 0-3 calf concentrate shown in Table 3.1 is within the range of maximum fat requirement, since the young calf is able to effectively utilize a very high level of dietary fat.

3.114 Insoluble Ash

As pointed out in Chapter 1, page 9, quantity of insoluble ash gives insight to the amount of dirt in the feedstuff. The results 0.555 and 0.303% respectively for

the 0-3 calf concentrate and the milking cow concentrate are permissible and normal.

3.115 Moisture Content

The 7.390% moisture for milking cow concentrate feedstuff shown in Table 3.2 is adequate when compared with the standards for moisture outlined by Cockerell et al (1975) (see page 12, Chapter 1). The 10.352% moisture given in Table 3.1 for the 0-3 calf concentrate feedstuff is adequate, as Matsushima (1979) (83) writes that in order to keep the feed from moulding or spoiling, the moisture content should be less then 15% under most normal conditions. But this result fails below the standard set by Cockerell et al (1975) which indicates insect infestation may be possible at 8-14% moisture content for a feedstuff.

3.116 Table Ash

Ash shown in Tables 3.1 and 3.2, the total ash percentage for 0-3 calf and milking cow concentrates are low and are adequate.

3.117 Nitrogen Free Extract

Since the fibre results are in order, the nitrogen free extract results for both feedstuffs given in Tables 3.1 and 3.2 are alright.

3.118 Thioglucoside Content

As given in Tables 3.1 and 3.2, the thioglucoside percentage for 0-3 calf concentrate and the milking cow concentrate are very high when the percentage of the total

ration is considered.

3.119 Mineral Composition

Analysis of the animal feedstuffs for the mineral content and a comparison of intake values with established requirements is probably the most useful way of determining mineral status of dairy cattle in practical situations. For this reason, the results of analyses of milking cow and 0-3 calf concentrate rations are compared here with the National Research Council mineral requirements (1978) as given in Tables 3.3 and 3.4, pages 71 and 72. The requirements of National Research Council compares well with Agricultural Research Council requirements (1965) (84a).

3.1110 Calcium

From the Table 3.3, the result of 0.90% obtained for milking cow concentrate feedstuff is a bit higher than the 0.6% established requirements of the National Research Council (1978) for dairy cattle. From Table 3.4 of 0-3 calf concentrate feedstuff, 0.065% obtained is much below the 0.60-0.7% standard of the National Research Council (1978) Table. We note that when dietary calcium is low, cattle absorb a higher percentage of that ingested and in excess dietary calcium, the percentage absorbed declines (84b, 85).

Information on the maximum safe levels of dietary calcium is much less adequate than for the minimum requirements (National Research Council 1978). Over a relatively wide range, cattle are able to avoid toxicity from high

dietary calcium by excreting the excess in the faeces - this supports the result for milking cow concentrate feedstuff. Nevertheless, it is believed that calcium levels above those presented in the National Research Council (1978) Table should be avoided.

Some studies indicate that calves absorb 90% of the calcium in milk. That is, calcium in milk fed to young calves is more efficiently absorbed and retained than that in rations consisting of forages and concentrates (Miller, 1979). This goes to support the low result recorded for the 0-3 calf concentrate.

3.1111 Phosphorus

As shown on Table 3.3, the result of 0.22% obtained for the milking cow concentrate does not tally with the National Research Council (1978) range of phosphorus requirements (0.31-0.38%) for lactating cows. The 0-3 calf concentrate feedstuff value of 0.176% shown in Table 3.4 fell below the National Research Council (1978) value of 0.42-0.50%.

But, Wise et al (1958) (86) has demonstrated that 0.22% of phosphorus in air dry ration was sufficient for maximum growth rate in young dairy animals. If this is the case, it means that the percentage for the lactating cow is also low, confirming the lower result obtained, since the digestibility of phosphorus for young calves is

about 90% while that of lactating or older dairy cattle is about 50 to 64%.

3.1112 Magnesium

Feeding a moderate excess of magnesium is more desirable than too little, because of the ability to eliminate via urine some excess magnesium and less effective homeostatic control with low intakes (Miller, 1975) (87, 88). Therefore, the results of 1750mg/kg, 2350mg/kg given in Tables 3.4 and 3.3 respectively for 0-3 calf and milking cow concentrates respectively are adequate even though the National Research Council (1978) Table gives the minimum requirements as 700mg/kg and 2000mg/kg for the calves and lactating cows respectively. Under conditions conducive to grass tetany for high producing lactating cows, 2500mg/kg or more is recommended. This means that the results obtained take care of such conditions as above.

3.1113 Sodium And Sodium Chloride

As given in Table 3.3, the result of sodium 0.115% for the milking cow concentrate feedstuff is a bit below the sodium requirement for lactating cows 0.18% of the National Research Council (1978). The sodium result 0.175% shown in Table 3.4 for 0-3 calf concentrate feedstuff is a bit above the 0.1% standard of the National Research Council (1978).

The values 0.18 and 0.1% for the milking cow and 0-3 calf rations respectively correspond to 0.46 and 0.25%

sodium chloride. Unfortunately, the results of sodium chloride 0.0585 and 0.039% given in Tables 3.3 and 3.4 respectively for the milking cow concentrate feed and the 0-3 calf concentrate feed are at variance with the National Research Council values.

3.1114 Potassium

From the Tables, 3.3 and 3.4, the results 1.10 and 0.70% obtained for milking cow concentrate and 0-3 calf concentrate are approximately adequate as supported by National Research Council (1978) and some workers (89, 90, 91).

3.1115 Iron

The result of 75.00mg/kg given in Table 3.4 for 0-3 calf feed is below the required National Research Council (1978) stipulations of 100mg/kg for the calf. For the milking cow concentrate ration, the result 125.00mg/kg on Table 3.3 is adequate even though the National Research Council standard is 50.0mg/kg. This is true because under most conditions, cattle can tolerate 1000mg/kg dietary Iron (National Research Council, 1978).

3.1116 Zinc

The results for zinc in tables 3.3 and 3.4 for milking cow concentrate and the 0-3 calf concentrate are respectively consistent with National Research Council 1978 standards. The estimated zinc requirements of dairy cattle is 40mg/kg in the dry matter of the diet. The maximum safe level of zinc for dairy cattle is far higher than its minimum

requirement. With lactating dairy cattle, 1279mg/kg zinc, dry matter basis did not reduce performance (Miller et al, 1965) (92). Also, in growing cattle, 500mg/kg zinc did not adversely affect performance.

3.1117 Cobalt

Results of cobalt given in Tables 3.3 and 3.4 for milking cow concentrate (17.50mg/kg) and 0-3 calf concentrate (20.00mg/kg are fairly above the minimum and the safe standards of National Research Council (1978) of 0.10mg/kg and 10.0mg/kg respectively. The cobalt levels are not commendable, although, Keener et al, (1949) (93) experiment confirmed that 30mg/kg in the diet was not detrimental to dairy calves. Toxic effects of higher concentrations have been outlined by workers (94, 95).

3.1118 Iodine

The results of 0.24mg/kg of iodine shown on Table 3.3 for milking cow concentrate is below the National Research Council (1978) standard of 0.5mg/kg for lactating cows. 0.22mg/kg value obtained for 0-3 calf concentrate feed shown on Table 3.4 is slightly below the recommended National Research Council (1978) nutrient requirement of 0.25mg/kg for growing dairy cattle.

3.1119 Selenium

Selenium results of 0.155mg/kg and 0.145mg/kg given in Tables 3.3 and 3.4 for milking cow concentrate and 0-3 calf concentrate rations respectively are adequate. This is true because the minimum and maximum safe levels

of selenium for dairy cattles are 0.1mg/kg and 5.0mg/kg (National Research Council, 1978). Ammerman and Miller (1975) (96) suggests 3-5.0mg/kg as a maximum safe level under influence of interacting factors such as lipids, protein and amino acids.

3.1120 Manganese

As given in Tables 3.3, and 3.4, the manganese values 13.5mg/kg and 12.5mg/kg for milking cow and 0-3 calf feeds respectively are below the minimum dietary manganese of 40mg/kg for dairy cattle (National Research Council, 1978) and should be stepped up.

3.1121 Copper

The results of copper for milking cow concentrate and 0-3 calf concentrate feeds shown in Tables 3.3 and 3.4 are consistent. The minimum requirement for copper is 10mg/kg but the dairy cattle safely tolerates about 70-100mg/kg copper for long periods and even higher levels for short periods (National Research Council 1978). The process of copper intake by calf is a very complex one and it is recommended that higher values will be more useful than lower values.

Table 3.1

Proximate Composition Including Thioglucoside Content of National Animal Production Research Institute Cattle Feed

	0-3 Calf Concentrate Feed Data[b]	National Research Council (1978) Data For Comparison
Moisture (%)	10.352	a
Dry Matter (%)	89.648	a
Crude Fibre (%)	15.363	17.0
Crude Protein (%)	17.806	16.0
Crude Fat (%)	5.280	2.0
Total Ash (%)	3.233	a
Insoluble Ash (%)	0.555	a
Nitrogen Free Extract (%)	58.319	a
Thioglucoside (%)	2.589	a

a = No comparable data.

b = Average of six determinations.

Table 3.2

Proximate Composition Including Thioglucoside Content Of National Animal Production Research Institute Cattle Feed

	Milking Cow Concentrate Feed Data[a]	National Research Council (1978) Data For Comparison
Moisture (%)	7.390	b
Dry Matter (%)	92.610	b
Crude Fibre (%)	21.425	17.0
Crude Protein (%)	18.068	13-16.0
Crude Fat (%)	5.655	2.0
Total Ash (%)	4.522	b
Insoluble Ash (%)	0.303	b
Nitrogen Free Extract (%)	50.330	b
Thioglucoside (%)	2.50	b

a = Average of Six determinations.

b = No comparable data.

Table 3.3

Mineral Composition of National Animal Production Research Institute Cattle Feed (In Percentage or Amount Per Kg Of Feed)

Mineral	National Research Council (1978) Maximum For All Classes	National Research Council (1978) Standard For Comparison	Milking Cow Concentrate Feedstuff Data[a]
Sodium (%)	b	0.180	0.115
Potassium (%)	b	0.800	1.100
Sodium Chloride (%)	5.00	0.460	0.0585
Manganese (mg/Kg)	1000.00	40.00	13.500
Magnesium (mg/Kg)	b	2000.00	2350.000
Iron (mg/Kg)	1000.00	50.00	125.000
Copper (mg/Kg)	80.00	10.00	6.000
Zinc (mg/Kg)	500.00	40.00	62.500
Cobalt (mg/Kg)	10.00	0.10	17.500
Calcium (%)	b	0.43-0.60	0.900
Phosphorus (%)	b	0.31-0.38	0.220
Iodine (mg/Kg)	50.00	0.50	0.240
Selenium (mg/Kg)	5.00	0.10	0.155

a = Average of Six determinations.

b = No comparable Data.

Table 3.4

Mineral Composition of National Animal Production Research Institute Cattle Feed (In Percentage or Amount Per Kg of Feed)

Mineral	National Research Council (1978) Maximum For All Classes	National Research Council (1978) Standard For Comparison	0-3 Calf Concentrate Feed Data[a]
Sodium (%)	b	0.10	0.175
Potassium (%)	b	0.80	0.700
Sodium Chloride (%)	5.0	0.25	0.039
Manganese (mg/Kg)	1000.0	40.00	12.500
Magnesium (mg/Kg)	b	700.00	1750.000
Iron (mg/Kg)	1000.0	100.00	75.000
Copper (mg/Kg)	80.0	10.00	25.000
Zinc (mg/Kg)	500.0	40.00	60.000
Cobalt (mg/Kg)	10.0	0.10	20.000
Calcium (%)	b	0.60-0.70	0.065
Phosphorus (%)	b	0.42-0.50	0.176
Iodine (mg/Kg)	50.0	0.25	0.220
Selenium (mg/Kg)	5.0	0.10	0.145

a = Average of six determinations.

b = No comparable data.

3.2 RESULTS AND DISCUSSION ON NATIONAL ANIMAL PRODUCTION RESEARCH INSTITUTE BROILER STARTER RATIONS

3.21 PROXIMATE AND TOXIC FACTORS

3.211 Moisture Content

The moisture results 10.155, 11.060, 10.929, 10.994 and 11.562% for rations 1, 3, 7, 9 and 13 respectively shown in Table 3.5 are within tolerance limit reported for all layers rations in standardization of analytical methodology for feed (1979) (97). But the values are within the limit of insect infestation as given in Chapter 1, page 12. The lower limit of moisture is more advisable.

3.212 Crude Fibre

The crude fibre results 3.50, 3.88% for rations 1 and 2 respectively given in Table 3.5 are within the safe level recommended by the Nigerian panel on feed standard 1979 (98). On the other hand the results 6.75, 6.51, and 9.86% for rations 7, 9, and 13 respectively (Table 3.5) are above the standards of the Nigerian Panel on poultry feed standards. We note that the Nigerian Panel on poultry feed standards is in line with the National Research Council (1971) (99) standard requirements for broiler starter chicks. The results for rations 7, 9 and 13 suggested that the composition of such feeds need reformulation to bring the fibre content low.

3.213 Crude Protein

Table 3.5 page 81, gives the crude protein results 23.056, 23.537, 22.325, 25.318 and 24.719% for broiler starter rations 1, 3, 7, 9 and 13 respectively. These results are approximately within the standard range of protein requirement recommended by the Nigerian Panel on poultry feed standard.

3.214 Crude Fat

The results of crude fat (maximum) 9.550, 9.235, 8.775, 9.981 and 12.045% for the broiler rations 1, 3, 7, 9 and 13 taken in order as shown on Table 3.5 page 81, are above the recommended maximum requirements for fats as given by the Nigerian Panel on poultry feed standards (1979). Well, the results are so because of addition of raw palm oil to the feeds to make up for tocopherol for the broilers (100).

3.215 Total Ash

As seen in Table 3.5 the total ash results 7.253, 7.121, 7.146, 8.068 and 8.136% are high and denotes excessive mineral matter content.

3.216 Insoluble Ash

The insoluble ash result 0.330% for ration 1 shown in Table 3.5 is quite minimal. The results 1.455, 1.355, 1.805 and 1.105% for rations 3,17, 9 and 13 respectively are very high and needs reduction. Their values show that more than one part out of hundred of each ration is

made up of dirt.

3.217 : Nitrogen Free Extract

The nitrogen free extract results 56.641, 56.220, 55.004, 50.125 and 46.240% shown in Table 3.5 for rations 1, 3, 7, 9 and 13 respectively indicate the digestible carbohydrate and the trend of decrease in values are affected by the crude fibre values.

3.218 Thioglucoside Content

The thioglucoside values 1.640, 2.072, 3.012, 2.359, 3.105% for rations 1, 3, 7, 9 and 13 taken in order as shown Table 3.5 are high. Even though the maximum or toxic levels are not established, the percentages tell us they may produce adverse effect on the birds.

3.219 Urease Activity

The results of urease activity 0.065, 0.13, 0.065, 0.063 and 0.07% for rations 1, 3, 7, 9 and 13 respectively are adequate. The value indicate that the residual enzymic activity or the quantity of proteins which adversely affect feed conversion efficiency are small compared to the total ration quantity.

3.22 MINERALS COMPOSITION

3.221 Sodium

As shown on Table 3.6 page 82, the sodium results 0.275, 0.275, 0.200, 0.300% for 3, 7, 9 and 13 taken in

order are adequate. This is true because the results are within ± 10% of the Nigerian Panel on poultry feed standards. The result 0.375% for ration 1 is fairly above the standard set by Nigerian Panel and needs ammendment.

3.222 Potassium

The potassium results given in Table 3.6 as 0.70, 0.550, 0.600, 0.650, 0.550% for rations 1, 3, 7, 9 and 13 taken in order are above the 0.45% standard recommended by Nigerian Panel on poultry feed standard (1979). A reduction of the values is necessary to have a standardized formulated feed.

3.223 Sodium Chloride

The results 0.234, 0.234 and 0.307% for rations 9, 13 and 3 respectively are outside acceptable deviation range from the 0.62% recommended by the Nigerian Panel on poultry feed standard as shown on Table 3.6. The results 0.60, and 0.541% for rations 1 and 7 are within the Panel's standard.

3.224 Manganese

A level of 50mg/kg manganese is generally recommended to provide a margine of safety and to cope with variation in calcium and phosphorus intakes. But poultry will tolerate manganese intakes as high as 1000.0mg/kg without observable ill effect (Underwood, 1966) (101). Based on the above the results 142.5, 87.5, 163.5, 120.0 and 142.5mg/kg obtained for rations 1, 3, 7, 9 and 13 shown on

Table 3.6 are adequate even though they fall above the Nigerian Panel on poultry feeds standard of 60.0mg/kg.

3.225 Magnesium

Nugara and Edwards (1963) (102) gives the minimum magnesium requirements for young chicks as 460mg/kg to 560mg/kg in dry matter ration and 590mg/kg when calcium and phosphorus percentages were high. These figures tally with National Research Council (1971) and Nigerian Panel on poultry feeds (1979) recommendations of 500mg/kg and 550mg/kg respectively. But the results shown in Table 3.6 as 1900, 1300, 1700, 1700 and 2300mg/kg obtained for rations 1, 3, 7, 9 and 13 taken in order are very high. Well, National Research Council (1971) writes that immature chicks show toxic effects of magnesium at about 6000mg/kg (103). In any case, it is better to be within ± 10% of the set standards.

3.226 Iron

Davis et al (1962),(104) found that chicks requirements for iron is between 65.0 and 105.0mg/kg of feed. This range of values compares well with that of the National Research Council (1971) and the Nigerian Panel on poultry feed standard (1979) given on Table 3.6. This means that the result of 102.0mg/kg for ration 3 as given in the above Table is adequate. Unfortunately, the results of iron 182.5, 435, 485 and 182.5 for rations 1, 7, 9 and 13 respectively are higher than the above standards - these need reconsideration.

3.227 Copper

The toxic level for copper have been rated as being high by workers (105, 106) - between 806.0mg/kg and 324mg/kg. The results 5.00 and 7.50mg/kg for rations 9 and 13 taken in order are within the range of values recommended by National Research Council, 1971 and Nigerian Panel on poultry feeds as shown on Table 3.6. On the other hand, the results 17.50, 17.50, 17.50mg/kg obtained for rations 1, 3, and 7 taken in order are a bit above both standards mentioned above (see Table 3.6). The finding can only be justified in that they are very much below the toxic level.

3.228 Zinc

The toxicity of zinc for immature chiken when mixed in the forms of zinc sulphate, zinc carbonate and zinc oxide are 15,000, 15000 and 3000mg/kg respectively as given by workers (107, 108). Brink et al (1959) (109) reports a tolerance level of 1,200-1,400mg/kg of feed. As given on Table 3.6 only the result 47.5mg/kg of ration 9 is within the recommended standards of the Nigerian Panel on poultry and National Research Council (1971). The values obtained for rations 1, 3, 7 and 13 are above, the above standards but may be deemed adequate based on the tolerance limit reported above. There is close relationship between weight of growing chick with concentration of zinc intake in a given ration (110b).

3.229 Cobalt

Turk and Kratzer (1960) (111) has placed the toxic level of cobalt as 5-50mg/kg. This indicates that the results 15.00, 12.50, 17.50, 12.50 and 17.50mg/kg of rations 1, 3, 7, 9 and 13 taken in order are within the toxic level and therefore abnormal for the broilers (see Table 3.6).

3.2210 Calcium

As given in Table 3.6 the calcium result of 1.075% for ration 9 is consistent with the National Research Council (1971) and the Nigerian Panel on poultry feed standard. The results of the other rations 3, 7 and 13 are below those recommended while ration 1 calcium result of 1.825% is above the two standards given in Table 3.6.

3.2211 Phosphorus

The phosphorus results shown in Table 3.6 are below the National Research Council (1971) and the Nigerian Panel on poultry feed recommendations.

3.2212 Iodine

National Research Council (1971) and Nigerian Panel on poultry (1979) gives the minimum requirements of iodine as 0.35 and 0.4mg/kg respectively. But the Iodine Education Bureau (1960) makes a generous allowance for poultry requirement as 50-100ug (112). Wilgus et al (1953) (113) place the minimum needs of growing and breeding birds as 1.0mg/kg. In the light of the above, all the iodine readings for rations 1, 3, 7, 9 and 13 respectively, are

within tolerable standard (see Table 3.6). High values of iodine have very toxic and various other effects which also disbalance the other minerals.

3.2213 Selenium

As given in the Table 3.6 selenium results for all broiler starter rations are within the range of standards values provided by National Research Council (1971) and the Nigerian Panel on poultry (1979). This means that their compositions are in order.

Table 3.5

Proximate Composition Including Thioglucoside And Urease Activity of National Animal Production Research Institute Broiler Starter Rations (In Percentage Dry Matter)

	Nigerian Panel on Poultry Feed Standard (1979)	Broiler Rations Data[a]				
		Ration 1	Ration 3	Ration 7	Ration 9	Ration 13
Moisture (%)	b	10.155	11.060	10.929	10.944	11.562
Dry Matter (%)	b	89.845	89.94	89.072	89.006	88.450
Crude Fibre (Maximum %)	5.0	3.500	3.880	6.750	6.510	8.860
Crude Protein (%)	23-24.0	23.056	23.537	22.325	25.318	24.719
Crude Fat (Maximum %)	3-5.0	9.55	9.235	8.775	9.981	12.045
Total Ash (%)	b	7.253	7.121	7.146	8.068	8.136
Insoluble Ash (%)	b	0.33	1.455	1.355	1.805	1.105
Nitrogen Free Extract (%)	b	56.641	56.220	55.004	50.125	46.240
Thioglucoside (%)	b	1.640	2.072	3.012	2.359	3.105
Urease Activity (%)	b	0.065	0.13	0.065	0.063	0.070

a = Average of six determinations.
b = No comparable data.

Table 3.6

Mineral Composition of National Animal Production Research Institute Broiler Starter Rations (In Percentage Or Amount Per Kg Of Feed)

Mineral	National Research Council (1971) Standard For Comparison	Nigerian Panel on Poultry Standard (1979) For Comparison	Broiler Starter Rations Data[a]				
			Ration 1	Ration 3	Ration 7	Ration 9	Ration 13
Sodium (%)	0.15	0.25	0.375	0.275	0.275	0.200	0.300
Potassium (%)	0.20	0.45	0.700	0.550	0.600	0.650	0.550
Sodium Chloride (%)	0.37	0.62	0.600	0.307	0.541	0.234	0.234
Manganese (mg/Kg)	55.00	60.00	142.500	87.500	163.500	120.000	142.500
Magnesium (mg/Kg)	500.00	550.0	1900.000	1300.000	1700.000	1700.000	2300.00
Iron (mg/Kg)	80.00	95.00	182.500	102.000	435.000	485.000	182.500
Copper (mg/Kg)	4.00	10.00	17.500	17.500	17.500	5.000	7.500
Zinc (mg/Kg)	50.00	40.00	157.500	105.000	132.500	47.500	142.500
Cobalt (mg/Kg)	b	b	15.00	12.500	17.500	12.500	17.500
Calcium (%)	1.00	1.2-1.3	1.825	0.775	0.750	1.075	0.775
Phosphorus (%)	0.70	0.85	0.595	0.34	0.310	0.460	0.370
Iodine (mg/Kg)	0.35	0.40	0.90	0.48	0.360	0.480	0.360
Selenium (mg/Kg)	0.10	0.20	0.108	0.12	0.115	0.115	0.135

a = Average of six determinations.
b = No comparable data.

3.3 RESULTS AND DISCUSSION ON PFIZER POULTRY FEEDSTUFFS (BROILER STARTER, CHICK STARTER, BROILER FINISHER AND GROWERS MASH)

3.31 PROXIMATE AND TOXIC FACTORS

3.311 Moisture Content

With reference to Tables 3.7, page 90, and 3.8 page 91, the values of moisture obtained for chick starter mash, broiler starter, broiler finisher and growers mashes are adequate even though they fall within the limit of insect infestation as given on page 12.

3.312 Crude Fibre

Still referring to the Tables above, the maximum crude fibre results of broiler starter and growers mashes are in line with the Nigerian Panel on poultry standard recommendations for such classes of birds. The maximum fibre results for chick starter and broiler finisher mashes are above the standards of the panel. We note that the Nigerian Panel standards are similar to the National Research Council (1971) standard nutrient requirements for poultry.

3.313 Crude Protein

As given in Tables 3.7 and 3.8 the protein values obtain for chick starter, broiler finisher and growers mashes are all in line with the Nigerian Panel's

recommended standards. The broiler starter mash fell below the panel's standard. This ration should have been reconsidered.

3.314 Crude Fat

All the results shown on Tables 3.7 and 3.8 for chick starter, broiler starter, broiler finisher and growers mashes are all within the standard maximum crude fat requirements given by the Nigerian Panel on poultry standard.

3.315 Total Ash

The total ash percentage for chick starter, broiler starter and broiler finisher mashes shown in Table 3.7 are too high. This points at the presence of excess mineral matter or dirt. The total ash percentage for the growers mash is moderate.

3.316 Insoluble Ash

The percentage insoluble ash for the chick starter broiler starter, broiler finisher and growers mashes shown in Tables 3.7 and 3.8 are high. These denote a high quantity of dirt in the feedstuffs.

3.317 Nitrogen Free Extract

The nitrogen free extract or soluble carbohydrate values are high and commendable for broiler starter, and growers mashes due to their low fibre values. The reverse is the case for chick starter and broiler

finisher mashes.

3.318 Thioglucoside Content

The thioglucoside percentages shown in Table 3.7 for chick starter and broiler finisher mashes indicate a low concentration of toxic substance. But the high percentages shown in Tables 3.7 and 3.8 for broiler starter and growers mashes indicate an abnormal concentration of the toxic substance. It is only reformulation of the feed that can reduce this.

3.319 Mineral Composition

Sodium

With the exception of chick starter result, the results of broiler starter, broiler finisher and growers mashes given in Tables 3.9, page 92, and 3.10, page 93, all fell above the estimated requirements given by both National Research Council (1971) and Nigerian Panel on poultry standard.

3.3110 Potassium

As given in Tables 3.9 and 3.10, the potassium results for chick starter, broiler starter, broiler finisher and growers mashes are extremely above the National Research Council 1971 and the Nigerian Panel on pountry feed standards. The values really confirm the high values of their total ash.

3.3111 Sodium Chloride

The sodium chloride result for chick starter mash as given in Table 3.9 is within the standard set by Nigerian Panel on poultry. The results of broiler starter and broiler finisher mashes shown on the same Table are higher than the recommended Nigerian Panel standard. The result obtained for the growers mash as given on Table 3.10 falls above the National Research Council (1971) standard but is in line with the set standard by Nigerian Panel on poultry standard (1979).

3.3112 Manganese

So far, no appreciable manganese standard has been recommended for the growing chicken. But all poultry will tolerate intake of manganese as high as 1,000.0mg/kg. The minimum requirement set for the chick is 60 and 55.0mg/kg by Nigerian Panel (1979) and National Research Council (1971) respectively. Based on the highest tolerable range, the results obtained for manganese as given on Tables 3.9 and 3.10 for chick starter, broiler starter, broiler finisher and growers mashes are in order.

3.3113 Magnesium

As given in Tables 3.9 and 3.10, the results of chick starter, broiler starter and broiler finisher mashes are quite above the recommendations of the Nigerian

Panel on poultry feed standard. The reading for gwowers mash has no comparable standard but looks high too. These results can only be justified in relation to toxic level of magnesium. National Research Council (1971) writes that immature chicks show toxic effect of magnesium at 6,000.0mg/kg (Chicco et al 1967). But it is better to keep the values within ± 10% of the recommended standards.

3.3114 Iron

Chicks requirements for iron has been placed at 65-105.0mg/kg by Davis et al (1962). And this range of values compares well with the National Research Council (1971) and the Nigerian Panel on poultry recommendations as given in Table 3.9. This means that the results 102.0mg/kg, 105.0mg/kg for chick starter and broiler starter mashes are within recommended standard. But the results 149.00 and 178.50mg/kg of the broiler finisher and growers mashes respectively are above the recommended standards (see Tables 3.9 and 3.10).

3.3115 Copper

The recommended copper requirement for chick is 4.0 and 10.0mg/kg as given by the National Research Council (1971) and the Nigerian Panel on poultry standards. The results given in Tables 3.9 and 3.10 for chick starter, broiler starter, broiler finisher and growers mashes are all above the standard. But some workers have put the toxicity level of copper as 324mg/kg or 806mg/kg. Based on this, one may say the results are in order.

3.3116 Zinc

With reference to Tables 3.9 and 3.10 the zinc results for chick starter, broiler starter, broiler finisher and growers mashes are all above the recommended standards of the National Research Council (1971) and that of the Nigerian panel on poultry feeds. But, Brink et al (1959) reports a tolerance level of 1,000.0mg/kg for zinc by poultry chicks. Based on this, one may accept the results as being normal.

3.3117 Cobalt

The toxic level of cobalt for chicks have been placed at 5-50.0mg/kg by Turk and Kratzer (1960). This indicates that the results given in Tables 3.9 and 3.10 for the chick starter, broiler starter, broiler finisher and growers mashes are all within the toxic level. This calls for reformulation of such rations.

3.3118 Calcium

As given in Table 3.9 the calcium result for chick starter mash is alright when compared with the National Research Council (1971) and the Nigerian Panel on poultry feed standards. The calcium results of broiler starter and broiler finisher mashes on the same Table 3.9 are below the above standards. The calcium result of 0.8% for growers mash shown on Table 3.10 is adequate when compared with the National Research Council (1971) recommendations.

3.3119 Phosphorus

The results of chick starter, broiler starter and broiler finisher mashes shown on Table 3.9 are all below the National Research Council (1971) and the Nigerian Panel standards. But the result of the growers mash in Table 3.10 is in accordance with the above standards.

3.3120 Iodine

As alreddy stated, the minimum requirement of iodine by growing and breeding birds is 1.0mg/kg (Wilgus et al (1953)). The National Research Council (1971) and the Nigerian Panel on poultry standards minimum for chick and growing chicks are 0.35 and 0.4mg/kg respectively. Based on the above, the readings obtained for chick starter, broiler starter, broiler finisher and growers mashes shown on Tables 3.9 and 3.10 are within tolerable limits.

3.3121 Selenium

The minimum requirements of selenium as given by National Research Council (1971) and the Nigerian Panel on poultry standards are 0.1 and 0.2mg/kg respectively. This means that the results shown on Tables 3.9 and 3.10 for chick starter, broilor starter, broiler finisher and growers mashes are adequate.

Table 3.7

Proximate Composition Including Thioglucoside Content of Pfizer Poultry Feeds (In Percentate Dry Matter)

	Nigerian Panel On Poultry Standard (1979) For Comparison	Chick Starter Mash Data[c]	Broiler Starter Mash Data[c]	Broiler Finisher Mash Data[c]
Moisture (%)	b	10.905	11.856	8.722
Dry Matter (%)	b	89.095	88.145	91.278
Crude Fibre (Maximum %)	5.0	5.765	4.528	7.105
Crude Protein (%)	a	20.694	14.613	19.556
Crude Fat (Maximum %)	3-5	2.775	4.527	4.795
Total Ash (%)	b	8.107	7.046	7.250
Insoluble Ash (%)	b	0.875	0.960	1.710
Nitrogen Free Extract (%)	b	62.660	69.287	61.290
Thioglucoside (%)	b	1.979	4.021	1.947

a = 20-21% for chick starter mash, 23-24% for broiler finisher mash and 19-21% for broiler finisher mash.
b = No comparable data.
c = Average of six determinations.

Table 3.8

Proximate Composition Including Thioglucoside Content of Pfizer Poultry Feed (In Percentage Dry Matter)

	Growers Mash Data[b]	Nigerian Panel On Poultry Standard (1979) For Comparison
Moisture (%)	8.399	a
Dry Matter (%)	91.602	a
Crude Fibre (Maximum %)	5.755	7.0
Crude Protein (%)	17.806	16-17
Crude Fat (Maximum %)	2.575	3-5
Total Ash (%)	5.445	a
Insoluble Ash (%)	0.700	a
Nitrogen Free Extract (%)	68.419	a
Thioglucoside (%)	3.360	a

a = No comparable data.
b = Average of six determinations.

Table 3.9

Mineral Composition Of Pfizer Poultry Feeds
(In Percentage Or Amount Per Kg Of Feed)

Mineral	National Research Council (1971) Standard For Comparison	Nigerian Panel On Poultry Feed Standard (1979) For Comparison	Chick Starter Mash Data[a]	Broiler Starter Mash Data[a]	Broiler Finisher Mash Data[a]
Sodium (%)	0.15	0.25	0.250	0.500	0.313
Potassium (%)	0.20	0.45	0.800	0.700	0.600
Sodium Chloride (%)	0.37	0.62	0.585	0.834	0.863
Manganese (mg/Kg)	55.00	60.00	77.500	80.00	86.500
Magnesium (mg/Kg)	500.00	550.00	1850.000	2125.000	1700.000
Iron (mg/Kg)	80.00	95.00	102.000	105.000	149.000
Copper (mg/Kg)	4.00	10.00	16.00	17.500	17.500
Zinc (mg/Kg)	50.00	40.00	112.500	125.000	120.000
Cobalt (mg/Kg)	b	b	17.500	17.500	17.500
Calcium (%)	1.00	1.2-1.30	1.300	0.650	0.475
Phosphorus (%)	0.70	0.85	0.400	0.425	0.355
Iodine (mg/Kg)	0.35	0.40	0.480	0.340	0.520
Selenium (mg/Kg)	0.10	0.20	0.115	0.095	0.080

a = Average of six determinations.
b = No comparable data.

Table 3.10

Mineral Composition Of Pfizer Poultry Feed
(In Percentage Or Amount Per Kg Of Feed)

Mineral	Growers Mash Data[a]	National Research Council (1971) Standard For Comparison
Sodium (%)	0.375	0.15
Potassium (%)	0.800	0.16
Sodium Chloride (%)	0.556	0.37
Manganese (mg/kg)	130.000	b
Magnesium (mg/kg)	2700.000	b
Iron (mg/kg)	178.500	b
Copper (mg/kg)	20.000	b
Zinc (mg/kg)	165.000	b
Cobalt (mg/kg)	17.500	b
Calcium (%)	0.850	0.80
Phosphorus (%)	0.470	0.40
Iodine (mg/kg)	0.880	0.35
Selenium (mg/kg)	0.080	b

a = Average of six determinations.
b = No comparable data.

3.4 RESULTS AND DISCUSSION ON THE NATIONAL ANIMAL PRODUCTION RESEARCH INSTITUTE LAMB CONCENTRATE (BREEDERS FEED)

3.41 PROXIMATE AND TOXIC FACTORS

3.411 Moisture Content

The value 10.638% shown on Table 3.11 page 100, for lamb concentrate is adequate when compared to Matsushima's (1979) suggestion that for safety from spoilage, moisture content of feeds should be less than 15% under most conditions. But the result falls below the standard set by Cockerell et al (1975) as outline on page 12.

3.412 Crude Protein

As given in Table 3.11 the protein result 11.222% for the lamb concentrate is in line with lamb nutrient recommendations of the National Research Council (1968) (114). Workers like Keith et al (1957 (115) have concluded that ewe lambs require rations containing approximately 13% protein. On the other hand Bush et al (1965) (116) suggest 11.8% protein as being favourable for fattening lambs. All these go to support the result obtained as being adequate.

3.413 Crude Fibre

As given in Table 3.11, the crude fibre result 11.763% for the lamb concentrate is adequate if we consider that the sheep is a ruminant and since the recommended National Research Council (1978) for the cattle is 17%

crude fibre, the result is normal. Besides, some workers have established that fibre is inversely related to energy of the ration(Chandler & Walker (1972)) (117) and influences animal performance. Also, maximum live weight gains were obtained with rations containing 12% acid detergent fibre (Jahn et al, 1970, Strozinski and Chandler 1971) (118, 119) and gains decreased as fibre was increased above 12%.

3.414 Crude Fat

So far, no stipulation as regards the amount of fat that should be calculated into breeders ration or any other sheep ration. But if we may take example from the dairy cattle ration a maximum of five percent is enough for rumen microbial action (see page 61). This then means that the result 3.565% fat obtained for the lamb concentrate shown in Table 3.11 is adequate.

3.415 Total Ash

The total ash result 2.513% shown on Table 3.11 is quite low and is normal.

3.416 Insoluble Ash

The result of 0.500% obtained is for the lamb concentrate is low and permissible. This is an indication of low quantity of dirt in the feedstuff.

3.417 Nitrogen Free Extract

As given in Table 3.11, the nitrogen free extract result is in order since other factors upon which it

depends are in order.

3.418 Thioglucoside

The Table 3.11 gives 5.466% as the thioglucoside content. This percentage seems high for the safe consumption of the lamb. Cockerell et al (1975) had stated the importance of testing for toxic factors when formulating poultry, pig, calf and lamb feeds. This particular parameter ought to have been checked for future formulations.

3.42 MINERAL COMPOSITION

3.421 Sodium

The result 0.40% obtained for sodium as shown on Table 3.12 page101 is quite above the minimum recommended by National Research Council (120).

3.422 Potassium

The potassium result of 0.750% shown in Table is slightly above the National Research Council recommendations of 0.50%. Since the maximum requirement is not established the result obtained may be taken to be within acceptable range.

3.423 Sodium Chloride

The National Research Council (1968) stipulates the minimum sodium chloride requirement as 0.6-1.0%. The result obtained according to Table 3.12 is 0.205%. This

shows that the right percentage was not mixed in the concentrate ration.

3.424 Manganese

The minimum requirement for manganese by breeding ewe lambs as given by National Research Council is 40mg/kg of feed. There is inadequate data as regards to the maximum requirement. One can only then say that the reading 82.500mg/kg obtained as in Table 3.12 is above the minimum requirement. But we know that the cattle has a high maximum dietary level of 1,000mg/kg of feed. If the lamb as a ruminant is compared to it, then the reading obtained may be said to be within safe range.

3.425 Magnesium

National Research Council, gives that 0.08mg/kg of magnesium is enough for maintenance and growth requirements of breeding lamb. Also National Research Council (1968), states that rations containing 600mg/kg are adequate for lambs. The result 1,250mg/kg given in Table 3.12 is above the standards recommended above, even though the maximum safe level is not known.

3.426 Iron

The minimum requirement for iron given by National Research Council is 50.0mg/kg of feed. But there is no recorded toxicosis of iron in farm animals. The result 105.000mg/kg obtained for the lamb concentrate as given in Table 3.12 is above the minimum given above. But there is no final conclusion on this result since the maximum

safe level for iron is unknown.

3.427 Copper

The copper requirement for cattle is probably higher than that of sheep but the level needed in the diet depends on the dietary intake of the other minerals. In some places 5 to 8mg/kg produced healthy animals while considerable higher levels of dietary copper is needed in other areas (121). The National Research Council, minimum recommendation is 5mg/kg of feed. The maximum safe level is unknown. But based on the foregoing statements, the result of 16.000mg/kg may be assumed adequate.

3.428 Zinc

The minimum requirement for zinc as given by National Research Council is 32.0mg/kg. Ott et al, 1964 (122) places the amount for maintenance of normal serum zinc concentrations at 18-33.0mg/kg. But Smith et al, (1962) (123) gave that 100ppm of zinc when fed to zinc deficient animals improved growth and weight gain and disappearance of clinical symptoms occurred. Maynard et al (1969) gives the toxic level of zinc as 1,000mg/kg of ration. This means that the result 159.00mg/kg obtained for lamb concentrate as shown in Table 3.12 is adequate.

3.429 Cobalt

National Research Council puts the minimum requirement for cobalt at 0.10mg/kg. Maynard et al 1969 put the toxic level of cobalt at 120.0mg/kg of ration. Based on these two extremes, the cobalt result shown on Table 3.12 as

22.50mg/kg is adequate.

3.4210 Phosphorus

The National Research Council (1968) requirements for phosphorus is 0.14 to 0.19%. Beeson et al (1944) (124) gives the phosphorus requirement as 0.17% in dry matter ration. Mitchell's (1947) (125) gives the minimum requirement as 0.15%. From the foregoing, the 0.198 result obtained for the lamb concentrate as given in Table 3.12 is adequate for the feedstuff.

3.4211 Iodine

The National Research Council puts the minimum requirement of iodine at 0.10mg/kg of feed. The same National Research Council notes on nutrient requirements gives 76mg/kg (0.0076%) as the concentration of iodine that can remove deficiency symptoms. Again, Iodine Education Bureau (1960), places the requirement for breeding ewes (lambs) at 1,000 to 2,000ug of iodine. Based on the above, the 0.4mg/kg result obtained for the lamb concentrate shown in Table 3.12 is within safe limit.

3.4212 Selenium

The National Research Council gives the minimum safe margine for selenium in lamb concentrate feeds as 0.10mg/kg. But Maynard et al 1969, puts the toxic level of selenium at 10.0mg/kg of ration. Considering this wide margin for maximum safety the result 0.115mg/kg obtained for the feed is very much adequate (see Table 3.12).

3.4213 Calcium

The calcium minimum requirements for the lambs ranges from 0.15 to 0.21% taking body weight into consideration as given by the National Research Council (1968). Unfortunately, the calcium result for lamb concentrate shown on Table 3.12 as 0.065% is quite below the recommended standard.

Table 3.11

Proximate Composition Including Thioglucoside Content of National Animal Production Research Institute Lamb Feed (In Percentage Dry Matter)

	Lamb Concentrate Feed (Breeders Ration) Data[a]	National Research Council (1968) Standard For Comparison
Moisture (%)	10.638	b
Dry Matter (%)	89.362	b
Crude Fibre (maximum %)	11.763	b
Crude Protein (%)	11.222	6.6-11.0
Crude Fat (maximum %)	3.565	b
Total Ash (%)	2.513	b
Insoluble Ash (%)	0.500	b
Nitrogen Free Extract (%)	70.938	b
Thioglucoside (%)	5.466	b

a = Average of six determinations.
b = No comparable data.

Table 3.12

Mineral Composition of National Animal Production Research Institute Lamb Feed (In Percentage or Amount Per Kg Of Feed)

Mineral	Lamb Concentrate Feed (Breeders Ration) Data[a]	National Research Council (1968) Standard For Comparison
Sodium (%)	0.400	0.10[c]
Potassium (%)	0.750	0.50[c]
Sodium Chloride (%)	0.205	0.6-1.0[b]
Manganese (mg/kg)	82.500	40.00[c]
Magnesium (mg/kg)	1250.000	0.08[c]
Iron (mg/kg)	105.000	50.00[c]
Copper (mg/kg)	16.000	5-8.00[c]
Zinc (mg/kg)	159.000	32.00[c]
Cobalt (mg/kg)	22.500	0.10[c]
Calcium (%)	0.065	0.15-0.21[b]
Phosphorus (%)	0.198	0.14-0.19[b]
Iodine (mg/kg)	0.400	0.10[c]
Selenium (mg/kg)	0.115	0.10[c]

a = Average of six determinations.
b = National Research Council 1968 tabluated standard.
c = A collection of data from National Research Council Nutrient requirement reports.

3.5 CONCLUSION

From the experimentals that led to the results, justice has been done to the method by which quality control is carried out through chemical analysis. On the other hand, the results and discussion have shown why it is important for commercial animal feedstuff manufacturers, government agencies and marketing enterprises to carry out analysis on their raw materials and finished products. From the discussion, one can see that most part of the mineral content in most Nigerian feeds need to be reconsidered. Also, standardization of other animal feedstuffs apart from poultry is recommended. Even, for the poultry feedstuffs there is need for a better legislative law for their sale, judging from the results obtained.

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