DEVELOPMENT OF MOLASSES-UREA MULTINUTRIENT BLOCK AND ITS USE AS SUPPLEMENT TO GROWING YANKASA SHEEP.

BY

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This thesis titled "Development of Molasses - urea multinutrient block and its use as supplement to growing Yankasa sheep" by Clarence Ayodele Mawo Lakpini meets the regulations governing the degree of Doctor of Philosophy (Ph.D) of Ahmadu Bello University and is approved for its literary presentation and contribution to scientific knowledge.

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DEDICATION

This thesis is dedicated first to God who has made it possible and then to:

My Father

Mr. CHRISTOPHER MAWO LAKPINI

My Mother

Mrs. COMFORT A. MAWO LAKPINI

My Wife

Mrs. MARY A. MAWO LAKPINI

My Son

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ABSTRACT

This work comprised four phases which were:

1. Fabrication of the steel mould.
2. Formulation of the mixture and moulding of the mixed components into blocks.
3. Physical testing of the blocks to determine their hardness and shearing properties.
4. Feeding trial using sorghum stover as basal diet and different types of graded level of molasses - urea blocks as supplement in feeding Yankasa yearling rams.

Three types of molasses-urea blocks which contained maize offal, rice bran or guinea corn spent grain as filler at 43% inclusion rate with each type containing graded levels of fertilizer grade urea at inclusion rates of 5%, 10% and 15% were made. The amounts of molasses in the block were 3 6%, 31% and 26% for the 5, 10 and 15% urea blocks respectively. Carbide oxide and cement were the binding agents added together in the block at the rate of 3% and 6% respectively. Potash, common salt, bone meal and vitamins were also added to form a total of 7% of the block mixture.

Forty five yearling Yankasa rams weighing between 13.0kg and 27.0kg were balanced for weight into 9 groups of 5 animals per group. The animals were fed individually at 09 hours every day with 500g of chopped sorghum stover. Each animal was supplemented with the appropriate molasses - urea block that corresponded with the group it belonged to as follows:

Group 1: 5% urea maize offal block
Group 2: 10% urea maize offal block
Group 3: 15% urea maize offal block
Group 4: 5% urea rice bran block

Group 5: 10% urea rice bran block
Group 6: 15% urea rice bran block
Group 7: 5% urea guinea corn spent grain block
Group 8: 10% urea guinea corn spent grain block
Group 9: 15% urea guinea corn spent grain block

The feeding trial was for a total of 84 days, including the first 21 days for adjustment. The left over of the stover and the remaining molasses-urea blocks were weighed daily before the day's feeding so as to determine the previous day's intake. Water was provided *ad-libitum.*

The animals were weighed weekly before the day's feeding in order to determine live weight changes.

The result of the organic matter digestibility shows that for the maize offal block and the guinea corn spent grain block, the lowest digestibility was at 15% and highest at 5% urea levels. The reverse was true of the rice bran blocks. For the 5% and 15% urea levels, the digestibilities of maize offal blocks were highest while those of the rice bran blocks were least. At 10% urea level, the highest digestibility was obtained for guinea corn spent grain block. Generally, the digestibilities of rice bran blocks were lowest (Table 4.1).

Tables 4,2 and 4.3 show that the higher the level of molasses inclusion, the softer the blocks to cut. For any given molasses level, maize offal produced the hardest block while rice bran blocks were softest.

The intake of sorghum stover was significantly ($P<0.05$) influenced by the type of block. At 5% urea level, the intake of stover was higher significantly ($P<0.05$) in the group supplemented with maize offal block than in those supplemented with guinea corn spent grain block.

At 10% and 15% urea levels, the stover intake by the group supplemented with maize offal block was significantly ($P<0.05$) higher than that supplemented with rice bran block.

The daily stover intake by the rams was between 320.0g and 342,2g and this constituted between 76.3% and 38.4% of the total dry matter intake. Increasing the level of urea in the block did not significantly influence stover intake.

The response of the rams to the various types of blocks was good. They reached a maximum intake in the 6^{th} week after the initial adjustment period of 3 weeks.

For each type of block, the higher the urea content, the lower the intake of the supplementing block. The intake of 5% urea maize offal block was 108.4% and 256.3% higher than the intakes of 10% and 15% urea maize offal blocks respectively. The intake of 10% urea rice bran block was significantly ($P<0.05$) less (58.5%) and higher (29.7%) than of 5% and 15% urea rice bran block respectively. The pattern for the guinea corn spent grain block was similar to the other two types.

Within urea levels, the intake of maize offal block was significantly ($P<0.05$) higher than for either rice bran block or guinea corn spent grain block. At 5% urea level, the intake of maize offal block was 55.9% and 88.4% higher than of the rice bran and guinea corn spent grain blocks respectively. The intake of 10% urea maize offal block was 18.6% higher than that of rice bran block while that of guinea corn spent grain block was 33.8% lower than the former at the same urea level. The intake of 15% urea guinea corn spent grain block was less than those of maize offal and rice bran blocks by 48.2% and 64.8% respectively.

The intakes of 5%, 10% and 15% urea maize offal blocks were 2.6%, 1.5% and 0.8% of their liveweights respectively while the corresponding values for rice bran blocks were

1.7%, 1.0% and 0.9% respectively. As for the guinea corn spent grain blocks, at 5% urea level, intake was 1.5% but 1.1% and 0.6% of the liveweight for 10% and 15% urea levels respectively.

The only group of rams which gained weight in the course of the experiment were those supplemented with 5% urea maize offal block and the daily gain was 2.19g. All other groups of animals lost weight within the range of - 118.9 to -392.6g daily.

The feed conversion of 5% urea maize offal block was significantly ($P<0.05$) higher than that of guinea corn spent grain block. Except for the conversion ratio of the 5% urea maize offal block which was positive (0.0438) those for the other blocks were negative (Table 4.5).

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CHAPTER 1

INTRODUCTION

The livestock industry in Nigeria represents an important national food and economic resource. It contributes about 5% to the Gross Domestic Product in addition to supplying animal protein to the populace. With a total livestock population of 11,000,000; 880,000; 7,650,000 and 22,500,000, Nigeria owns 7.1, 11.5, 4.9 and 18.7% of the total cattle, pigs, sheep and goats in Africa respectively (Table 1.1). Available estimates show the annual meat supply from cattle, pig, sheep and goats in Nigeria as 251,000; 42,000; 40,000 and 123,000 metric tonnes respectively (FAO, 1980). FAO (1980) also showed that the proportion of meat supply from small ruminants to total meat supply in Nigeria declined from 26% in 1969 - 1971 to 20% in 1980. One of the constraints to increased production in Nigeria's livestock is inadequate feeding. Forage is the cheapest source of feed for ruminant livestock. Nigeria has a total land area of about 92 million hectares (Table 1.2). Out of these, about 80% is savanna land. At present, about 45 million hectares of the savanna land are available for livestock grazing (Adegbola, 1982).

With increasing population and urbanization in Nigeria, less land will become available for pastoral farming (Table 1.3). To meet effective demand for meat therefore will mean intensifying livestock management systems.

The major feed resources used for feeding sheep and goats in Nigeria are byproducts from oilseed processing and

flour mills, kitchen wastes and crop residues. However, the unavailability and relatively high cost impose constraints on the use of agro-industrial byproducts. Therefore, crop residues have a unique position in the economic and intensive feeding of sheep and goats and indeed ruminants in Nigeria. It is known that of the 3 most important cereal crops grown in Nigeria (maize, millet and sorghum), sorghum is quantitatively the most important in terms of crop residue yield (Alhassan, 1988). It is estimated that 5.9 million tonnes of sorghum grain produced in Nigeria annually result in about 23.6 million tonnes of sorghum stover (Anon, 1981; Alhassan, 1988). Of the total stover produced, it is estimated that about 5.2 million tonnes are leaves which constitute the most nutritious part of the stover (Ward *et._al.*, 1979; Powell, 1984). Stalks of sorghum are of great economic value in Nigeria's rural life. They are used for roofing, fencing, in making beds and doors and in constructing dikes to control flood and dry season watering points (Fricke, 1979; Okaiyeto, 1980).

Nutritionally, crop residues are characterised by high content of cellulosic materials and are low in nitrogen as well as in micro-nutrients. Due to their limitations in fermentable energy and nitrogen, physical and chemical treatments and/or judicious supplementation have been suggested as remedy (Alhassan *et. al.* 1983, Leng and Preston, 1983; Lufadeju, 1988).

The technology of treating straws and stovers to improve intake and digestibility of crop residues has been introduced into Nigeria. Chemical treatment of crop residue is limited by the requirement for large volumes of water, labour in gathering and chopping the residue as well as the unavailability and cost of ammoniating agent (urea). Therefore current research efforts have been intensified on

supplementation.

To maximize the efficiency of crop residue utilization, other nutrients particularly energy and protein must be provided in the rumen and must be balanced to support efficient rumen ecosystem (Preston and Leng, 1984). It is therefore essential for ruminant feeding systems to aim at optimizing rumen microbial protein synthesis and facilitate passage of undegraded dietary protein and other nutrients into the small intestine. Molasses, urea and molasses-urea blocks have been intensively used in the developed and developing countries to achieve this goal with varying degrees of success (Preston and Leng, 1987).

1.1 MOLASSES:-

This is a viscous byproduct from the sugar industry. It contains fermentable soluble carbohydrates, and minerals such as calcium, sulphur and potassium (Preston and Leng, 1987). In many developing countries, molasses often times poses a disposal problem to the sugar industries. In such cases, it has been poured on roads and into rivers. It has however been used as a livestock feed and is currently being used in the distillation of alcohol (Preston and Leng, 1987). It can be offered to livestock in water or as a composite portion of rations at a rate up to 50% where it has the added advantage of being a carrier of other feed ingredients (Preston and Leng, 1987; Lufadeju *et. al.*, 1987; and Olayiwole *et. al.*, 1986). The use of molasses as livestock feed has its limitations. Its viscosity poses a problem to its use by farmers (Neric *et. al.*, 1984; Sansoucy, 1986). For the farmer, special transportation and storage tanks have to be provided to make its distribution and usage practical. The farmer is also faced with the problems associated with mixing molasses with other feed materials in

a balanced ration. If the molasses is also not properly stored, there are the chances of it becoming rancid.

Toxicity has also been associated with excessive consumption of molasses by livestock (Munoz *et. al.*, 1970 cited by Preston and Leng, 1987). The signs associated with its toxicity include - excessive salivation, standing in "dejected" posture with head lowered, and leaning against the fence or trough. The eye sight becomes affected and the animal may become blind. The animal may also have an unsteady and unco-ordinated gait with the brain becoming necrotic (Munoz *et. al.* 1970 cited by Preston and Leng, 1987).

Solutions to the limitations of the use of molasses as livestock feed may be found in its "solidification." Solidifying and packaging molasses will ease its transportation and distribution while at the same time avert its excessive consumption by livestock to the extent of precipitating toxicity because its hardness limits intake.

1.2 UREA:-

Urea is a product of the combination of two molecules of ammonia and carbon dioxide. It is hydrolysed by urease to release ammonia and carbon dioxide. Urea has been used to supply nitrogen to the rumen micro-organisms in livestock. There has been a great deal of research on the use of urea as supplementary feed for livestock (Alhassan *et. al.* 1984; Adu *et. al.* 1986; Olayiwole *et. al.* 1986; Lufadeju, 1987; Lufadeju *et. al.* 1987).

Urea being easily hydrolysed, provides ammonia four times the rate at which it can be utilized by the rumen microbial organisms. The excess ammonia is absorbed into the peripheral blood and taken to the liver where it is reconverted to the non-toxic urea. However, if the

threshold of this detoxification by the liver is exceeded, then ammonia accumulates in the peripheral blood and is transported to various body tissues, where it is toxic (Preston and Leng, 1987).

Most of the livestock farmers in Nigeria are not educated and the transfer of the technology of using urea as supplement will be an economic risk to them. To avert the dilemma of using urea, it could be provided in a ready form to farmers so that its intake by the animal could be controlled.

1.3 MOLASSES-UREA BLOCK:

In harnessing the benefit of feeding molasses and urea without incurring toxicity, molasses-urea multinutrient blocks have been developed and improved upon (Preston and Leng, 1987). Molasses can be combined with urea and other feed ingredients to form molasses-urea multinutrient blocks. The functions of molasses in such a block include - being an excellent carrier for urea, improving the palatability of the block to animal and providing easily fermentable energy and minerals (Sansoucy, 1986). A good molasses-urea block should be solid enough to limit intake and prevent urea toxicity and yet should not be too hard to prevent adequate consumption. It should be durable enough to withstand the rigour of transportation in trucks over long distances particularly on rough roads (Sansoucy, 1986).

In Australia and South Africa, grazing animals on standing forage with low protein content had a continuous supply of urea through the provision of molasses-urea blocks (Leng *et. al.*, 1973). The needed nitrogen for the development of the ruminal flora and better utilization of fibrous feed is provided by the urea in the block. The liveweight response by animals grazing poor quality forage

supplemented with molasses-urea blocks has been variable (Leng *et. al.*, 1973). The variability may have been due to differences in the quality and intake of the molasses-urea blocks by the animals.

The use of molasses-urea blocks in Nigeria is aimed at enabling the small scale farmers supplement, at an acceptable cost, poor quality roughage with a view to improving its utilization (Beames, 1963). The blocks improve the efficient use of fibrous feed which make the bulk of ruminants' diets. The blocks create a rumen ecosystem which is efficient and is favourable for milk production and growth of young animals (Sansoucy and Aarts, 1986).

Molasses-urea blocks have also been proposed as a means of administering anthelmintics and acaricides for the control of endo-and ecto-parasites (Leng, 1984). Molasses-urea blocks have an applicable technology for farmers in Nigeria as it will readily fit into the farmer's routine and reduce labour in feeding their stock (Leng, 1984).

It is therefore the aim of the project to develop a suitable molasses-urea multinutrient block using available local materials and determine the utilization of such block by sheep in Nigeria.

CHAPTER II

LITERATURE REVIEW

2:1 FEED RESOURCES AND THEIR UTILIZATION BY RUMINANTS

The most abundant plant material on earth are ligno-celluloses which comprise 50% of all biomass and with annual production of 50 billion tonnes (Goldstein, 1981 and Wood, 1985). The three primary components of lignocellulose are hemicellulose, lignin and cellulose. Ash, protein, lipid and extractives are also contained in small quantities (Ragg, 1984). Cell contents constitute less than 25% of the total dry matter of plant material while the greater portion is cell wall. Cell contents are highly digestible by animals but cell walls are not (Pearce, 1984). All crop residues have cellulose content of over 35%. They contain high potassium but the phosphorus content is low (Orskov, 1977).

In Asia, Africa and Central America, crop residues and agro-industrial byproducts constitute perhaps the cheapest and most widely available ruminant feed resources. The developing countries produce 2, 61, 54 and 42% of the World's total maize, sorghum, rice and millet straws respectively (O'Donovan, 1983).

Fibrous roughages which are of low digestibility and undergo fermentative digestion, are largely the basal feeds for ruminants. Factors that govern intake by ruminants are the rate of digestion, the rate at which the indigestible feed particles are removed and the potential rumen volume (Orskov, 1982). When the digestibility of basal feed is low, it becomes a major impediment to production as the feed intake is limited by rumen capacity (Leng and Preston, 1983). Although the nutritive value of crop residues cannot be generally linked to their chemical composition and digestibility, there are however, definite

trends in that direction (O'Donovan, 1983). The works of Anderson (1978) and Mathison *et. al.* (1981) show that crude protein and phosphorus are the most deficient nutrients in crop residues while calcium levels are low. It is also known that zinc deficiency may result when animals are fed on straw for a long period (Anderson, 1978; and Mathison *et. al.*, 1981).

For sorghum stover, Alhassan and Bello (1987) reported the average crude protein of stalk to be 4.5% and 6.9% for the leaf. It contained low soluble carbohydrates. The NDF and lignin of stalk were higher than for leaf. The leaf had an average apparent in-vitro organic matter digestibility (IVOMD) of 62.3% which was much higher than for the stalk (28.0%). The leaf total phenolics content averaged 12.2% while the stalk value was 6.3%. The crude protein content of leaves (6.9%) is adequate to meet the maintenance requirement for crude protein in ruminants that consume them (National Research Council, 1970, 1981). The high leaf phenolics content (10.0 - 15.2%) could inhibit voluntary intake and rumen metabolism (McLeod, 1974; Tripathi, 1975; International Livestock centre for Africa, 1984; Kumar and Manohar, 1984).

The cell wall constituents (NDF and lignin) of sorghum stover is probably more important in determining its nutritive value than the total phenolics content (Alhassan and Bello, 1987). Even when lignin is removed, cellulose also contains some crystalline "regions" which slows down its degradation (Bisaria and Ghose, 1981), thus making the cellulose unevenly available for enzymic attack. The amorphous "regions" are more available for degradation than the crystalline regions. A synergistic action of group of enzymes acting together carries out the degradation of cellulose and hemicellulose (Halliwell, 1979; Tsao and

Chiang, 1983).

When used as feed, straw and stover may be fed to animals as untreated (Barber *et. al.*, 1984), chemically treated (Owen, 1984) or as conserved pellated feed (Deschard, 1983; Deschard *et. al.*, 1984). Conserving the whole crop (i.e the grain and stover together) for fattening cattle gave the highest profit margin while the least profitable was feeding untreated stover to beef cattle (Doyle *et. al.*, 1988). Owen *et. al.*, 1987, observed that goats allowed to refuse 50% of the untreated and unprocessed straw offered, had higher dry matter intakes than those allowed 20% refusal rate. This implied that selection of more nutritious straw parts by goats allowed higher refusal rate. In grazing crop residues, small ruminants are very selective compared with cattle or buffalo. Therefore, in practice, stovers can be grazed, the residue collected and chemically upgraded and refed to the less selective animals. Owen *et. al.* (1987) reported that when straw was fed at 50% refusal rate to small ruminants and the residue was treated with ammonia and refed, the intake figures were higher.

2:2 TECHNOLOGIES FOR IMPROVING CROP RESIDUE UTILIZATION

Many techniques - physical, chemical and biological are being tried to improve the efficiency of utilizing crop residues for livestock feeding. These methods aim at increasing available surface area of the material and removing some of the more indigestible fractions such as lignin (Cowling and Kirk, 1976; Wood, 1985).

Physical processing of crop residue is aimed at partially facilitating its inclusion in mixed diets and improving its nutritional value. By rupturing the outer lignin layer, the cellulose fibres become more accessible for breakdown by rumen micro-organisms. Mathison (1976)

found that chopping crop residues only reduces straw wastage and has no effect on weight gain. On the contrary, Adu and Lakpini (1983) reported that chopping groundnut haulms not only increased efficiency of utilization but also the liveweight gains of sheep. The grinding and pelleting of poor quality roughage have the advantage of: increasing the dry matter intake up to 80%; and increasing the utilization of feed energy for both maintenance and production.

To enhance degradation in the rumen and improve nutritional value, crop residues have been treated with fertilizer grade urea with a nitrogen content of about 46%. Urea treatment is reported to increase the energy and protein values of crop residues. Ammoniation of straw improves the digestibility and crude protein content of the fibrous residue (Lufadeju *et. al.*, 1985) and raises the nutrient density of the diet (Perdok, 1983). Feed intake and digestibility have been known to be increased by spraying urea on crop residue (Lufadeju *et. al.*, 1985). Olayiwole and Olorunju (1986) however, found that urea treatment of stover caused slight depression in digestibility in cattle while no significant change in digestibility was observed in sheep. Ammoniation as a technique has very limited application in Nigeria because of: the continuous additional labour needed in spraying crop residue with urea; the apprehension by farmers that they could possibly poison their animals; the need to plan ahead in treating the crop residue; the intricate and arduous labour in stacking, dissolving and spreading of the urea solution on the crop residue and; the prohibitive cost to small scale farmers.

Therefore, it is necessary to direct research at solving these problems if only to take advantage of the

abundance of crop residues in our agricultural system.

2:3 REVIEW OF RESEARCH ON FEEDING CROP RESIDUES TO LIVESTOCK

Preston and Leng (1981) proposed that ruminant nutrition requirements can best be understood when the nutritional needs of an efficient rumen fermentation is first considered before the complementary needs of the host animal.

Crop residue utilization efficiency is improved by providing bypass energy, especially when it gives rise to glucose or its precursor (Preston and Leng, 1987) as well as bypass protein. The principles determining the efficiency of supplementation to ruminants involve aiming at satisfying the rumen micro-organism requirements by yielding sufficient microbial protein and volatile fatty acids, complementing and balancing these nutrients to meet production requirement. Byproducts such as oilseed meals, the brans, molasses and polishings derived from grain processing are the potential supplements and are usually in short supply.

2.3.1. FEEDING UNSUPPLEMENTED CROP RESIDUES

The low voluntary intake of fibrous crop residues is principally due to their slow fermentation rate in the rumen. At low rates of straw inclusion (e.g 10 - 20%) in a mixed roughage diet, there is no apparent depression in the rate of gain. Thirty percent inclusion of coarsely chopped wheat straw caused significant decrease in daily gain of fattening lambs (O'Donovan and Ghadaki, 1973). From the work of Lamming *et. al.* (1966); Forbes *et. al.* (1969 a & b); Raven *et. al.* (1969); and O'Donovan and Ghadaki (1973), as straw increases over 30% inclusion level, feed intake decreases while the energy, dry and organic matter digestibilities are depressed (Swam and Lamming, 1967; Owen

et. al., 1969; Levy et. al., 1972; White *et. al.*, 1971, 1972, 1974 and 1975). Increasing the level of crop residue inclusion rate increases the amount of lignin which depresses the digestibility of the ration.

Based on the rate of gain, pattern of volatile fatty acid production and carcass yields, White and Reynolds (1960) concluded that 20% straw inclusion in mixed roughage diet was the optimum. Devendra (1975a & b); Devendra and Raghaven (1978) opted for 30% as the optimum inclusion rate since there was no significant difference between 20% and 30% inclusion rates. Using optimum levels of crop residues without significant decline in productivity cuts down cost of production.

Generally, more feed is needed per liveweight gain as the dietary straw increases (Lamming *et. al.*, 1966; Swan and Lamming, 1967 and 1970; Forbes *et. al.*, 1969a & b; Raven *et. al.*, 1969; O'Donovan and Ghadaki, 1973; Weisenburger and Mathison, 1976). As the straw levels increase, the dressing percentages decrease thus reducing the carcass yield (Swan and Lamming, 1967 and 1970; Forbes *et. al.*, 1969a; Kay *et. al.*, 1970a and 1970b). There is an increase in carcass waste (i.e gut fill and percentage bone) and reduced deposition of carcass fat as the dietary straw levels increase (Swan and Lamming, 1967 and 1970). When lambs are given straw alone to provide half the energy of maintenance, both fat and protein were lost because the body fat and protein had to be mobilized to meet the energy requirement.

2.3.2. SUPPLEMENTING UNTREATED CROP RESIDUES

The limitations of poor nutrient content and low digestibility of crop residues have warranted the need to meet the nutrient requirements of livestock placed on such poor quality roughage by supplementation. Supplementation

has been in the form of energy and protein sources which are the main nutrients deficient in crop residues.

2.3.3 SUPPLEMENTATION WITH FERMENTABLE ENERGY

Molasses and cereals are ready sources of fermentable energy that are commonly used as supplements to crop residues.

It was found that to get maximum response with straw rations, about 30% dietary starch is required. However, when moderate to large quantities of "soluble" carbohydrates are included in a ration, the digestibility of the "insoluble" carbohydrate fraction of the feed is reduced (Preston, 1972b). The readily available dietary carbohydrate puts the protozoa in the rumen ecosystem to be in a competititve advantage because they can rapidly store carbohydrates for subsequent use. The presence of fermentable substrates in rumen fluid may increase the death rate of other microbes (Leng and Nolan, 1984). Generally, protozoal pool size is inversely related to bacterial pool size probably because protozoa compete for nutrients and can engulf large numbers of bacteria (Kurihara *et. al.*, 1968).

It is apparent that ruminal protozoa most likely lower animal production by decreasing protein supply to the intestine when protein: energy ratio is low and the animal's protein requirement is relatively high. Lindsay and Hogan (1972); and Rowe *et. al.* (1980) reported a 16% increase in microbial outflow from the rumen of sheep defaunated by feeding alfalfa to concentrates and moderate - quality hay respectively. Knight *et. al.* (1978) got a 70% increase in the outflow of microbial nitrogen as a result of defaunation in response to feeding linseed or coconut oils as supplement to a hay basal diet given to sheep. Generally, when sources of energy are readily

available, the uitlization of ammonia - nitrogen is enhanced thus affecting the rate of microbial protein synthesis (Aboa Akkada and El-Shazly, 1976). The feed resources that have been used as energy supplements inlude:-

a. Molasses

Molasses and sugar beet pulp are highly digestible but have low nitrogen content. Molasses being a concentrated plant juice contains many minerals, vitamins, sugars (sucrose, glucose and fructose, usually in the ratio of about 2:1:1) and is particularly rich in potassium and sulphur. There was an increase in feed intake when molasses was given as supplement to good quality forage (Preston, 1972a). Molasses has been observed to improve animal productivity especially milk production (Preston, 1972a; Clark *et. al.*, 1973). This may be due to changes in the balance of digestion end-products. The additional nutrients taken in through molasses increase the efficiency of utilization of the feed (Orskov and Hovell, 1978; Sudana and Leng, 1986). The rate of fermentation in the rumen is rapid, which makes it mandatory that the nitrogen source must be rapidly degraded into ammonia for efficient utilization (Orskov and Hovell, 1978).

The rumen fermentation of highly digestible tropical by-products (except for rejected banana fruit) results in high concentration of butyric acid (30 - 40% molar) (Marty and Preston, 1970) and only 15 - 20% molar concentration of propionic acid. High concentration of rumen butyric acid and low production of propionic acid from molasses feeding could be responsible for the insignificant liveweight gain as reported by Alhassan *et. al.*, 1986. Molasses is also known to encourage an increase in the population of holotrich ciliate protozoa which engulf bacteria and reduce

microbial protein available for post-ruminal digestion (Leng and Nolan, 1984).

Ewes in early pregnancy lost about 100g/day when fed chopped wheat straw supplemented with 200g molasses per ewe/day (Silva *et. al.*, 1988). which was not enough to meet the nutritional requirements. This loss may have been due to the extra nutritional demand by the foetus for growth and development in the pregnant ewe. When unmolassed sugar beet pulp and dried grass were given at a level of 150g kg^{-1} straw dry matter, there was an increase in the rate and extent of degradation of straw dry matter. Sugar beet pulp had to be included at a greater proportion (0.45) in the diet before the rate of digestion was increased as compared with rolled barley (0.35) (Fahmy *et. al.*, 1984). Supplementing a diet with molasses when the feed is of low to moderate digestibility may be counter - productive (Preston, 1972a).

b. Cereals:-

The feedstuffs which are more resistant to rumen microbial fermentation and are susceptible to gastric enzymic action are shifted to the abomasum and intestine for digestion, thus increasing their efficiency of energy utilization. Even when appetite is limited by rumen distension, a supplement which bypasses rumen fermentation may still be ingested (Leng and Preston, 1983). Growth rate in animals has been observed to be limited when they depend solely on the products of ruminal fermentation, i.e they receive no bypass nutrients from the diet (Blackburn, 1968). This is because fermentation is an inefficient process of generating metabolic energy for animal use as compared with hydrolytic digestion.

Cereals generally fall into the category of rumen relatively resistant bypass energy sources. When the same

quantities of crude protein and metabolizable energy were supplied by molasses and barley, Drennan (1980) observed that the form of energy in barley was superior to that in molasses. Mills *et. al.* (1944) and Bell *et. al.* (1951) reported that corn is more effective than molasses in promoting protein synthesis or gains in animals fed forage diets containing urea. Fermentation of cereal grain is more efficient than of molasses and produces more propionate and less butyrate (Leng, 1981).

2.3.4. SUPPLEMENTATION WITH NON-PROTEIN-NITROGEN (NPN)

The efficiency of utilization of straws or stover is enhanced by supplementing with non-protein-nitrogen and this optimizes microbial protein synthesis and fermentation in the rumen (Leng and Preston, 1983; Leng, 1984). When the ration nitrogen level is below 0.96 - 1.28% as is common in the tropics, supplementing with a nitrogen source in the presence of other nutrients such as sulphur, energy and other minerals increases intake. One of the major nutrient deficiencies that must be corrected is the supply of fermentable nitrogen. Urea has proved to be the most useful and cheapest nitrogen compound suitable for this. However, ammonia toxicity could become acute when animals with liver dysfunction or damage as in liverfluke infestation suddenly ingest urea. The loss of an animal as a result of ammonia toxicity can be a colossal loss to farmers.

Feedstuffs with low digestibility and low nitrogen content e.g. cereal stover, cereal husks etc do not give efficient utilization in combination with high concentrate diets or molasses. This is because fermentable nitrogen is required for optimum rumen fermentation and microbial activity. Such combinations will require additional NPN for efficient use (Orskov and Hovell, 1978).

The ammonia - nitrogen in the rumen is lost through incorporation into microbial cells that pass out of the rumen, ammonia absorption through the rumen wall and the fluid which pass out of the rumen. A proportion of ammonia nitrogen lost through the above is recycled into the rumen. When ruminal ammonia nitrogen concentration is low (5mg/100ml) non-protein-nitrogen (NPN) can be utilized as well as plant protein nitrogen in protein synthesis. But when ruminal ammonia concentration exceeds 5mg/100ml, it is no more beneficial to supplement with NPN (Satter and Roffler, 1976).

Houpt (1970) however, obtained maximum rate of microbial synthesis at ammonia concentration of 90mg N/litre while Allison (1970), Orskov (1970) and Pisulewski *et. al.* (1981) obtained maximum synthesis at between 50 and 80mg N/litre. Miller (1973) and Mehrez and Orskov (1977) observed 240 to 290mg N/litre to be optimum concentrations for maximum rate of fermentation.

From the experiment of Satter and Roffler (1976), it appears that once ammonia concentration begins to exceed 5mg NH_3-N/100 ml of rumen fluid, the protein output does not increase by further supplementation with NPN. They further reported that NPN utilization is over 90% when ruminal ammonia nitrogen concentration is 2mg/100ml or less but when above 5mg/100ml, utilization of additional NPN is nil. As NPN replaces part of the ration protein, the amount of true dietary protein escaping ruminal degradation decreases thus resulting in an increase in the fractional quality of dietary nitrogen going through the ruminal ammonia pool. Ruminal ammonia concentration usually reaches a peak about 1 to 2 hours after feeding and then declines. The critical concentration of ammonia nitrogen required for maintaining maximum rumen microbial growth is

about 2mg/100ml.

From experimental observations, growing sheep fed NPN performed only 80% as well as those fed plant protein (Satter and Roffler, 1976). Loosli and McDonald (1968) concluded that the response of sheep to urea supplementation of low quality roughage is not as efficient as in cattle.

Increased level of ammoniation increased significantly ($P<0.01$) the apparent digestion coefficient of organic matter (OM), neutral detergent fibre (NDF), acid detergent fibre (ADF) and hemicellulose fractions of the stover (Brown *et. al.*, 1987). As dietary urea increased, dry matter intake reduced slightly while crude protein digestibility increased significantly ($P<0.01$) when steers were fed 70% bagasse as basal diet and supplemented with concentrate mixture containing urea which gave dietary nitrogen of 0, 28 or 56% levels. Lufadeju (1988) however, observed that the daily dry matter intake of untreated gamba (Andropogon gayanus) hay was increased by 27% when Friesian - Bunaji heifers were supplemented with urea at the rate of 10g/kg of hay at feeding time. The digestibility of the other dietary components was not affected by the urea level.

Rumen degradable nitrogen (RDN) be it of dietary or endogenous origin could be of nutritional value to the host in two principal ways;

- it supports a healthy and active rumen microbial population, especially with respect to digestion and through microbial protein synthesis, it provides amino acids to the host (Smith *et. al.*, 1987). A higher efficiency of microbial protein synthesis was obtained in steers fed urea than those fed natural protein sources.

When supplemented with urea, phosphorus and sulphur,

maize stover was observed to be better utilized than rice straw and barley straw by sheep (Oh *et. al.*, 1971). A daily gain of 0.3 kg was got when calves were fed on rice straw supplemented with urea and molasses as against 0.56 kg per day when given maize silage (Kang *et. al.*, 1970). However Adu *et. al.*, (1986) fed untreated maize stover with supplementation using molasses and urea supplementation but found that this feed regime could not support maintenance in growing Yankasa sheep as they lost condition and died.

2.3.5 SUPPLEMENTATION WITH PLANT PROTEIN

The fraction of dietary true protein which is degraded to ammonia is not efficiently utilized when ruminal ammonia nitrogen exceeds 5mg/100ml of rumen fluid. Using cattle fed on 35 different rations, Satter and Roffler (1976) found that the mean ruminal ammonia concentration reached 5mg N/100 ml at about 13% dietary crude protein (on DM basis). Ruminal ammonia increased rapidly along with the bacterial growth rate as the quantity of ammonia converted to microbial protein is increased by the amount of fermentable energy available to the bacteria.

In sheep, the dietary crude protein level at which ruminal ammonia begins to accumulate (5mg N/100ml) is about two percent units lower than in cattle given similar rations (Satter and Roffler, 1976).

From the works of Ganev *et. al.* (1979) and Siddon and Paradine (1981) rumen in-situ protein degradation was lower with cereal than with forage diets. This suggests that, at least for feedstuffs of plant origin, an important determinant of protein degradation is the rate of fibre digestion. Protein supplements of vegetable origin were usually more gradually degraded in the rumen of animals consuming high concentrate diets compared with high roughage diets (Ganev *et. al.*, 1979). This is probably due

to inhibition of microbial activity by the acidic concentrate the fermentation produces. All the feedstuffs, except fish meal, used by Siddon *et. al.* (1983), showed lower rumen in-situ protein degradation in steers than in sheep and cellulose degradation was lower also.

When the rumen outflow rate is low, the protein supplements normally given are usually degraded to a greater extent resulting in a very constant protein: energy ratio to be absorbed by the animals even when the dietary crude protein produced has a direct relationship with the energy fermented. The microbial protein produced is insufficient to meet the protein demand for tissue maintenance in young ruminants when they are given a maintenance energy diet and this results in loss of protein and liveweight. If less than maintenance energy is given, the animals lose even more protein. The change in the supply of crude protein does not usually affect the effective protein: energy ratio because of the degradation process in the rumen. Relatively undegraded protein supplements in the rumen can make it possible to significantly change the effective protein: energy ratios available to the host animal thus manipulating body fat stores as a source of energy (Orskov and Hovell, 1986). When nitrogen is not limiting, the amount of microbial protein produced is related to the amount of carbohydrate fermented (Orskov and Hovell, 1986). They also reported that the relationship between energy intake and microbial protein supply in normally fed ruminants, results in protein undernutrition which is always associated with energy undernutrition .

Protein is degraded to peptides and amino acids by bacterial (usually surface) proteases and peptidases (Blackburn, 1968). Their time of stay in the rumen, and

other factors like their rates of solubilization and enzymatic degradation, determine the fermentation of particular protein. Lipids or other water-insoluble substances that are associated with or encapsulating proteins, reduce the surface area of protein accessible to microbial proteases in the rumen fluid (Leng and Nolan, 1984). Whole cotton seed contains oil and when fed causes digestibility depressions similar to free fat added at the same level. Low level feeding results in virtually all the protein supply to the animal being of microbial origin which is related to the energy fermented. To increase protein supply by supplementation therefore, a protein source of low degradability such as fish meal or meat and blood meal has to be used. On the other hand, the rumen degradability of a protein can be reduced chemically (i.e protected) thus making it suitable for supplementation.

Bypass protein is the next to bypass energy in the priority list of nutrients needed to raise animal productivity on fibrous crop residues (Kempton *et. al.*, 1977). Such bypass protein supplements include fishmeal and oilseed meals. They are known to increase feed intake and feed utilization efficiency. When extra bypass protein in the concentrate supplements straw diets given to cows, weight gain is promoted (Mathison, 1974a; Weisenburger and Mathison, 1977; Mathison *et. al.*, 1981). Dietary bypass protein supplementation of low protein, high-fibre diets, increases dry matter intake (Leng, 1984) and productivity of cattle on straw based diet (Sa'adullah *et. al.*, 1981). Cottonseed meal alone increases the concentration of ammonia in the rumen and provides peptides and amino acids which are activators of microbial activity (Sudana and Leng, 1986). Feed intake is increased when small supplements of intestinally digestible but

rumen-undegradable protein is given and when the rates of fragmentation of particles in the rumen and of clearance of undigested feed residues from the rumen are increased (Kempton, 1982).

Even though amino acid composition of the undegraded protein nitrogen is important to ruminants, the degree of its usefulness is determined by the extent of its degradation.

Lindsay and Armstrong (1982), and Tamminga (1983) concluded that there is a remarkable constance in the amino acid profile of the protein entering the small intestine. This is an assumption that dietary proteins that escape fermentation within the rumen have the same biological value and apparent digestibility of 0.70 within the intestines as that of microbial protein (Rooke, 1985). The microbial proteins are good quality proteins that contain all the essential amino acids.

O'Donovan and Ghadaki (1973), Lawlor and O'shea (1979) found that straw intake was increased in sheep when about 17.5% crude protein was fed to them. Supplementation with fish meal caused loss of fat but increase in body protein in lambs. When straw was given at a high level and supplemented with protein, each animal gained 4 kg in empty body weight but lost fat tissue. This showed that fat and protein deposition were negatively correlated even though it is conventionally believed that fat is usually positively correlated with protein. It is noted that increased protein supply to the intestine will not necessarily lead to increased animal productivity, especially when the primary limitation is not protein deficiency.

The work done by Pate *et. al.* (1985) shows that cottonseed meal nitrogen seems to be more efficiently

utilized than urea nitrogen. When urea and cottonseed meal are the nitrogen supplements and molasses and corn are the energy supplements to the high-urea diet, dry matter digestibility in the rumen for urea-molasses supplemented diet was significantly ($P<0.01$) higher than for the cottonseed meal diet. It was concluded that urea was inferior to cottonseed meal as crude protein source in sugar cane diets, particularly when molasses was the energy supplement (Pate *et. al.*, 1985). Generally, conventional animal and plant proteins are known to be superior to urea as ruminant feeds.

Pregnant ewes fed chopped wheat straw and supplemented with 200g/head of cottonseed meal reverted loss of 5.4 kg over 49 days to a net gain of 0.9 kg (Ghadaki *et. al.*, 1972) while there was an increase of 310g/ewe/day in straw consumption. Supplementing basal straw diet with 150g of soyabean meal increased the straw intake and changed weight losses to gains of 40g/day in growing and fattening lambs (Hadjipanayiotou *et. al.*, 1975). Supplementing with 200g of cottonseed meal/ewe/day caused an increase in straw intake and maintained liveweight (Ghadaki *et. al.*, 1972). A limit to increase in crop residue intake by supplementing with cottonseed cake was noted by Alhassan *et. al.* (1986). He found that supplementing cereal crop residues (sorghum, millet and maize) with cottonseed cake in excess of 90g/day/sheep and 75g/day/goat depressed crop residue intake.

It can be deduced that the efficiency with which supplementation with protein is utilized depends on whether the protein is rumen degradable or not. Supplementation with rumen degradable protein will not increase liveweight significantly (Fattet *et. al.*, 1984). However, feeding little amount of digestible but rumen undegradable protein

increases crop residue intake and productivity in terms of liveweight gain (Fattet *et. al*, 1984; Orskov and Hovell, 1986; Orskov and Chowdhury, 1990).

2.3.6. SUPPLEMENTING WITH FAT AND OTHER METABOLITES

There are some nutrients and metabolites which affect the intake and utilization of crop residues by ruminants. When fat is added to feed at a level of 2 to 4%, it is expected to stimulate feed intake and increase digestible energy intake by steers (Moore *et. al.*, 1986). But if inclusion rate of fat exceeds 5% in feed, it interferes with digestion in ruminants by reducing the rate of cellulose digestion and consequent depression in voluntary feed intake. It is asserted that this may partly be due to a decline in ammonia concentration (Kowalczyk *et. al.*, 1976 ; and Orskov and Grubb, 1978). Blaxter (1962) observed that the infusion of acetic acid into the rumen depressed the efficiency of utilization of metabolizable energy for tissue synthesis. It was concluded that high acetic acid production in high fibre diets in the rumen leads to inefficient conversion of metabolizable energy for tissue synthesis. Orskov and McDonald, (1979) showed that efficiency of energy utilization for tissue synthesis was positively related to the propionic acid proportion in the rumen and not acetic acid proportion.

2.3.7 REVIEW OF RESEARCH ON TREATED CROP RESIDUES INCLUDING SUPPLEMENTATION STUDIES

Treatment of crop residues is aimed at improving their nutrient content and digestibility. Sodium hydroxide and urea are the most commonly used chemicals for treating crop residues. Because of the non-availability, cost and corrosiveness of sodium hydroxide, urea is more commonly used to treat crop residues. In Nigeria, the results of improvement of crop residues with urea treatment have been very variable and this has necessitated the emphasis on supplementation studies (Olayiwole and Olorunju,1986; Lufadeju *et. al.*, 1985; Adu *et. al.*, 1986).

In determining the effective and appropriate amount of urea and water needed to elicit maximum degradation of poor quality roughages, Lufadeju *et. al.* (1985) found that urea treatment improves utilization by enhancing rumen microbial protein production which increases forage degradation and voluntary intake. The nitrogen content of urea treated gamba hay improved from 0.55 to 1.78% percent over the untreated hay (Lufadeju, 1988). Brown *et. al.* (1987) observed that the apparent digestion coefficients of organic matter, neutral detergent fibre, acid detergent fibre and hemicellulose increased with ammoniation as compared with nontreated forages plus urea or molasses-urea as supplements. Promma *et. al.* (1984) showed that there was slight improvement in digestibility but reduced intake in heifers fed urea-ammonia treated straw while their daily gain was comparable with those fed fresh grass or grass hay. The daily dry matter intake by Friesian x Bunaji heifers was increased by 27% when gamba hay was treated with 40g urea/kg (Lufadeju, 1988).

Animals given ammonia-treated barley straw or hay respectively had significantly ($P<0.01$) higher roughage degradation than those fed untreated barley straw. When

viewed under electron microscopy, it was observed that the bacterial colonization was quantitatively and qualitatively highest in those animals given ammonia-treated barley straw or hay (Silva and Orskov, 1988). A liveweight gain of 400g per day was observed in steers fed ammonia-treated straw over those fed untreated straw (Creek *et. al.*, 1983).

Using maize stover treated with urea and molasses, Adu *et. al.* (1986) improved stover intake by 19.2% when supplemented with wheat offal at 1% of body weight. When Olayiwole *et. al.* (1986) treated sorghum stover with 0.25% acqueous solution of urea and blackstrap molasses at the rate of 0.5% before ensiling, there was an increase in intake of stover in cattle by about 50% over the untreated stover. Treatment of stover caused a slight depression in digestibility in cattle while no significant change in digestibility was observed in sheep. Supplementing urea-treated crop residues with further urea increased roughage degradation in the rumen of cattle (Lufadeju, 1987).

Lufadeju, (1988) observed that treatment of gamba hay with urea improved nitrogen retention by 40% while supplementing with urea improved it by 100%. The supplement action of urea treated hay with molasses reduced the daily rate of weight loss by 20% while supplementation with cottonseed cake improved daily weight changes by 60%. Adu *et. al.* (1986) recorded that there was 28.6g daily weight gain in sheep given urea treated maize stover as basal diet and supplemented with wheat offal. The results of Alhassan *et. al.* (1984); Adu *et. al.* (1986); Olayiwole *et. al.* (1986) and Lufadeju *et. al.* (1987) using urea treated stover, sorghum stover, millet stover and gamba hay supplemented with cottonseed cake, wheat offal plus urea, groundnut haulms and molasses respectively show that sheep, goats and cattle can only be maintained by these rations.

2:4 DEVELOPMENT AND USE OF MOLASSES - UREA BLOCKS

Some attempts have been made in Australia, Egypt, India, Pakistan and the Philippines to improve livestock productivity by supplementing low-quality feed with molasses-urea blocks (Leng, 1984). Several benefits enumerated by Sansoucy (1986) have been advanced for the use of molasses-urea blocks as supplement for ruminants. These include:-

a. increase in the basal diet (straws or other fibrous feed) intake,
b. increased concentrations of ammonia and volatile fatty acids in the rumen fluid,
c. improved digestibility of straws,
d. increased average daily weight gain and
e. increased milk production and fat content of milk.

The smell and taste of molasses make molasses-urea blocks attractive and palatable for ruminants. It is also a way of providing NPN steadily to the animals. Solidified molasses-urea can therefore be used to correct macro - and micro - nutrient deficiencies in ruminants. The "solidification" of molasses provides a way of solving problems encountered in the distribution of molasses while also being a good medium for incorporating many other feed ingredients.

In formulating molasses-urea blocks, the following nutritional principles have to be put in perspective:-

a. maintenance of adequate and uninterrupted release of ammonia in the rumen through the continuous licking of the block by the animal,
b. provision of fermentable energy (molasses and corn) in a limited quantity to minimize the inverse interaction between fermentable carbohydrates and fibre digestion,

c. an optimum nitrogen:sulphur ratio ranging between 6.8 and 13.1 with an overall average of 10:1 to meet the requirement for the biosynthesis of thioamino acids,

d. the addition of potassium (3 to 4% in the block) to facilitate the utilization of ammonia-nitrogen by rumen micro-organisms. It also makes up for the potassium lost as a result of the diuretic action of the absorbed ammonia. There is the need to add vitamins and macro- (e.g sodium chloride) and micro-elements at recommended levels.

Heating and the level or amount of urea and molasses are known to be related factors which determine the degree of solidification of the block. Heating the molasses to between 80 and 100^{0}C prior to the addition and mixing of other ingredients produced excellent blocks (Sudana and Leng, 1986; Sansoucy, 1986). It is recommended that when urea level is as high as 20%, the molasses component should not exceed 40 to 45% of the ingredient (El Fouly and Leng, 1986).

The urea contained in blocks provides fermentable nitrogen. When gradually and continuously supplied, urea increases the intake of straw by about 40% and digestibility by about 20%. Blocks are very effective in controlling the intake of urea so as to avoid urea toxicity (Sansoucy and Aarts, 1986). It is believed that the slow rate of intake of urea from the block and the improved rate of fermentation and use of rumen ammonia prevented toxicity in sheep (Leng and Preston, 1983). Common salt is usually added while the binding agent (calcium oxide or cement) provides most of the calcium needed. Quick lime has been used as the binding agent but cement has also been successfully used as its substitute (Sansoucy and Aarts, 1986). Magnesium oxide, bentonite, calcium hydroxide have also been used as binders or gelling agents (Sansoucy and

Aarts, 1986).

The purpose of incorporating wheat or rice bran into molasses-urea blocks is to provide energy, protein and phosphorus while it also absorbs the moisture in the molasses and gives structure to the block (Sansoucy , 1986).

Many chemicals or drugs used for the control of parasites or for manipulation of rumen fermentation (e.g anti-protozoal agents, ionophores) can be incorporated in the blocks (Leng, 1984). The rate of intake of molasses-urea blocks is determined by the level of urea content, the supplementing minerals contained and the adaptation of the animal to licking behaviour (El Fouly and Leng, 1987).

There are three types of processes in the manufacture of molasses - urea blocks, - the "hot", "warm" and "cold" processes. The "hot" process involves heating the mixed ingredients to 100 - 120^{0}C for 10 minutes, cooled to 70^{0}C and cottonseed meal added (Leng, 1986). For the "warm" process, the mixed ingredients are heated to 40 - 50^{0}C. El Fouly and Leng (1987) found that blocks with same urea and Calcium oxide levels become harder if the molasses was preheated to 80^{0}C from 55^{0}C. The heating process in both the "hot" and "warm" processes makes the manufacture expensive. Under tropical conditions it may not be necessary to heat before getting a good block. However, the "cold" process requires more time for setting and the hygroscopicity of the final product may cause storage problems. Molasses and urea decrease the hardness of the block while the gelling agents and bran increase it (Sansoucy and Aarts, 1986). Sansoucy (1986) recommended that the ingredients for molasses-urea blocks be mixed in the following sequence - molasses, urea, salt, lime and/or

cement and bran. A block of 25 x 20 x 20 cubic cm weighs about 10 kg.

Block hardness is a very important factor in transportation and consumption of blocks by animals. Factors that affect hardness are:-

a. dilution of molasses with water which is not desirable,

b. the "Brix" degree (Dean, 1979) of molasses should be equal to or more than 85^0. This is a measure of the viscosity of molasses.

c. type of binder and proportions of ingredients.

Increase in the quantity of molasses reduces hardness. When the level of molasses is fixed, hardness becomes a function of the binder and bran. Due to the hygroscopic property of urea and salt, their proportion also affects the hardness of the block (Sansoucy, 1986).

Preliminary studies done by Umoh et. *al.*(1985) compared two types of binders. They reported that carbide oxide which is cheap and readily available, is a very effective binder which produces physically good blocks.

2:4.1 MOLASSES-UREA BLOCKS AS SUPPLEMENT TO CROP RESIDUES

Leng (1984) reported that when molasses-urea mixtures were fed without a molasses control treatment, all the response were erroneously credited to the urea without taking cognisance of the contribution made by energy and other nutrients in molasses. Since molasses contains calcium, phosphorus, sodium and some trace elements, molasses-urea blocks can be used to correct their deficiences. Under experimental conditions when animals graze on small land areas and have regular access to molasses blocks, they made positive response to non-protein inputs (Leng, 1984).

In Australia and South Africa molasses-urea blocks have

been used as supplement to cattle grazing dry pastures with crude protein content as low as 3% for sometime now (Leng, 1984). Umoh *et. al.* (1985) in their initial feeding trial with molasses-urea block in Shika showed that a 7 kg dry matter block lasted 6 days per cattle and 40 days per sheep. Sansoucy and Aarts (1986) enumerated the factors influencing the intake of molasses-urea blocks as hardness of the block, the level of urea, starvation and type of animal. El Fouly and Leng (1987) concluded that the rate of block intake by lambs is inversely related to the urea content of the block. Intake of block is increased when it contains some minerals which are deficient in the diet.

Lambs gradually adjust to block licking and attain maximum intake after about 3 weeks (El Fouly and Leng, 1987). The molasses-urea blocks used in India contain up to 20% urea without causing any problems in the animals. It was observed that upon first introduction, about 40% of adult cattle immediately started licking the blocks while the others gradually became receptive to them. Sheep under laboratory conditions were known to have initially ingested enough block that provided over 100g urea per day without any ill-effect. El Fouly and Leng (1987) observed that the rate of intake of block had a positive linear relationship with the quantity of straw consumed by lambs. The slow release of urea-nitrogen from the block provides a continuous supply of other nutrients, increase the rate of digestion of straw and the rate at which rumen emptied. Sudana and Leng (1986) reported that when the basal diet was supplemented with molasses-urea blocks, straw dry matter intake by lambs was significantly ($P<0.01$) increased from 333 to 420g day^{-1}. Molasses-urea blocks alone have been observed to increase the intake of straw by 25 to 30%. Provision of concentrate along with blocks caused an

increase of only 5 to 10% in straw consumption (Sansoucy and Aarts, 1986).

Sudana and Leng (1986) found that the digestibility of straw using the nylon bag technique in the rumen was increased by supplementation using protein meals but this was further increased by additional supplementation using molasses-urea blocks. Digestibility of straw dry matter was increased from 42.7 to 44.2% by molasses-urea blocks while the addition of 150g cottonseed meal further increased it to 48.8%.

There was less fluctuation in the ruminal ammonia - nitrogen concentrations in lambs consuming molasses-urea blocks. The nitrogen concentration was maintained between 107 and 224mg/l during the diurnal cycle. Molasses-urea multinutrient blocks have the advantage of maintaining continuously high levels of ammonia-nitrogen in the rumen during the diurnal cycle. It is therefore a convenient means of providing adequate ammonia (and peptides and amino acids) continuously to optimize fermentation of low protein forage based diets in the rumen (El Fouly and Leng, 1987). Providing the blocks during the late evening synchronizes the availability of nitrogen with fermentation of straw dry matter (Sudana and Leng, 1986).

Using molasses-urea blocks as supplement resulted in higher rumen ammonia concentrations and straw intake than when a concentrate containing 20% crude protein was used. Additional nitrogen required for fermentation of straw was provided by molasses-urea block thus increasing straw intake (Campling *et. al.*, 1962; Leng, 1984). The consumption of molasses-urea block caused a small but significant shift in the VFA productions towards a higher propionate production thus increasing the efficiency of feed utilization for growth (Preston and Leng, 1984). The

long chain fatty acids from the molasses in the block were probably efficiently utilized in fat synthesis in adipose tissue (Sudana and Leng, 1986).

In an experiment where molasses-urea block was made available with straw as basal diet *ad libitum* and 1 kg/day concentrate (containing high good bypass protein), Jersey bulls had a three-fold increase in rate of weight gain. This response was explained by Leng and Preston (1983) to be due to increase in the efficiency of nutrient utilization when molasses-urea block was fed to the animals. El Fouly and Leng (1987) found that their molasses-urea block containing 15% urea when fed to lambs had at least the same nutritional potential as pelleted ration containing 14% crude protein when the basal diet in each treatment was rice straw offered *ad libitum*. A daily weight loss of 53g on the basal diet was reverted to a liveweight gain of 10g daily with supplementation using the block (Sudana and Leng 1986). Neric *et. al.* (1984) reported that liveweight gain was improved in cows fed molasses-urea-mineral block by providing enough quantity of fermentable nitrogen in the rumen.

Molasses-urea blocks as supplements to straw met the maintenance requirements and when some bypass protein was provided (e.g. cottonseed meal, nough cake) the average daily gains of animals was synergistically improved. Preston and Leng (1986) reported that supplementing straw with blocks gave better results than spraying urea on straw. This is due to the supplementary energy provided by the molasses and its stimulatory effect on the rumen ecosystem.

The cost of liveweight gain using molasses-urea block was one third of those without the block (Leng and Preston, 1983; Leng, 1984).

The use of molasses-urea blocks has helped in stabilizing productivity in livestock in some areas of the world with seasonal fluctuating feed resources. Since the raw materials (molasses and urea) are relatively cheap agro-industrial byproducts, supplementation of crop residues with molasses-urea blocks can be a way of enhancing production and deriving an optimum cost/benefit effect in livestock production.

The raw materials for the manufacture of molasses-urea blocks are supposed to be in abundant supply in Nigeria given the sugar industries in Bacita (Kwara State) and Numan (Gongola State) as well as the National Fertilizer Company in Oone, Port-Harcourt (Rivers State).

The prospective alternative binders such as cement dust, slaked lime, quicklime and cement are also produced in cement industries in Ashaka (Gongola State), Ukpilla (Bendel State), Sokoto (Sokoto State) Ewekoro (Ogun State), Makurdi (Benue State) etc of Nigeria. Another binder is carbide oxide which is also easily available as a waste in the acetylene gas welding workshops which commonly abound all over the country. The possible fillers for the manufacture of molasses-urea block such as maize offal, rice bran, guinea corn spent grain and guinea corn offal are commonly found in all parts of the country.

With the abundant resources available for the manufacture of molasses-urea blocks, the use of these blocks by livestock farmers after an indepth study will be of great benefit in expanding the feed base for Nigeria's livestock. It is therefore the aim of this study to explore this option of alternative feed supplements.

CHAPTER III

MATERIALS AND METHOD

The study comprised of different aspects namely:-

1. Fabrication of the steel mould
2. Formulating the mixture and moulding of the mixed components into blocks
3. Physical testing of the blocks for hardness and shearing properties; and
4. Feeding of the blocks to Yankasa sheep as supplement to basal sorghum stover diet.

The fabrication of the steel mould and the physical testing of the blocks were done in the Concrete Laboratory of the Civil Engineering Department, Ahmadu Bello University, Zaria while phases 2 and 4 were carried out at the National Animal Production Research Institute, Ahmadu Bello University, Zaria.

3.1 LOCATION OF EXPERIMENT

The experiment was conducted in the experimental unit of the Small Ruminant Research Programme of National Animal Production Research Institute, Shika, Zaria, Nigeria. Shika falls between latitudes 11 and 12^{o}N and between longitudes 7 and 8^{o}E with an altitude of 640m above sea level. Shika is located within the Northern Guinea Savannah Zone with an average annual rainfall of about 1092mm. The rainfall is mainly between June and October. There are two major seasons - rainy season as mentioned above and dry season which spans from November through May. The experiment was conducted during the dry season. The mean maximum temperature was between 27 and 35^{o}C.

3.2 MATERIALS

The materials used in the experiment include:-

- A steel mould with dimensions 22.5 x 12.5 x 8.9 cubic

cm

- Molasses
- Urea containing 42.4%N
- Carbide oxide
- Cement
- Mineral salt - containing bone meal, common salt, sulphur and potash
- Vitamin premix - containing vitamins A,D,E and K.
- Maize offal
- Rice bran
- Guinea corn spent grain
- Fire wood
- Avery scale
- MFL UT SYSTEM Machine (Plate 2).

3.3 **METHODS**

Two experiments were conducted:-

3.3:1 Experiment 1 - FORMULATION OF MOLASSES-UREA BLOCKS

The first experiment was aimed at formulating and establishing the process of manufacturing molasses-urea multinutrient blocks.

The preliminary investigation involved 15 different formulations and/or processes of compounding and moulding molasses-urea blocks (Table 3.1). The formulations were made by varying the quantities of molasses, maize offal, urea, carbide oxide (binder) and mineral/vitamin premix mixture. The rationale for changing the proportions of the components was to obtain the best formulation and process of manufacturing molasses - urea blocks from locally available raw materials . In the first two formulations as shown in table 3.1, molasses was 38%, maize offal 41%, urea 10%. In formulation 1, the binder was 2% but was doubled to 4% in formulation 2. The mineral/vitamin premix mixture comprised 40% bone meal,

38.6% common salt, 14.3% potash, 4.3% sulphur and 2.8% vitamin premix. Nine percent of the mineral/vitamin premix mixture was added in formulation 1 but reduced to 7% in formulation 2. In formulation 3, the molasses level was raised to 40%, the maize offal reduced to 39% while the urea, binder and mineral/vitamin premix levels were maintained as in formulation 2. There was reduction in the molasses level in formulation 4 to 39% with the maize offal level increasing to 42% while the urea, binder and mineral/vitamin premix mixture levels were 5, 5 and 9% respectively. The molasses in the 5th formulation was 34% while maize offal, urea, binder and mineral/vitamin premix mixture constituted 39, 15, 5 and 7% respectively. The 6th formulation comprised 38% molasses, 43% maize offal, 5% urea, 5% binder and 9% mineral/vitamin premix mixture. Formulations 1 to 6 inclusive were made using the "cold" process.

The remaining formulations which included 7 to 15, except formulation 9, were done using the "hot" process. Formulation 7 had the composition as shown in table 3.1. The mixture of urea, carbide oxide and mineral/vitamin premix was moistened with 500 ml of water before boiling at 105^{0}C for 10 minutes to enable urea dissolve and mix with the other components. Cement was added while the mixture was off fire. In all blocks made, the ratio of cement : carbide oxide was 2 : 1. The molasses was boiled separately to a temperature of 102^{0}C for 10 minutes before adding it to the earlier boiled mixture. The final mixture was added to a measured maize offal already ground to a size of 1.00mm and kneaded to a homogeneous "dough". The kneaded mixture was then used to fill the steel mould (Plate 1) 4 times and each time compounding it 20 times manually with a wooden pestel. The

final compression was made 5 times with the mould lid before extruding the block. All the moulded blocks were left to cure and air dry for 2 weeks while turning them every two days. The composition of formulations 8 to 15 is as shown in table 3.1. and the process of block preparation and moulding was as described above. In formulation 8, the mixture of urea, carbide oxide and mineral/vitamin premix was boiled to a temperature of 105^{o}C for 10 minutes. Molasses was not boiled before adding it to the boiled mixture.

All the components in formulation 9 were prepared and mixed in the "cold" process. The difference between formulations 9 and 10 was that in the latter case, urea, carbide oxide, and mineral/vitamin premix mixture were boiled before adding cement and molasses. The processes for formulations 12 to 15 were similar to that of formulation 7 except that the maize offal was not ground in the former set of formulations.

All the blocks moulded were observed for cracks and compactness using the MFL UT SYSTEM machine in order to determine the most appropriate method of manufacture.

The best block was selected based on physical qualities such as minimum cracks and hardness and its process of production adopted as the standard procedure for manufacturing molasses - urea blocks. These physical properties determine the ease of transportation and storage. From the results of the above preliminary study, the process used for formulation 7 was adopted as the standard procedure.

The adopted process from the above trial was then used to formulate and compound nine different types of blocks based on 3 levels of urea (5%, 10% and 15%) and 3 fillers (maize offal, rice bran and guinea corn spent

grain), As given in table 3.2, the first 3 blocks had 43% as maize offal with 5, 10 and 15% urea and 36, 31 and 26% molasses in blocks 1, 2 and 3 respectively. Blocks 4, 5 and 6 contained 43% rice bran, 5, 10 and 15% urea and 36, 31 and 26% molasses respectively. The last set which were blocks 7, 8 and 9 was made up of 43% guinea corn spent grain, 5, 10 and 15% urea and 36, 31 and 26% molasses respectively. Each of the blocks manufactured contained 3% carbide oxide, 6% cement, 6% mineral/vitamin premix and 1% potash.

The moulded blocks were cured and air dried for 2 weeks while turning them every two days. After drying, 3 samples of each type of blocks were taken to the Civil Engineering Department to determine the hardness and shearing force of the blocks using the MFL UT SYSTEM machine (Plate 2).

To determine the hardness and shearing force, the weight of each block was determined using an Avery Weighing Scale. The block hardness was obtained by determining the block crush failure.

3.3.1.1 **Determination of block crush failure load**

The MFL UT SYSTEM machine was used to determine the block crush failure load. The block under test was placed between 2 forces. A downward force was applied from the top of the block while an upward force was applied from the bottom. The forces compressed the block to determine the force required to crush it. This force was recorded in Kilo Newton (KN) by the machine and the hardness of the block calculated from the formula

$$\text{Strength } (N/M^2) = \frac{\text{Failure load}}{\text{Block top surface area}}$$

Where N = Newton

M^2 = Square meter

The MFL UT SYSTEM Machine was also used to determine the block shear failure load. The molasses-urea block on test was placed on two concrete blocks (B and C) located at the two edges of the molasses-urea block as shown in Figure 3.0 below. A third concrete block (A) was then placed at the middle top of the molasses-urea block. Upward forces (F_2, F_3) were applied through concrete blocks B and C. A third force (F_1) was at the same time applied downward through the middle of concrete block A. The two types of forces were adjusted until they equalized and the reading on the machine recorded in Kilo Newton (KN). The block shearing was calculated from the formula given below:-

$$\text{Block shear } (N/M^2) = \frac{\text{Failure load}}{\text{Block shear surface area}}$$

Where N = Newton

M^2 = Square meter

3:3.1 Experiment II - FEEDING TRIAL

Forty five yearling Yankasa rams ranging between 13.00 kg and 27.00 kg were purchased from the open market. They were put in quarantine for one month and given prophylactic treatment against endo- and ecto-parasites. They were also given 3 doses of long acting tetracycline (20mg/kg body weight every 3 days) systemically against any possible bacterial diseases they could be incubating.

After the quarantine period, the animals were balanced for weight and were blocked into 9 groups of 5 animals per group. Each ram was penned individually and fed 500g of chopped sorghum stover per day supplemented with the appropriate molasses-urea multinutrient block as shown in Table 3:2

TABLE 3.1 BLOCK COMPOSITE FORMULATION

FORMULATION	MOL (%)	MO (%)	UREA (%)	BINDER (%)	MIN/VIT (%)	REMARK
1.	38	41	10	2	9	
2.	38	41	10	4	7	
3.	40	39	10	4	7	
4.	39	42	5	5	9	
5.	34	39	15	5	7	
6.	38	43	5	5	9	
7.	36	43	5	9	7	Boil urea, carbide oxide, min/vit before adding cement.Then boil molasses separate and add ground maize offal.
8.	38	41	5	7	9	Urea, carbide oxide and min/vit were boiled.
9.	36	43	5	7	9	
10.	36	43	5	7	9	Urea, carbide oxide, min/vit were boiled before adding cement.
11.	36	43	5	7	9	Urea, carbide oxide, cement and min/vit boiled.
12.	36	43	5	7	9	Urea, carbide oxide, min/vit boiled before adding cement. Molasses boiled separately.
13.	36	43	5	9	7	Same as in 12 above
14.	31	43	10	9	7	Same as in 12 above
15	26	43	15	9	7	Same as in 12 above

MOL=Molasses
MO =Maize Offal

MIN/VIT=Mineral/Vitamin premix

F1=Downward Force

F2,F3=Upward Forces

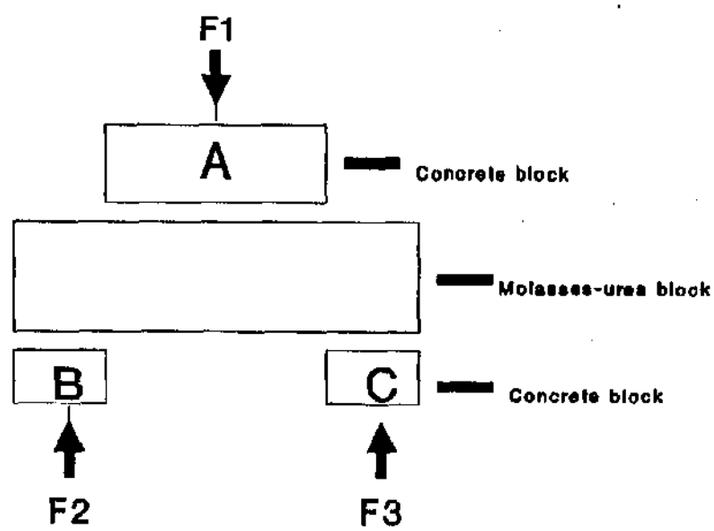


FIG. 3.0 Determination of Block Shear Failure Load

TABLE 3:2 % COMPOSITION OF MOLASSES - UREA BLOCKS

	Maize offal	Rice bran	G/corn spent grain	Urea	Molasses	Carbide oxide	Cement	Min/vit premix
1.	43	-	-	5	36	3	6	6
2.	43	-	-	10	31	3	6	6
3.	43	-	-	15	26	3	6	6
4.	-	43	-	5	36	3	6	6
5.	-	43	-	10	31	3	6	6
6.	-	43	-	15	26	3	6	6
7.	-	-	43	5	36	3	6	6
8.	-	-	43	10	31	3	6	6
9.	-	-	43	15	26	3	6	6

An initial adjustment period of 3 weeks was allowed the animals to stabilize on their respective feeds and pens before measurements commenced.

The animals were weighed weekly using a suspension Avery scale. Each pen was cleaned early in the morning. Each animal was fed 500g of chopped sorghum stover at about 09 hours each day. The left over of the stover fed was weighed the following morning to determine the daily intake by each animal. The molasses-urea block offered to each animal was also weighed every morning and the difference between each day's weight was regarded as the daily intake by the animal. When any animal was about finishing its block, a sample of it was taken for laboratory analysis before the block was replaced with a new one. Samples of the stover fed and its left over were also taken daily and bulked weekly from which samples were taken for laboratory analysis. The in vitro digestibility of the feed samples was determined according to the method of Tilley and Terry, 1963.

Water was made available to the animals *ad libidum*. The feeding trial lasted for a total of 84 days including the first 21 days for adjustment to the new feed.

3:4 Carcass analysis

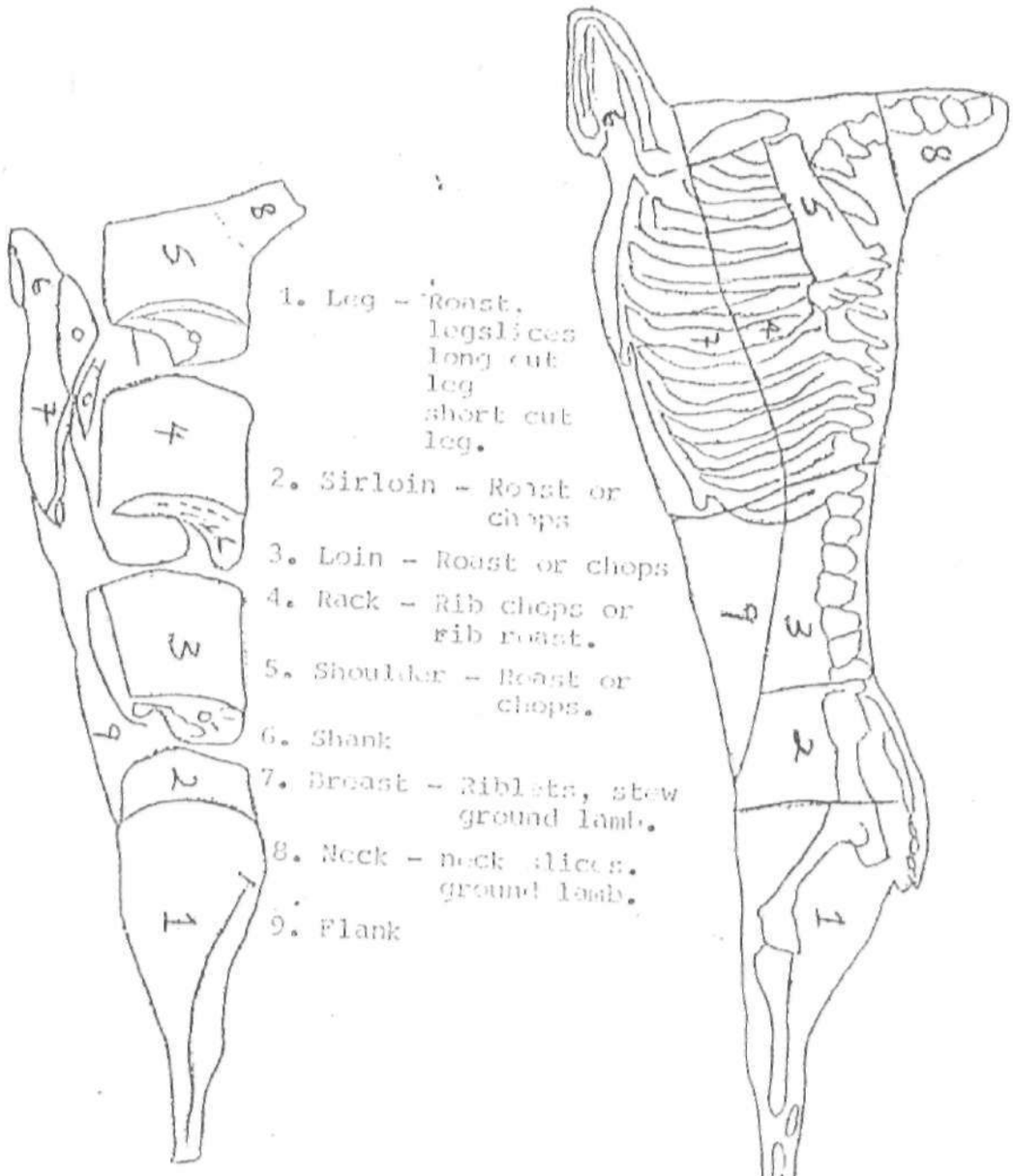
Two rams were randomly selected from each treatment group at the end of the 84 day feeding trial. All the selected animals were slaughtered and a complete carcass analysis performed on each carcass as shown in tables 3.3, 3.4, and 3.5.

All the carcasses were chilled in a deep freezer for 18 hours at $2^{o}C$. After chilling, each cold carcass was weighed and bissected along the spines of the vertebral column into two approximately equal halves. Each left carcass was split into nine cuts comprising: leg, sirloin,

loin, rack, shoulder, shank, breast, neck and flank. The various cuts and their descriptions are shown in figure 3.1

Each cut was weighed and dissected into muscle, bone and fat and the weights of each of these components were recorded. Samples of the heart, lung, spleen and liver were taken from the warm carcass while samples of the kidney, bone, muscle and fat were taken from the cold carcass. The muscle sample was obtained from the 11th and 12th intercostal muscles of the right half carcass.

FIGURE 3.1 LAMB CUTTING CHARTS



3:5 Data Analysis The data collected from the experiment was subjected to statistical analyses using the "SAS Statistical Package" to determine the means, standard error of mean, ranking of means and analysis of variance. The means were tested by Duncan Multiple Range Test at ($P<0.05$) (Steel and Torrie,1960).

CHAPTER IV

RESULTS AND DISCUSSION

4.1 PROXIMATE COMPOSITION OF FEEDS

The results of the proximate analysis of feeds are given in table 4.1. The NDF content at any urea level was least in the maize offal blocks compared with the other two types of blocks followed by guinea corn spent grain blocks. This was because maize offal contained less NDF than guinea corn spent grain while rice bran contained the highest (Table 4.1)

The gross energy of each type of block decreased as the molasses level decreased. For any given urea level, the gross energy in the blocks were comparable (Table 4.1). All filler types of 5% urea blocks contained higher nitrogen than expected because of the complementing nitrogen in the fillers themselves. However, at 10 and 15% urea levels, the nitrogen content in the blocks were less than expected because there was a higher volatilization of the ammonia in the urea during the process of block manufacture as the urea level increased. The in-vitro digestibility of the blocks as shown in Table 4.1 showed that maize blocks and guinea corn spent grain blocks were similar while rice bran blocks were least digestible. The lowest digestibility of maize offal block and guinea corn spent grain block was obtained at 15% while the highest was at 5% urea levels in the blocks. The reverse was true of the rice bran blocks. At 5% and 15% urea levels,the digestibility of maize offal blocks was highest while that of the rice bran blocks was least. At 10% urea level guinea corn spent grain block gave the highest digestibility. (Table 4.1) .

The Crude protein in rice bran was about 14.8% while

that in guinea corn spent grain was 21.5%. The level of crude protein in maize offal (23%) was not significantly different from that in guinea corn spent grain.

4.2 EFFECTS OF PROCESS OF MOLASSES-UREA BLOCK MANUFACTURE.

During the preliminary study, blocks that were manufactured through the "cold" process proved to be of less physical quality compared with those manufactured through the "hot" process. The blocks made from formulations 1 to 6 in table 3.1 were less cohesive, had shallower and smaller cracks and disintegerated more easily than those produced by the "hot" process (Table 4.2). The drying of the blocks manufactured by the "hot" process was better and faster. The block hardness of the preliminary formulation in table 4.2 shows that blocks produced by "cold" process were softer than those preduced by "hot" process (Sansoucy, 1986). This may have been because the the water content in the "hot" process formulations was lower due to the dehydrating effect of the process of heating to boil. Under the "cold" process, the solid particles of the blocks could not dissolve and adhere as much in the liquid mixture medium as in the "hot" process hence the softness. However, because of the higher temperature differential, heat and moisture were lost at a faster rate from blocks produced by the "hot" process than from those produced by the "cold" process resulting in deeper cracks in the blocks from the former process. The non-adhesiveness of the blocks produced through the "cold" process may encourage easy intake by animals but is a disadvantage in transporting them. The deep cracks in the blocks produced by the "hot" process reduced their aesthetic value.

4.3 EFFECTS OF MOLASSES ON BLOCK HARDNESS AND SHEARING

Molasses is one of the components of molasses-urea block which affects block hardness. Sansoucy (1986) asserted that the more the molasses, the less the hardness. At a given rate of molasses content, hardness varies with the proportion of binder and bran. Considering tables 4.2 and 4.3, the higher the molasses level, the softer the block. The urea content was inversely related to the molasses and as the urea level increased, the block became harder. A similar result was obtained by Brishare and Stock (1972) who observed that higher level of molasses in the block made it softer and easier to cut through (shearing) after drying.

At any given molasses level, maize offal blocks were hardest while rice bran blocks were softest. The guinea corn spent grain blocks were intermediate. This is probably because maize offals contain more starch which improved cohesion than the other two fillers while rice bran contains the least amount of starch.

Blocks that required 0 to 1.0 (N) compression were classified as hard blocks while those that required 1.6 to 2.0 (N) were considered to be very hard. The moderately hard blocks required 1.1 to 1.5 (N).

4.4 EFFECTS OF THE FILLERS ON THE PHYSICAL PROPERTIES OF MOLASSES-UREA BLOCK:

The fillers used in molasses-urea block which in this case were maize offal, rice bran and guinea corn spent grain were absorbents of moisture in the molasses and also gave structure to the block (Sansoucy and Aart, 1986). The extent to which these fillers were able to confer these physical properties on blocks vary from one filler to the other. As observed by Sansoucy (1986), rice bran like rice straw produced spongy blocks.

4.5 FEED INTAKE

Table 4.4 shows the daily intake of stover by weeks. In the first two weeks, there was no significant difference in stover-intake due to urea level and filler types of block. During the 3rd week, the maize offal block containing 10% urea influenced stover intake significantly ($P<0.05$) over those containing 5 and 15% urea. The stover intake by animals on rice bran and guinea corn spent grain blocks did not differ significantly irrespective of the urea level. In the 4th, 5th and 6th weeks, stover intake was not affected by urea level in any of the 3 filler types of blocks. There was no significant difference in stover intake due to the influence of urea level or filler type of block during the 7th, 8th and 9th weeks.

In table 4.5, the mean daily stover, supplement and total(stover + supplement) daily intakes, weight changes and feed conversion ratio are presented. There was no significant difference in stover intake due to the level of urea contained in any of the specific filler type of blocks used for supplementation. Between filler types of blocks and within 5% urea level, the stover intake in the group supplemented with maize offal block was significantly ($P<0.05$) higher than that of the group supplemented with guinea corn spent grain block while those supplemented with rice bran block did not have intake that differed significantly from those of the other 2 types of blocks. At 10% urea level, only the difference in stover intake in the group supplemented with rice bran block was significantly ($P<0.05$) lower than that of maize offal block supplemented group but did not differ from those supplemented with guinea corn spent grain blocks. As for 15% urea level, the stover intake in maize offal block

supplemented group was significantly ($P<0.05$) higher than that of rice bran block supplemented group and this difference was only 6.6%. However, the difference between stover intake in the rice bran and guinea corn spent grain block groups was not significant and this difference was only 4.8%.

The daily stover intake in maize offal block supplemented group showed depression in week 3 over all the 3 levels of urea. The highest depression was at 5% urea level while the least was at 10% urea level. There was also a slight depression of stover intake in week 7 at 15% urea level (Fig. 4.7.1).

Fig. 4.7.2 shows the pattern of stover intake by week in the rice bran block supplemented group. Daily stover intake was depressed also in week 3 for all levels of urea. The least depression was at 5% urea level while the highest depression was at 15% urea level. While the intake peaked at week 5 for 5% and 10% urea levels, intake at 15% urea level peaked at week 9. The intake at 15% urea level was slightly depressed in week 6.

In the 3rd week, stover intake was depressed at all urea levels for guinea corn spent grain block supplemented group (Fig. 4.7.3). The depression at 5% and 10% urea levels were to the same extent in the 3rd week. The depression at 15% urea level was slightly less than at the other two levels. The stover intake peaked at the same point in week 5 for 10% and 15% urea levels. The peak of intake for 5% urea level was in the 7th week from where it plateaued till week 9.

The proportion of stover intake to total intake is shown in Figure 4.7.4. For all types of block, the proportion of stover intake increased with increase in urea level. Guinea corn spent grain block group had the highest

proportion of stover at all urea levels. Rice bran block group was higher than maize offal block group at 5 and 10% urea levels but lower at 15%. The rates of increase were 23.3%, 17.2% and 31.1% per unit increase in urea level respectively for guinea corn spent grain, rice bran and maize offal block groups.

The cellulose content (25.15%) in the sorghum stover used is much lower than the over 35% estimated for crop residues generally by Orskov (1977). The marked difference between this result and that of Orskov (1977) may have been due to the fact that the sorghum stover used for the experiment was of poor quality probably resulting from its late collection from the field and loss of leaves before storage. With less leaves in the stover, the amount of cellulose also reduced.

During the period of quarantine, the animals were fed on good quality gamba hay (Andropogon gayanus) and supplemented with 300g/head/day concentrate supplement compounded from maize, cottonseed cake, minerals and vitamins. This placed the animal on good plane of nutrition.

From onset of the experiment, their basal diet was changed to sorghum stover whose dry matter digestibility was determined by in vitro technique to be 34.5% and only 0.75% N as contained in Table 4.1. Even though the digestibility was low, the daily dry matter intake of the stover was between 320.0g and 342.2g. The stover intake of between 1.4 and 2.1% of the liveweight constituted between 76.3 and 38.4% of the total dry matter intake. Although total intakes were high, the animals generally lost weight due to inadequate nitrogen content in the feed. Total dry matter intake decreased as the stover intake increased. This is in agreement with the findings of Raven *et. al*

(1969) and O'Donovan and Ghadaki (1973) which showed that as straw increased over 30% inclusion level, total feed intake is reduced while energy, dry and organic matter digestibilities are also suppressed (Swan and Lamming, 1967; Forbes *et. al.*, 1969a; Owen *et. al.*, 1969; Levy *et. al.*, 1972; White *et. al.*, 1971, 1972, 1974 and 1975; O'Donovan and Ghadaki, 1973; Olayiwole *et. al.* 1986). This is because sorghum stover being the basal diet caused the intake of a large amount of lignin which depressed digestibility hence total intake.

From stover intake at 5% urea block supplementation, maize offal blocks were better than guinea corn spent grain blocks. This is probably due to the fact that the CP of the maize offal used was higher than that of guinea corn spent grain thus making available to the animals more bypass energy and proteins which stimulated intake. This observation confirms the finding of Leng and Preston (1983) who asserted that even though appetite is limited by rumen distension, a supplement which bypasses rumen fermentation may still be ingested.

In this experiment, increasing the urea level in any of the blocks did not influence stover intake (Table 4.5). This did not support the results of Brown *et. al.* (1987) who found a significant increase in apparent digestion coefficient of organic matter, neutral detergent fibre, acid detergent fibre and hemicellulose fractions of stover thus increasing its intake . Lufadeju (1986) got a similar response with cattle fed gamba hay. This discrepancy may be due to the fact that the response of sheep to urea supplementation of low quality roughage is not as efficient as in cattle (Loosli and McDonald, 1968).

However, increase in the urea level was directly related to proportion of stover intake (Fig. 4.7.4)

probably due to the fact that increase in urea correspondingly increased the fermentation of stover as observed by Leng and Preston (1983), and Leng,(1984).

As shown in Table 4.5, there was no relationship between the intakes of block and stover while El Fouly and Leng (1987) observed a positive linear relationship between the intake of block and stover in lambs where the intake of blocks increased straw intake by 25% to 30%. The difference between the two observations may be that while El Fouly and Leng (1987) compared intakes of straw in groups supplemented or unsupplemented with molasses urea blocks, this experiment compared intake of stover by groups supplemented with blocks of 3 different filler types and 3 urea levels. Thus in this experiment, each of the groups consumed at least $0.82gN/kgW^{0.75}$ from the block which was adequate in providing optimum rumen ammonia nitrogen concentration of 5mg/100ml needed to facilitate efficient rumen function in the degradation of stover.

The daily supplement intake by week is shown in table 4.6. The intakes of blocks in weeks 1 and 2 were significantly ($P<0.05$) affected by the level of urea. The higher the urea level contained, the less the intake. For maize offal block, the intake of the block with 5% urea during the first 2 weeks was 108% higher than for the block containing 10% urea while the latter block was 71% better consumed than that containing 15% urea. These differences were significant ($P<0.05$).

In the 3rd, 4th, 6th and 7th weeks, the intake of 5% urea maize offal block was significantly ($P<0.05$) higher than those of 10 and 15% urea maize offal blocks while the difference between the last two was not significant. The intake in the 8th and 9th weeks differed significantly ($P<0.05$) between urea levels for maize offal blocks.

The pattern of maize offal block intake through the weeks as affected by urea level is given in Fig. 4.7.5. The intake of the 5% urea level block peaked in week 9. The depressions were in weeks 3 and 7 while the rate of increase in intake from weeks 7 to 9 was about 14% per day. The 10% urea block intake also peaked in week 9 but depressed in weeks 3 and 7. The rate of increase in its intake from weeks 7 to 9 was about 17% per day. The intake of 15% urea block was fairly more constant than the other 2 levels with peak attained in the 4th and 5th weeks and depression by the 9th week.

Consumption of the 5% urea rice bran block was significantly ($P<0.05$) more (58.5%) than the 10% urea rice bran blocks in the 1st and 2nd weeks. As for the rice bran block, there was no significant difference between 5 and 10% urea levels from the 3rd week except for weeks 8 and 9. In weeks 8 and 9, the intake of 5% urea blocks was significantly ($P<0.05$) higher than for 10% urea blocks, the difference being as high as 149%. Except for the 5th week, the intakes of the 10% and 15% blocks were similar (Table 4.6). Even though more of the 10% urea blocks were eaten, this difference was not significant compared to those containing 15% urea.

From Fig. 4.7.6, the 5% urea rice bran block intake attained peak in week 9 but was depressed in weeks 4 and 6. The rise in intake from the 8th week was very sharp and was at the rate of 25% per day. The peak of intake of the 10% urea block was in week 5 with depressions in weeks 6, 8 and 9. The decline in intake of the 10% urea block from weeks 7 to 8, before plateauing to the 9th week was at the rate of 7.1% per day. The least intake from weeks 1 to 9 was of the 15% urea blocks with peaks in the 5th and 7th weeks and depression in week 6. From week 7, the rate of

reduction in intake of the 15% urea block was 2.1% per day.

In table 4.6 during the first 2 weeks, the intakes of 10% and 15% urea containing guinea corn spent grain blocks did not differ significantly but differed significantly ($P<0.05$) from that of the 5% urea block which was 48.0% higher than the next best (10% urea).

Sheep on the guinea corn spent grain block had a significantly ($P<0.05$) higher intake at 5% urea level than 10% only in the 5th and 9th weeks or else intakes were similar from the 3rd week to the 8th. The difference between 10% and 15% urea level intakes was significant ($P<0.05$) in weeks 5, 7 and 9.

In Fig. 4.7.7, the intake of 5% urea guinea corn spent grain block was higher than the other two levels of urea. It peaked at week 5 with piths at weeks 3, 4, 6 and 8. The intake increased from weeks 8 to 9 at a rate of 21% per day. The intake of 10% urea block reached the peak also at week 5 . The lowest intake was at weeks 3, 6 and 8 from where it maintained a plateau till the 9th week. In the 4th week, the 15% urea block reached the peak and gradually tappered down to the 9th week at a rate of 0.7%.

The total intake of the 5% urea maize offal block supplemented group was significantly ($P<0.05$) higher than that of the 10% urea maize offal block in all weeks. The difference between the total intake of 10% and 15% urea maize offal block supplement was not significant except in the 8th and 9th weeks (Table 4.7).

The total dry matter intake (Fig. 4.7.8) for 5% urea maize offal block was highest in weeks 2, 5 and 9. The lowest intake was in the 3rd and 7th weeks and the rate of increase from the 7th to the 9th week was 1.4% per day. The intake of the 10% urea block was next to 5% urea intake but intercepted with the intake of 15% urea block after the

3rd week to become lower than the intake of 15% urea block while increasing as from the 4th week to intercept the 15% urea block intake. The 10% urea block intake peaked in week 9 and pithed in week 3 with the rate of increase in intake from the 7th to the 9th week being 10% per day. The intake of the 15% urea block reached its lowest ebb in the 3rd week and peaked in week 4.

The total daily intake for the rice bran block is given in Fig. 4.7.9 with peak intake in the 9th week for the 5% urea level. There were depressions in weeks 3, 4, 6 and 8 and about 21% per day rise in intake from weeks 8 to 9. There was a peak in the 5th week for the intake of 10% urea block and a gradual decline from weeks 7 to 9 at the rate of 11% per day. A peak in intake of 15% urea block was attained in the 4th week followed by a decline in week 7 at a gradient of about 35% per day.

The guinea corn spent grain block group total dry matter intake was highest at 5% urea level than at 10% and 15% (Fig. 4.7.10). The intake reached its lowest in the 3rd, 6th and 8th week. The intake of the 10% urea block intercepted that of the 5% urea block in weeks 4 and 6 and peaked in the 5th week but depressed in weeks 3, 6 and 8. The 15% urea block had the lowest intake with peak also in the 5th week and depression in the 3rd, 7th and 9th weeks.

Supplementing with molasses-urea block provided intakes as high as 2.99g urea/kg$W^{0.75}$/day for the 10% urea maize offal block and as low as 1.53g urea/kg$W^{0.75}$/day for the 5% urea guinea corn spent grain block. The maximum obtained is lower than the 7.46g urea/kg$W^{0.75}$/day obtained by Leng and Preston (1983) which did not cause any problems of toxicity in the animals. El Fouly and Leng (1987) noted that blocks containing up to 20% urea have been used in

India without any adverse effects.

Fig. 4.7.11 is the inverted form of Fig. 4.7.4 and shows the percentage supplement intake as a proportion to total dry matter intake. The proportion of supplement to total intake declined for all types of block as urea level increased.

The immediate response in intake by the animals to the various types of block was good compared to the experience of El Fouly and Leng (1987) who observed that only about 40% of the cattle introduced to molasses-urea blocks immediately started licking them.

Using lambs, the maximum intake of the blocks was obtained after about 3 weeks (Sudana and Leng (1986). In this experiment, peak of intake of all the blocks was first reached in the 5th week after the initial adjustment period of 3 weeks. This showed that it took a longer time for the rams in this experiment to adjust to the blocks. Even though the early acceptability of the block may have been due to the inquisitiveness of the rams, their longer period of adjustment could have been due to their unfamiliarity with and probable unpalatability of the blocks and the constitutents of the molasses-urea blocks.

The daily block intake as shown in Table 4.5 was determined by urea level with intake from 5% blocks being highest and 15% blocks the least. The block that contained 5% urea also contained 36% molasses while that with 15% urea contained 26% molasses. Urea is known to be unpalatable and the higher its level in the block, the more unpalatable it is. On the other hand, molasses improves the smell, palatability and softness of blocks. Therefore the higher the level of molasses, the softer and more palatable the block is for the animal to eat (Sansoucy and Aarts, 1986). The fact that the 5% urea blocks also

contained more molasses made the animals eat them more than the other two and the same principle governed the intake relationship between the 10% and 15% blocks.

Generally, within urea levels, intake was significantly ($P<0.05$) higher for maize offal blocks than for the other two. Although intake was least for the guinea corn spent grain blocks, the difference with that of rice bran blocks was not significant.

The intake of supplement as shown in table 4.5 shows that for each type of block, there was a significant ($P<0.05$) difference between the urea levels. Taking maize offal block, the intake of 5% urea block was significantly ($P<0.05$) highest and these differences were 108.4% and 256.3% compared to the intakes of 10% and 15% urea blocks respectively. As for rice bran blocks, there was a significant ($P<0.05$) difference in intake of 10% urea block and this was 58.5% less and 29.7% more than those of 5% and 15% urea blocks respectively. The intake of guinea corn spent grain block followed the same pattern as in the other two types of blocks with the 5% urea block intake being 48% and 180.4% higher than 10% and 15% urea block intakes respectively.

Considering the 5% urea level, the maize offal block intake was 55.9% and 88.4% significantly ($P<0.05$) higher than the rice bran and guinea corn spent grain block intakes respectively. The difference between the intakes of maize offal and rice bran blocks at 10% urea level was significant ($P<0.05$) with the former being 18.6% higher. The intake of guinea corn spent grain block at 10% urea level was 33.8% lower than that of maize offal block intake while the difference between the rice bran and guinea corn spent grain block intake was not significant ($P>0.05$). At 15% urea level, even though maize offal block intake was

lower than rice bran block intake, the difference was not significant ($P>0.05$). The intake of guinea corn spent grain block at 15% urea level was significantly ($P<0.05$) lower than those of maize offal and rice bran block intakes by 48.2% and 64.8% respectively.

Fig. 4.7.12 shows the daily supplement intake response to level of urea in the block. For all urea levels, daily intake was lowest for guinea corn spent grain block and there was a steady decline in intake as the urea level increased. As for rice bran blocks, intake declined at a more rapid rate up to 10% urea content but the rate of decline decreased between 10% and 15% urea levels. The intake of maize offal block was generally the highest until it intercepted with the rice bran block. At 15% urea level, intake of rice bran block was higher than the other two types of blocks.

In Table 4.5, the 5%, 10%, and 15% urea maize offal block intakes were 2.6%, 1.5% and 0.8% of their live weights respectively. The corresponding values for rice bran blocks were 1.7%, 1.0% and 0.9% respectively. In the case of guinea corn spent grain blocks, at 5% urea level, intake was 1.5% of the liveweight but 1.1% and 0.6% for 10% and 15% respectively. This shows that on live weight basis, at 5% urea level, intake was still highest for maize offal, followed by rice bran and guinea corn spent grain blocks in that order. At 10%, this pattern was slightly modified with guinea corn spent grain block intake being higher than rice bran block while at 15% level rice bran block intake was highest.

The group supplemented with 5% urea maize offal block ate 47.1% and 76.8% more than those supplemented with 10% and 15% urea maize offal blocks during the first 2 weeks respectively and these differences were signficant

(P<0.05).

The total daily intake in table 4.5 shows a significant (P<0.05) difference between urea levels 5% and 10% in all the 3 filler types of blocks. However, there was no significant difference between 10% and 15% urea levels. The difference in total daily intakes between urea levels 5% and 10% were 32.5%, 15.6% and 10.1% for maize offal, rice bran and guinea corn spent grain blocks respectively. Between 5% and 15% urea levels, total daily intakes were significantly (P<0.05) different and the intake of the former level was higher by 42.3%, 24.7% and 23.8% for maize offal, rice bran and guinea corn spent grain blocks respectively. Comparing the total daily intakes of maize offal and rice bran block supplemented groups at 5% urea level showed a significant (P<0.05) difference which accounted for 23.4% difference in favour of the maize offal block. There was no significant difference in the total intakes between those supplemented with 5% urea containing rice bran and guinea corn spent grain blocks. The total daily intakes from the 3 filler types of blocks at 10% or 15% urea levels did not differ significantly.

The total intake response to urea level showed similar pattern (Fig. 4.7.13) to that of supplement intake. There was a steady decline in total intake for guinea corn spent grain block as urea level increased from 5% to 15%. The rate of decrease in total intake of rice bran blocks containing 5% and 10% urea was slightly higher than for 10% and 15% urea containing blocks. The total intake for maize offal block decreased drastically between 5% and 10% urea levels while the rate of decline slowed down between 10% and 15% urea levels. Total intake of maize offal and rice bran intercepted at 15% urea level.

The total dry matter intakes for the 5%, 10% and 15% urea maize offal block were 8.8%, 7.2% and 5.3% of the $kgW^{0.75}$ respectively. For rice bran blocks, the total dry matter intakes were 7.1%, 5.2% and 5.3% of the $kgW^{0.75}$ in 5%, 10% and 15% urea block groups respectively . The guinea corn spent grain blocks showed that total dry matter intakes were 6.9%, 5.1% and 5.0% of the $kgW^{0.75}$ for 5%, 10% and 15% urea levels respectively.

In terms of expected nitrogen intake which was derived from the amount of urea contained in the supplement consumed (Figure 4.7.14), more nitrogen was taken in maize offal block than in guinea corn spent grain block at all levels and in rice bran block at 5% and 10% urea levels. The peak of nitrogen intake was obtained at 10% urea level for both maize offal and guinea corn spent grain blocks while the peak was attained at 15% urea level in rice bran blocks. There was an interception in expected nitrogen intake for maize offal and rice bran blocks with the latter being higher at 15% urea level. While the overall trend for maize offal block was a decline, that of guinea corn spent grain block stabilized and for rice bran block the trend was increased as the level of urea increased.

The actual nitrogen intake was based on the nitrogen contained in the supplement eaten (Figure 4.7.15). The highest intake at 5% and 10% urea levels was obtained for maize offal block. The trend for maize offal block was gradual decline as the urea level increased. Intake of rice bran block was higher than of guinea corn spent grain block at 5% and 15% but only at 15% urea level for maize blocks while it was lower than for both types of blocks at 10% urea level. The trend for rice bran block was that of slight decline. The trend for guinea corn spent grain block was also that of decline as the urea

level increased.

For all the filler types of block, the higher the urea content, the lower the intake because of the decrease in palatability of the block resulting from the decrease in the molasses content and the bitterness of the urea (Tables 3.2; 4.5 and Fig. 4.7.16). This observation was similar to what Sansoucy and Aarts (1986) reported, and accounted for the intake of the 5% urea blocks being higher than those of 10 and 15% urea blocks. The crude protein content of about 21% in maize offal and guinea corn spent grain provided adequate nitrogen to the rumen microbial organisms to such extent that increase in urea content in the blocks had a depressing effect on the digestibility of the blocks. This resulted in reduced rumen out flow rate and reduced block intake. The much lower crude protein content of about 15% in rice bran caused the increase in urea content to increase the digestibility of rice bran blocks. Nonetheless, the high crude fibre content of rice bran made the digestibility for rice brain block lowest compared to the other types of block. Even though Leng and Preston(1983) and Leng (1984) observed that supplementation with a nitrogen source increased intake when ration nitrogen level was below 0.96 - 1.28%, this result showed that ration nitrogen level had a negative correlation with intake when ration nitrogen was as high as 3.1% and above.

The decrease in the ratio of supplement: stover intake with increase in urea level must have been due to the unpalatability of the block coupled with stimulation of rumen fermentation of the stover resulting in increased stover intake. The actual nitrogen intake in supplement was generally higher than what was expected at all urea levels in all the filler types of block. This was because the nitrogen in the fillers complemented that provided by

urea. The actual nitrogen intake for maize offal and rice bran blocks decreased as the urea level increased because there was significant decrease in the supplement intake as the urea level increased. However, the highest actual nitrogen intake for the guinea corn spent grain block was at 10% urea level because the over 100% increase in the nitrogen content of the 10% urea guinea corn spent grain block compared to the 5% urea block, magnified the quantity of the nitrogen in the supplement consumed.

Figure 4.7.17 portrays the percent total intake per metabolic weight ($kgW^{0.75}$). As for the maize offal block supplemented group, total dry matter intake decreased with increase in urea level at the rate of 37% per unit urea level. A similar trend was obtained for guinea corn spent grain block but the rate of decline was 23% per unit rise urea level. In rice bran blocks, there was initial decline in total dry matter intake between 5 and 10% urea levels at the rate of 44% but increased between 10 and 15% urea levels at the rate of 4% per unit of urea level.

The response curves of daily supplement and total intakes as shown in Figures 4.7.12 and 4.7.13 are similar. This is because intake of supplement mainly determined the total intake. In the case of 5% urea maize block, its intake turned out to be a substitute rather than to be a supplement to the stover basal diet. This is probably due to the higher digestibility of 5% urea maize block.

4.6 DAILY LIVEWEIGHT CHANGE

The average daily liveweight change (ADWC) was derived from the liveweight change as in Table 4.5 and so they show the same pattern. Of all the treatments, only the group supplemented with 5% urea maize offal block had a positive daily weight change of 2.19g. All the other groups lost weight. With maize offal block

supplementation, the liveweight change at 5% urea level was significantly ($P<0.05$) higher than at 15% urea level and this difference was by 149%. The difference in weight change between 10% and 15% urea maize offal blocks as supplements did not differ significantly in ADWC between urea levels in rice bran or guinea corn spent grain block supplementation. At 5% urea level, the ADWC due to maize offal block was significantly ($P<0.05$) higher than that due to guinea corn spent grain block but not significant compared to those on rice bran blocks. Figure 4.7.18 is the daily weight change (ADWC) response to urea levels in the blocks. Only maize offal block supplementation responded by weight gain at 5% urea level but responded by weight loss to urea level of above 5%. The weight response of guinea corn spent grain block supplementation to urea level consistently declined at about the rate of 20% for every 1% urea level increase. The rice bran block gave a response of about 40% rate of decline between 5% and 10% urea level but this rate of decline reduced to 10% between 10% and 15% urea levels.

Table 4.10 shows the average daily liveweight change (ADWC) by weeks. The ADWC in the first 2 weeks did not have any significant difference either on the basis of type of block or level of urea in the block.

In the 3rd week, the ADWC in the maize offal block supplemented group was significantly ($P<0.05$) higher at the 5% urea level than at 15% urea level, this difference being 215%. However, the differences between the 10% urea level and the other two levels were not significant. In weeks 4 to 9, there was no significant difference between urea levels.

In Fig. 4.7.19, the pattern of the liveweight change by weeks for the groups supplemented with maize offal

blocks is given. While the ADWC for 5% and 10% urea blocks peaked in week 3 at over 100g and 30g respectively, ADWC for the 15% urea block pithed in the same week to as low as below -130.4g. The ADWC for the 5% urea block group pithed in the 6th week but peaked again to a positive change in the 8th week and then declined by 7.1% per day to the 9th week. In the 10% urea block group, the ADWC reached its lowest ebb in the 5th week with a loss of about -80g but gradually ascended until it gained over 30g in the 8th week before declining in the 9th week. The ADWC in the 15% urea block supplemented group peaked in the 4th week to over 40g. There was another fall in ADWC in the 6th week which gradually increased positively until it plateaued between the 8th and 9th weeks.

The ADWC in the rice bran block or guinea corn spent grain block supplemented groups did not differ significantly between urea levels by weeks.

In the case of rice bran blocks (Fig. 4.7.20) ADWC for all the 3 urea levels peaked in the 4th week at positive gains. There was a sharp drop from the 4th to the 5th week and a more gradual one till the 6th week for 5% urea block group before attaining a height in rate of weight change by the 8th week. From the 8th week, the ADWC rose sharply to a positive gain of about 14g. The ADWC for the 10% urea blocks attained its peak in the 4th week and had its highest loss of weight in the 6th week with a decline from the 8th to the 9th week at the rate of about 14%. The lowest ADWC was in the 3rd and 6th weeks with a 10.7% rate of decline from the 8th to the 9th week.

Figure 4.7.21 shows that for guinea corn spent grain block, while in the 15% urea block group the ADWC peaked in the 3rd week, 5% and 10% urea block levels had low ebbs. The greatest weight loss for the 15% urea block group were

in the 4th , 5th and 7th weeks. The ADWC for the 3 urea level blocks showed increases from the 8th week to the 9th with the increases being positive for 5% and 15% levels.

Considering differences in ADWC within urea level and between types of block, there was significant ($P<0.05$) difference between maize offal block and guinea corn spent grain block at 5% urea level but the difference between rice bran block and the other two types of blocks did not differ significantly. In the same week, the differences between types of block at 10% or 15% urea levels did not differ significantly.

In the 4th week, at 5% urea level, the rice bran block had a significantly ($P<0.05$) higher ADWC than guinea corn block but maize offal block did not differ significantly from either rice bran or guinea corn spent grain blocks. At 10% and 15% urea levels, there was no significant difference between types of blocks.

There was no significant difference between types or levels of urea in the other weeks of the experiment. The loss of weight ranged from -118.9 to -392.6g daily.

Sudana and Leng (1986) reverted daily weight loss of 53g in lambs on straw as basal diet to a gain of 10g/day by supplementing with molasses-urea blocks. The greater weight loss and the minimal weight gain recorded in this experiment as compared with results obtained by Sudana and Leng (1986) could have been due to the higher quantity of basal diet fed by them.

The 5% maize offal block group with a positive daily weight change and 2gN/kg $W^{0.75}$ daily intake was the only group that had its minimum nitrogen requirement met (Table 4.5 and Fig. 4.7.15) (Cuthbertson, 1969) . This resulted in its feed conversion being the most efficient. The other groups whose minimum nitrogen requirement was not met

responded by negative feed conversion and weight loss.

4.7 FEED CONVERSION RATIO

The feed conversion ratio as shown in Table 4.5 shows that the urea level did not significantly affect the feed conversion ratio within any of the block types. Only within 5% urea level was the feed conversion ratio of maize offal block significantly ($P<0.05$) higher than that of guinea corn spent grain block.

Maize offal block gave a positive conversion ratio up to an estimated urea level of 8% and the decline between 5% and 10% urea levels was about 125% while between 10% and 15% urea levels it decreased by 40%. The conversion ratios of rice bran and guinea corn spent grain blocks were negative. There was a decline in conversion ratio from 5% to 15% urea levels at a rate of about 90% for every 1% urea level increase (Fig. 4.7.22). The highest conversion ratio for guinea corn spent grain block was about -0.05 at 10% urea level. From 5% to 10% urea levels, conversion ratio increased at the rate of 40% but declined at a rate of 80% from 10% to 15% urea level per percentage unit increase in urea level (Fig. 4.7.22)

Figure 4.7.23 is the feed conversion ratio by weeks for maize offal blocks . In the first 2 weeks there were no significant differences either between urea levels or types of blocks. Only in the 3rd week did maize blocks show significant ($P<0.05$) difference between 5% and 10% urea level while there was no significant difference between the 10% and 15% urea levels (Table 4.11). In the same week, there was no significant ($P<0.05$) difference between urea level in either rice bran blocks or guinea corn spent grain blocks. Within urea levels, only at 5% was maize offal block utilization more efficient than the guinea corn spent grain block while the difference between

rice bran block and either of the other two types of blocks was not significant. Within levels at 10% and 15%, there was no significant difference between the types of block.

In the 14th week, there was no significant difference between urea levels for all types of block. However, at 5% and 15% levels, only rice bran blocks were significantly ($P<0.05$) more efficient than guinea corn spent grain blocks by 156.7% and 4.2% respectively.

In all other weeks there was no significant difference either between urea levels or types of blocks.

4.8 CARCASS ANALYSIS

None of the factors (types of block and levels of urea) examined was significant ($P<0.05$) for any of the cuts or tissues as shown in Tables 4.10.1 to 4.10.6 The dressing percentage of the group supplemented with 5% urea maize blocks was the highest followed by those supplemented with 10% urea rice bran blocks (Table 4.10.6). The difference between 5% and 10% urea maize offal blocks was 13% and 12.7% compared with 15%. The lowest dressing percentage was obtained for 10% urea guinea corn spent grain blocks and the difference between it and the best, which was 5% urea maize block was 28%.

The highest dressing percentage of the 5% urea maize offal block group must have been due to its more efficient positive feed conversion and the liveweight gain compared to the other groups. The negative feed conversion and weight change in the other groups must have led to the loss of protein and fat from the body tissue hence the lower dressing percentage

4.9 COST OF MOLASSES - UREA PRODUCTION

The main objective of developing molasses-urea block is to explore suitable and cheap source of supplementing livestock on crop residue as basal diet. It is therefore

appropriate to cost its production in order to determine whether it is economically worth it or not. Table 4.12 shows the prices as at February, 1990, of the constituents of the molasses-urea blocks manufactured. The prices are the basis of costing the production of the blocks and the economics of supplementing with the blocks. These prices have been overtaken by inflation and some of the constituent materials are not as easily available as they were at the time of producing the blocks.

The material and labour cost of producing 10kg molasses-urea blocks is given in table 4.13. The fillers were the highest cost of constituents in maize offal and guinea corn spent grain blocks and they accounted for about 29.4% in both types but 11.1% of the total cost for the rice bran blocks.

The cost of producing maize offal and guinea corn spent grain blocks was similar and about 25.9% higher than the cost of producing rice bran blocks. The economics of producing molasses-urea blocks is therefore tied to the availability and current cost of the constituent materials.

The fillers are cheapest at the time of harvest and most expensive at the time of rainy season. Freshly obtained fillers during the rainy season have the tendency of not being dry enough and becoming moldy. This will definitely affect the quality of the blocks produced.

Further economic factors that will affect the cost of producing the blocks is the availability of the constituent materials locally. Even though the rice bran blocks were cheapest in this experiment, if they were produced in an area where the rice bran had to be transported over a long distance, the high transportation cost would increase their production cost even beyond the other two filler types of blocks.

The cost of molasses has continued to sky rocket due to stiff competition with alcohol distillers. Because these distillers are able to offer higher prices for the product, it has become increasingly more difficult for livestock farmers to get molasses to buy.

4.10 ECONOMICS OF UTILIZATION OF MOLASSES-UREA BLOCK BY RAMS.

Beside the low cost aspect of molasses-urea block production, the paramount means of determining its use is the economy of its utilization by the animals it is fed to. Table 4.14 shows the economic index of the utilization of the molasses-urea blocks by the rams used for the feeding trial.

The highest cost of supplementation was incurred by animals given 5% urea maize offal blocks. Its economic index ranks topmost. In other words it was the best in terms of production, value for money. Even though the cost of supplementation using 10% urea maize offal block was more than 50% less expensive, it ranked 2nd with negative economic index. The least cost of supplementation was obtained when the animals were given 15% urea guinea corn spent grain blocks and like all other groups except that supplemented with 5% urea maize offal blocks, the economic index was negative. The economic index is dependent on the feed conversion ration and the cost of the block. There was a direct relationship between the feed conversion ratio and the economic index.

TABLE 4.1 CHEMICAL COMPOSITION AND DIGESTIBILITY OF FEEDS

FEED		DM (%)	NDF (%)	ADF (%)	H.CEL (%)	G.E kCAL/gDM	N (%)	ASH (%)	%DMD	%OMD
MAIZE OFFAL BLOCK	5%	93.5	14.6	7.7	6.9	3.6	3.6	54.5	77.1	78.6
	10%	91.5	16.7	4.9	11.9	3.3	5.2	32.5	69.6	72.2
	15%	92.2	17.6	2.3	15.4	2.3	6.2	30.5	65.8	69.6
RICE BRAN BLOCK	5%	92.5	25.7	18.9	6.7	3.3	3.4	40.4	53.8	55.4
	10%	91.0	29.4	21.8	7.6	2.9	6.1	49.4	54.2	56.9
	15%	95.2	36.2	25.1	11.1	2.7	6.9	45.4	55.6	59.2
G/CORN SPENT	5%	91.7	13.1	8.6	4.5	3.4	3.1	38.5	75.0	76.0
GRAIN BLOCK	10%	93.0	18.9	6.3	12.5	3.0	6.1	35.7	70.1	74.5
	15%	94.1	19.4	4.4	15.0	3.0	7.0	34.4	65.2	68.5
LOCAL SULPHUR		90.2	-	-	-	2.2	0.4	0.1	-	-
MIN/VIT										
PREMIX		97.3	-	-	-	1.8	2.1	94.9	-	-
POTASH		99.0	-	-	-	-	0.6	80.7	-	-
UREA		63.2	-	-	-	4.2	42.4	26.9	-	-
CEMENT		99.7	-	-	-	-	0.5	97.0	-	-
SORGHUM STOVER		96.7	79.5	54.4	25.2	4.2	1.4	12.4	34.5	38.6
CARBIDE OXIDE		99.3	-	-	-	-	0.8	96.7	-	-
MAIZE OFFAL		94.2	48.6	11.4	37.2	4.5	3.5	8.5	-	-
RICE BRAN		94.0	72.0	48.9	23.1	4.2	2.4	15.1	-	-
G/CORN SPENT GRAIN		97.6	61.3	29.3	32.0	3.6	3.4	33.0	-	-

TABLE 4.2: THE CRUSH FAILURE LOAD AND HARDNESS OF THE MOLASSES - UREA BLOCKS MOULDED

FORMULATION	BLOCK WEIGHT (Kg)	CRUSH FAILURE LOAD (N)	BLOCK HARDNESS (N)	CRACKS PER BLOCK
1.	8.25	9	0.20	9
2.	2.30	13	0.53	4
3.	8.05	11	0.25	6
4.	6.75	40	0.91	2
5.	7.35	49	1.21	12
6.	7.00	43	0.98	8
7.	6.20	56	1.28	14
8.	6.55	55	1.14	7
9.	9.80	50	1.14	9
10.	8.75	57	1.30	5
11.	7.00	58	1.32	10
12.	6.10	63	1.43	8
13.	8.25	71	1.62	9
14.	9.20	87	1.98	12
15.	7.50	88	2.00	5

TABLE 4.3: PERCENT COMPOSITION AND STRUCTURAL PROPERTIES OF MOLASSES - UREA BLOCKS

Maize offal	Rice bran	G/Corn spent grain	Urea	Molasses	Carbide oxide	Cement	Min/Vit premix	Potash	Block hardness (N)	Block shearing (N)
43	-	-	5	36	3	6	6	1	1.28^{a}	0.65
43	-	-	10	31	3	6	6	1	1.98^{b}	1.04
43	-	-	15	26	3	6	6	1	2.00^{b}	1.15
-	43	-	5	36	3	6	6	1	1.16^{a}	0.48
-	43	-	10	31	3	6	6	1	1.58^{c}	0.72
-	43	-	15	26	3	6	6	1	1.72^{bc}	0.97
-	-	43	5	36	3	6	6	1	1.20^{a}	0.56
-	-	43	10	31	3	6	6	1	1.82^{b}	0.88
-	-	43	15	26	3	6	6	1	1.94^{b}	1.10

TABLE 4.4: DAILY SORGHUM STOVER INTAKE (g) BY WEEKS

FACTOR TYPE	UREA LEVEL (%)	WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6	WEEK7	WEEK8	WEEK9	MEAN
M O B	5	339.40	339.40	249.70^{c}	329.10^{abc}	352.60^{a}	351.40^{a}	353.70	354.90	354.00	336.02
	10	339.40	339.40	314.00^{a}	332.60^{ab}	338.60^{ab}	343.10^{a}	344.80	345.10	344.60	337.96
	15	346.30	346.30	281.40^{bc}	353.90^{a}	352.40^{a}	356.10^{a}	334.70	355.30	353.30	342.19
MEAN		341.70	341.70	281.70	338.53	347.87	350.20	344.40	351.77	350.63	338.72
R B B	5	329.10	329.10	288.60^{ab}	322.40^{bc}	345.30^{a}	326.70^{ab}	331.40	334.30	335.30	326.91
	10	328.10	328.10	275.30^{bc}	312.40^{bcd}	332.30^{ab}	329.00^{ab}	334.70	336.70	340.00	324.07
	15	324.90	324.90	269.00^{bc}	319.00	311.90^{b}	304.70^{b}	333.60	343.30	349.00	320.03
MEAN		327.37	327.37	277.63	317.93	329.83	320.13	333.23	338.10	341.40	323.67
G C S G B	5	324.70	324.70	262.60^{bc}	288.00^{d}	331.40^{ab}	341.90^{a}	341.10	335.00	349.30	322.08
	10	328.70	328.70	263.60^{bc}	299.70^{cd}	356.40^{a}	353.10^{a}	337.10	334.70	331.90	325.99
	15	330.40	330.40	279.60^{bc}	311.00^{bcd}	359.00^{a}	358.60^{a}	331.90	334.70	342.40	330.89
MEAN		327.93	327.93	268.60	299.57	348.93	351.20	336.70	334.80	341.20	326.32

SEM=±6.54

NB:Values within a factor and column with the same superscript are not significantly (P>0.05) different

MOB = Maize Offal Block

RBB = Rice Bran Block

GCSGB = Guinea Corn Spent Grain Block.

TABLE 4.5: MEAN DAILY STOVER, SUPPLEMENT AND TOTAL INTAKES (g),WEIGHT CHANGE AND FEED CONVERSION RATIO

FACTORS TYPE	UREA LEVEL(%)	STOVER INTAKE	SUPPLEMENT INTAKE	TOTAL INTAKE	LIVEWEIGHT CHANGE(g)	DAILY WEIGHT CHANGE(g)	FEED CONVERSION RATIO
M O B	5	336.0^{abc}	522.7^{a}	858.7^{a}	137.8^{a}	2.19^{a}	0.0438^{a}
	10	338.0^{abc}	242.3^{c}	580.3^{bcd}	-118.9^{ab}	-1.89^{ab}	-0.0133^{ab}
	15	342.2^{a}	153.5^{f}	495.7^{d}	-281.5^{b}	-4.47^{b}	-0.0541^{ab}
MEAN		338.72	306.16	644.88	-87.53	-1.39	-0.0079
RBB	5	326.9^{bcd}	330.8^{b}	657.7^{b}	-155.6^{ab}	-2.47^{ab}	-0.0022^{ab}
	10	324.1^{d}	231.3^{d}	555.4^{cd}	-296.3^{b}	-4.70^{ab}	-0.0459^{ab}
	15	320.0^{d}	175.4^{ef}	495.4^{de}	-336.1^{b}	-5.33^{b}	-0.0894^{b}
MEAN		323.67	245.83	569.50	-262.67	-4.17	-0.0458
GCSGB	5	322.1^{d}	256.9^{c}	579.4^{bc}	-250.0^{b}	-3.97^{b}	-0.0686^{b}
	10	326.0^{cd}	195.1^{de}	521.1^{cde}	-313.5^{b}	-4.98^{ab}	-0.0503^{ab}
	15	330.9^{bcd}	110.6^{g}	441.5^{e}	-392.6^{b}	-6.23^{b}	-0.0926^{b}
MEAN		326.32	187.54	513.86	-318.70	-5.06	-0.0705
SEM		±2.16	±8.15	±25.92	±0.013	±0.018	±0.034

NB: Values within a factor and column with the same superscript are not significantly (P>0.05) different.

MOB = Maize Offal Block

RBB = Rice Brown Block

GCSGB = Guinea Corn Spent Grain Block

TABLE 4.6: DAILY SUPPLEMENT INTAKE (g) BY WEEKS

FACTOR TYPE	UREA LEVEL (%)	WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6	WEEK7	WEEK8	WEEK9	MEAN
M O B	5	542.0^{a}	542.0^{a}	428.3^{a}	496.6^{a}	573.4^{a}	485.7^{a}	453.1^{a}	550.9^{a}	632.6^{a}	522.73
	10	260.1^{bcd}	260.1^{bcd}	169.4^{cd}	188.6^{bc}	293.1^{bc}	202.3^{bc}	199.4^{bc}	261.1^{c}	346.3^{c}	242.27
	15	152.1^{ef}	158.6^{ef}	158.6^{d}	196.7^{bc}	197.1^{e}	141.0^{c}	122.9^{c}	135.2^{e}	119.0^{e}	153.47
MEAN		318.07	320.23	252.10	293.97	354.53	276.33	258.47	315.73	365.97	306.16
R B B	5	347.7^{b}	347.7^{b}	301.9^{b}	271.4^{b}	363.9^{b}	283.9^{b}	295.3^{b}	301.0^{b}	464.7^{b}	330.83
	10	219.3^{cde}	219.3^{cde}	256.7^{bc}	251.4^{b}	320.4^{bc}	209.6^{bc}	238.1^{b}	180.0^{cde}	186.7^{d}	231.28
	15	169.1^{def}	169.1^{def}	172.1^{cd}	187.1^{bc}	197.6^{e}	159.3^{c}	216.9^{b}	178.7^{cde}	128.6^{de}	175.39
MEAN		245.37	245.37	243.57	236.63	293.97	217.60	250.10	219.90	260.00	245.83
G C S G B	5	287.7^{bc}	287.7^{bc}	184.7^{cd}	188.3^{bc}	340.7^{b}	202.9^{bc}	274.7^{b}	231.1^{bcd}	314.3^{c}	256.90
	10	194.4^{cdef}	194.4^{cdef}	152.1^{d}	186.9^{bc}	233.3^{cd}	198.6^{bc}	236.4^{b}	180.4^{cde}	179.7^{d}	195.13
	15	102.6^{f}	102.6^{f}	113.8^{d}	137.6^{c}	134.3^{e}	122.9^{c}	109.0^{c}	92.4^{e}	80.0^{e}	110.58
MEAN		194.9	194.90	150.2	170.93	236.10	174.80	206.70	167.97	191.33	187.54

SEM=±24.60

NB: Values within a factor and column with the same superscript are not significantly (P>0.05) different.
MOB = Maize Offal Block
RBB = Rice Bran Block
GCSGB = Guinea Corn Spent Grain Block

TABLE 4.7: TOTAL DAILY DRY MATTER INTAKE (STOVER + SUPPLEMENT)

FACTOR TYPE	UREA LEVEL (%)	TOTAL INTAKE (g) BY WEEKS WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6	WEEK7	WEEK8	WEEK9	MEAN
	5	881.4^{a}	881.4^{a}	678.0^{a}	825.7^{a}	926.0^{a}	837.1^{a}	806.9^{a}	905.7^{a}	986.6^{a}	858.76
	10	599.1^{bcd}	599.1^{bcd}	483.4^{cd}	521.1^{bcd}	631.7^{bcd}	545.4^{bc}	544.3^{bc}	606.3^{bc}	690.9^{c}	580.14
	15	498.4^{de}	498.4^{de}	440.0^{cd}	550.4^{bcd}	549.6^{de}	497.1^{c}	497.0^{cd}	490.4^{de}	472.4^{d}	497.30
MEAN		659.63	659.63	533.80	632.40	702.43	626.53	610.07	667.47	716.63	
R B B	5	676.9^{b}	676.9^{b}	590.4^{ab}	593.9^{b}	709.0^{b}	610.4^{b}	626.7^{b}	635.3^{b}	800.0^{b}	657.72
	10	547.4^{cd}	547.4^{cd}	531.9^{bc}	564.3^{bc}	652.9^{bcd}	538.6^{bc}	572.9^{bc}	516.7^{cde}	526.7^{d}	555.42
	15	494.0^{de}	494.0^{de}	441.1^{cd}	506.1^{bcd}	509.3^{e}	464.0^{c}	550.4^{bc}	519.0^{cde}	477.6^{d}	495.06
MEAN		572.77	572.77	521.13	554.77	623.73	537.67	583.33	557.00	601.43	
G C S G B	5	612.4^{bc}	612.4^{bc}	447.1^{cd}	476.3^{cd}	672.1^{bc}	544.7^{bc}	615.7^{b}	566.1^{bcd}	663.6^{c}	578.93
	10	523.1^{cde}	523.1^{cde}	415.7^{d}	486.4^{bcd}	589.7^{cde}	551.7^{bc}	573.6^{bc}	515.0^{cde}	511.4^{d}	521.08
	15	433.0^{e}	433.0^{e}	393.3^{d}	448.6^{d}	493.3^{e}	481.4^{c}	441.0^{d}	427.1^{e}	422.4^{d}	441.46
MEAN		522.83	522.83	418.70	470.43	585.03	525.93	543.43	502.73	532.47	

SEM=±25.92
MOB=Maize Offal Block
RBB=Rice Bran Block
GCSGB=Guinea Corn Spent Grain Block
NB. Values within a factor and column with the same superscript are not significantly (p>0.05) different.

TABLE 4.8 PERCENT INTAKE AS SORGHUM STOVER

FACTOR TYPE	UREA LEVEL (%)	PERCENT INTAKE BY WEEKS WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6	WEEK7	WEEK8	WEEK9	MEAN
M O B	5	38.5	38.5	36.8	39.9	38.1	42.0	43.8	39.2	35.9	39.19
	10	56.6	56.6	65.0	63.8	53.6	62.9	63.3	56.9	49.9	58.73
	15	69.5	69.5	64.0	64.3	64.1	71.6	69.9	72.5	74.8	68.91
MEAN		54.87	54.87	55.27	56.0	51.93	58.83	59.0	56.2	53.53	55.61
R B B	5	48.6	48.6	48.9	54.3	48.7	53.5	52.9	52.6	41.9	50.00
	10	59.9	59.9	51.8	55.4	50.9	61.1	58.4	65.2	64.6	58.58
	15	65.8	65.8	61.0	63.0	61.2	65.7	60.6	66.1	73.0	64.69
MEAN		58.10	58.10	53.90	57.57	53.60	60.10	57.30	61.30	59.83	57.76
GCSGB	5	53.0	53.0	58.7	60.5	49.3	62.8	55.4	59.2	52.6	56.06
	10	62.8	62.8	63.4	61.6	60.4	64.0	37.6	65.0	64.9	60.28
	15	76.3	76.3	71.1	69.3	72.8	74.5	75.3	78.4	81.1	75.01
MEAN		64.03	64.03	64.40	63.80	60.83	67.10	56.10	67.53	66.20	63.78

SEM=±2.49
NB: Values within a factor and column with the same superscript are not significantly (P>0.05) different.

MOB = Maize Offal Block
RBB = Rice Bran block
GCSGB = Guinea Corn Spent Grain Block

TABLE 4.9: PERCENT INTAKE AS SUPPLEMENT

FACTOR TYPE	UREA LEVEL (%)	PERCENT INTAKE BY WEEKS WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6	WEEK7	WEEK8	WEEK9	MEAN
MOB	5	61.5	61.5	63.2	60.1	61.9	58.0	56.2	60.8	64.1	60.81
	10	43.4	43.4	35.0	36.2	46.4	37.1	36.7	43.1	50.1	41.27
	15	30.5	30.5	36.0	35.7	35.9	28.4	30.1	27.5	25.2	31.09
MEAN		45.13	45.13	44.73	44.00	48.07	41.17	41.00	43.80	46.47	44.39
RBB	5	51.4	51.4	51.1	45.7	51.3	46.5	47.1	47.4	58.1	50.00
	10	40.1	40.1	48.2	44.6	49.1	38.9	41.6	34.8	35.4	41.42
	15	34.2	34.2	39.0	37.0	38.8	34.3	39.4	33.9	27.0	35.31
MEAN		41.90	41.90	41.90	46.1	42.43	46.40	39.90	42.70	38.70	40.17
GCSGB	5	47.0	47.0	41.3	39.5	50.7	37.2	44.6	40.8	47.4	43.94
	10	37.2	37.2	36.6	38.4	39.6	36.0	62.4	35.0	35.1	39.72
	15	23.7	23.7	28.9	30.7	27.2	25.5	24.7	21.6	18.9	24.99
MEAN		35.97	35.97	35.60	36.20	39.17	32.90	43.90	32.47	33.80	36.22

SEM=±2.49

NB: Values within a factor and column with the same superscript are not significantly (P>0.05) different.

MOB = Maize Offal Block
RBB = Rice Bran Block
GCSGB = Guinea Corn spent Grain Block.

TABLE 4.10: DAILY LIVEWEIGHT CHANGE (g) BY WEEKS.

FACTOR TYPE	UREA LEVEL(%)	WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6	WEEK7	WEEK8	WEEK9	MEAN
MOB	5	19.7	19.7	115.7^{a}	37.1^{ab}	14.3	-60.0	-14.3	15.7^{ab}	-41.4^{ab}	11.83
	10	-16.9	-16.9	34.3^{bc}	-71.4^{b}	-82.9	-64.3	-38.6	37.1^{a}	-12.9^{ab}	-29.65
	15	-40.2	-40.2	-133.4^{c}	40.3^{ab}	-81.0	-107.1	-45.2	-28.6^{ab}	-33.3^{ab}	-52.08
MEAN		-12.47	-12.47	5.53	2.00	-49.9	-77.13	-32.70	8.07	-29.20	
RBB	5	-22.2	-22.2	-11.9^{abc}	142.9^{a}	-23.8	-45.2	-2.4	-138.1^{b}	14.3^{ab}	-12.07
	10	-42.3	-42.3	-35.7^{abc}	38.1^{ab}	-76.2	-104.8	-2.4	14.3^{ab}	-90.5^{b}	-37.98
	15	-48.0	-48.0	-139.3^{c}	66.1^{ab}	-25.0	-150.0	-107.1	26.8^{ab}	-33.9^{ab}	-50.93
MEAN		-37.50	-37.50	-62.30	82.37	-41.67	-100.00	-37.30	-32.33	-36.70	
GCSGB	5	-35.7	-35.7	-94.6^{bc}	-62.5^{b}	-62.5	-119.0	-16.1	-26.8^{ab}	91.1^{a}	-40.20
	10	-44.8	-44.8	-89.3^{bc}	-50.0^{b}	-50.0	-60.0	-17.9	-41.1^{ab}	1.8^{ab}	-44.01
	15	-56.1	-56.1	-45.2^{abc}	-104.8^{b}	-104.8	-71.4	-104.8	-42.9^{ab}	59.5^{ab}	58.51
MEAN		-45.53	-45.53	-76.37	-72.43	-72.43	-83.47	-46.27	-36.93	50.80	

SEM=±0.052
MOB=Maize Offal Block
RBB=Rice Bran Block
GCSGB=Guinea Corn Spent Grain Block
NB/Values within a factor and column with the same superscript are not significantly (P>0.05) different.

TABLE 4.11 FEED CONVERSION RATIO BY WEEKS

FACTOR TYPE	UREA LEVEL(%)	WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6	WEEK7	WEEK8	WEEK9	MEAN
M O B	5	0.0438	0.0438	0.1920^{a}	0.0580^{abc}	0.0340	-0.0440	0.0020	0.0400	-0.0140	0.0391
	10	-0.0133	-0.0133	0.0780^{ab}	-0.1000^{bc}	-0.1000	-0.0980	-0.0280	0.0620	-0.0120	-0.0387
	15	-0.0541	-0.0541	-0.2667^{c}	0.0733^{abc}	-0.1000	-0.1767	-0.0633	0	-0.0533	-0.0772
MEAN		-0.0079	-0.0079	0.0011	0.0104	-0.0553	-0.1062	-0.0311	0.0340	-0.0264	
R B B	5	-0.0022	-0.0022	-0.0400^{abc}	0.2667^{a}	-0.0033	-0.0500	0.0267	-0.1667	0.0300	0.0066
	10	-0.0459	-0.0459	-0.0500^{abc}	0.1233^{ab}	-0.0667	-0.1333	0.0200	0.0600	-0.1333	-0.0030
	15	-0.0894	-0.0894	-0.2750^{c}	0.1250^{ab}	-0.0425	-0.3250	-0.1700	0.0500	-0.0575	-0.0971
MEAN		-0.0458	-0.0458	-0.1217	0.1717	-0.0375	-0.1694	-0.0411	-0.0189	-0.0536	
G C S G B	5	-0.0686	-0.0686	-0.3050^{c}	-0.1100^{bc}	-0.0875	-0.2167	-0.0075	-0.0350	0.1500	-0.0832
	10	-0.0503	-0.0503	-0.1625^{bc}	-0.0500^{c}	-0.0500	-0.0600	-0.0125	-0.0400	0.0250	-0.0500
	15	-0.0926	-0.0926	-0.1400^{bc}	-0.2000^{c}	-0.1667	-0.1000	-0.2000	-0.0667	0.1400	-0.1021
MEAN		-0.0705	-0.0705	-0.2025	-0.1200	-0.1014	-0.1222	-0.0733	-0.0472	0.1050	

SEM=±0.099
NB/ Values within a factor and column with the same superscript are not significantly (P>0.05) different.
MOB = Maize Offal Block
RBB = Rice Bran Block
GCSGB = Guinea Corn Spent Grain Block

4.11 CONCLUSION

Molasses-urea blocks manufactured through the "hot process" were better than those produced by the "cold process". The structural integrity of the blocks was compact and did not disintegrate easily as was the case with those produced by the "cold process".

The physical hardness and shearing properties of molasses - urea blocks were determined by the level of inclusion of molasses and fillers in the block. As molasses increased, the block became softer while there was a direct relationship between the amount of filler and the hardness of the block.

The 5% urea maize offal block was the best of all the blocks used as supplement in terms of intake, digestibility, feed conversion, growth response by the rams and dressing percentage. The 5% urea maize offal block could only maintain rams as supplement to sorghum stover. The other blocks could not maintain the rams on sorghum stover as basal diet.Therefore, only the 5% urea maize offal block can be used as dry season supplement for rams fed sorghum stover.

The economics of production showed that rice bran blocks_were cheapest while there was no difference between producing__maize offal blocks and guinea corn spent grain blocks. The index which was formulated from the cost of block and feed conversion showed that the 5% urea maize offal block ranked best.

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APPENDIX

TABLE 1.1 LIVESTOCK POPULATION IN THOUSAND

Continent/country	*Cattle	*Pig	*Sheep	**Goat
Africa	155,775	7,669	155,219	**120,295
Nigeria	11,000	880	7,650	22,500
% Nigeria: Africa	7.1	11.5	4.9	18.7

Source: *International, Historical Statistics. Africa and Asia (1982). B.R. Mitchel. The MacMillan Press Ltd., London and basing Stroke.
**Production Year Book Vol. 29 (1975). Food & Agriculture Organization of the United Nations - Rome.

TABLE 1.2 **LAND USE (1974) IN THOUSAND HECTARES

Continent/Country	Total Area	Arable and land under permanent crop	Permanent meadows and pasture
Africa	3,031,178	217,478	793.333
Nigeria	92,377	25,300	20,720
Nigeria:Africa	3.1	11.6	2.6

Source: **Production Year Book Vol. 29 (1975).
Food & Agricultural Organization of the United Nations-Rome

TABLE 1.3 ***POPULATION, RATE OF POPULATION INCREASE, SURFACE AREA AND DENSITY - THOUSAND

Continent / Country	Population	Annual rate	Surface area (Km^2)	Density
Africa	401,000	2.6	30,319,000	13
Nigeria	62,925	2.7	923,768	68
Nigeria:Africa	15.7	-	3.1	-

*** 1976 Statistical Year Book. United Nations

TABLE 3.3: LIVEWEIGHT, CARCASS WEIGHT AND WEIGHTS OF ORGANS (KG) FORM (A)

Tag No.	Liveweight (kg)	Slaughter weight (kg	Dressing percentage (kg)	Hot carcass (kg)	Shrink loss (%)	Mesentric fat (kg)	Blood (kg)	Head (kg)	Feet (kg)	Skin (kg)

TABLE 3.4: LIVEWEIGHT, CARCASS WEIGHT AND WEIGHTS OF ORGANS (KG) FORM (B)

Tag No	Gastro-intestinal tract (full) (kg)	Gastro-intestinal tract (empty) (kg)	Heart (kg)	Liver (kg)	Lungs (kg)	Spleen (kg)	Kidneys (kg)	Kidney-fat (kg)

TABLE 3.5: WEIGHTS OF CUTS AND TISSUES IN CUTS

Tag No

Cut/Tissue	Left Half Carcass	Leg	Sirlion	Lion	Rack	Shoulder	Shank	Breast	Neck	Flank
Whole Cut										
Muscle										
Bone										
Fat										

TABLE 4:10,1 WEIGHTS OF CARCASS CUTS AND TISSUES

FACTOR TYPE	UREA LEVEL (%)	INITIAL WT(Kg)	INITIAL MET.WT ($KgW^{0.75}$)	FINAL WT(Kg)	FINAL MET.Wt ($KgW^{0.75}$)	SLAUGHTER WT (Kg)	HOT CARCASS WT (Kg)	COLD CARCASS WT (Kg)	MESENTERIC FAT WT. (g)	BLOOD WT(Kg)	HEAD WT(Kg)	FEET WT. (Kg)	SKIN WT. (kG)
MOB	5	20.8	9.73	21.4	9.95	20.6	8.9	8.6	284.0	0.8	1.9	0.6	1.7
	10	16.3	8.11	14.4	7.39	13.7	5.3	5.2	0	0.7	1.4	0.5	1.1
	15	19.5	9.28	16.0	8.00	15.3	5.9	5.6	0	0.7	1.4	0.5	1.0
MEAN		18.87	9.04	17.27	8.45	16.53	6.70	6.47	94.67	0.73	1.57	0.53	1.27
RBB	5	19.3	9.21	15.6	7.85	15.0	5.5	5.4	0	0.6	1.4	0.5	1.0
	10	23.5	10.67	20.3	9.56	19.4	8.2	7.3	0	0.9	1.9	0.6	1.4
	15	19.5	9.28	14.8	7.55	13.9	5.2	5.1	0	1.0	1.5	0.6	1.1
MEAN		20.77	9.72	16.90	8.32	16.10	6.30	5.93	0	0.83	1.60	0.57	1.17
GCSGB	5	17.0	8.37	15.8	7.92	15.2	5.8	5.6	0	0.6	1.3	0.5	1.2
	10	17.6	8.59	16.9	8.34	16.3	5.5	5.5	0	0.5	1.4	0.5	1.1
	15	17.9	8.70	13.8	7.16	13.4	5.2	5.0	0	0.5	1.4	0.5	1.0
MEAN		17.50		15.50		14.97	5.50	5.37	0	0.53	1.37	0.50	1.10
SEM		±2.45		±2.61		±2.56	±1.36	±1.21	-	-	±0.24	-	-

TABLE 4:10.2 WEIGHTS OF CARCASS CUTS AND TISSUES CONTD

FACTOR TYPE	UREA LEVEL (%)	G.I.T FULL (kg)	G.I.T EMPTY (Kg)	HEART (g)	LIVER (g)	LUNGS (g)	SPLEEN (g)	KIDNEY (g)	KIDNEY FAT(g)	LEG MUSCLE (g)	LEG BONE (g)	LEG FAT (g)
MOB	5	6.2	1.9	90.0	252.5	182.5	25.0	57.5	82.5	750.0	282.5	37.5
	10	4.7	1.1	70.0	177.5	187.5	12.5	45.0	10.0	452.5	240.0	0
	15	5.5	1.2	67.5	185.0	200.0	17.5	42.5	7.5	484.0	256.5	0
MEAN		5.47	1.40	75.83	205.00	190.00	18.33	48.33	33.33	562.17	259.67	12.50
RBB	5	5.4	1.4	65.0	165.0	185.0	17.5	45.0	7.5	395.0	317.5	0
	10	6.8	1.2	73.0	205.0	171.5	31.5	48.0	8.0	652.0	297.0	16.0
	15	5.0	1.2	72.0	147.5	142.5	12.5	40.0	5.0	367.0	297.0	0
MEAN		5.73	1.27	70.00	172.5	166.33	20.50	44.33	6.83	471.33	303.83	5.3
GCSGB	5	5.6	1.3	75.0	185.0	152.5	12.5	50.0	7.5	485.0	240.0	2.5
	10	6.6	1.3	67.5	205.0	160.0	15.0	42.5	7.5	445.0	258.0	0
	15	3.9	1.1	67.5	157.5	157.5	15.0	42.5	7.5	374.5	275.5	0
MEAN		5.37	1.23	70.00	182.50	156.67	14.17	45.00	7.50	434.83	257.83	0.8

TABLE 4:10.3 WEIGHTS OF CARCASS CUTS AND TISSUES CONTD

FACTOR TYPE	UREA LEVEL (%)	SIRLOIN MUSCLE (g)	SIRLOIN BONE (g)	SIRLOIN FAT (g)	SIRLOIN CUT (g)	LOIN MUSCLE (g)	LOIN BONE (g)	LOIN FAT (g)	LOIN CUT (g)	RACK MUSCLE (g)	RACK BONE (g)	RACK FAT (g)	RACK CUT (g)
MOB	5	150.0	60.0	12.5	222.5	175.0	160.0	42.5	377.5	207.5	122.5	5.0	335.0
	10	65.0	55.0	0	120.0	107.5	115.0	0	222.5	125.0	102.5	0	227.5
	15	73.0	52.5	0	125.5	143.0	88.5	0	231.5	128.5	162.0	12.0	302.5
MEAN		96.00	55.83	4.17	156.00	141.83	121.17	14.17	277.17	153.67	129.00	5.67	288.33
RBB	5	82.5	62.5	0	145.0	97.5	72.5	0	170.0	82.5	112.5	0	195.0
	10	193.0	51.0	44.0	288.0	148.0	89.5	4.0	241.5	204.5	158.0	0	362.5
	15	80.0	49.5	0	129.5	90.0	67.0	0	157.0	81.5	111.0	0	192.5
MEAN		118.50	54.33	14.67	187.50	111.83	76.33	1.33	189.50	122.83	127.17	0	250.00
GCSGB	5	90.0	47.5	5.0	142.5	122.5	120.0	10.0	252.5	121.5	95.0	0	216.5
	10	88.0	49.5	0	137.5	89.5	100.0	0	189.5	80.5	80.5	0	161.0
	15	83.0	52.0	0	135.0	97.5	75.5	0	173.0	94.5	99.5	0	194.0
MEAN		87.00	49.67	1.67	138.33	103.17	98.50	3.33	205.00	98.83	91.67	0	190.50

TABLE 4:10.4 WEIGHTS OF CARCASS CUTS AND TISSUES CONTD

FACTOR TYPE	UREA LEVEL (%)	SHOULDER MUSCLE (g)	SHOULDER BONE (g)	SHOULDER FAT (g)	SHOULDER CUT (g)	SHANK MUSCLE (g)	SHANK BONE (g)	SHANK FAT (g)	SHANK CUT (g)
MOB	5	470.0	200.0	42.5	712.5	210.0	127.7	15.0	352.5
	10	275.0	165.0	0	440.0	130.0	105.0	0	235.0
	15	262.5	137.5	11.5	411.5	200.5	137.5	0	338.0
MEAN		335.8	167.5	18.0	521.3	180.0	123.3	5.0	308.5
RBB	5	285.0	257.5	0	542.5	137.5	80.0	0	217.5
	10	458.0	215.5	0	673.5	203.5	102.0	0	305.5
	15	251.5	242.5	0	494.0	125.5	67.0	0	192.5
MEAN		331.50	238.50	0	570.00	155.5	83.00	0	238.50
GCSGB	5	312.5	182.5	0	495.0	160.0	105.0	0	265.0
	10	336.5	163.0	0	499.5	132.0	107.0	0	239.0
	15	192.0	164.5	0	356.5	175.0	131.5	0	306.5
MEAN		280.33	170.00	0	450.33	155.67	114.50	0	270.17

TABLE 4:10.5 WEIGHTS OF CARCASS CUTS AND TISSUES CONTD

FACTOR TYPE	UREA LEVEL (%)	BREAST MUSCLE (g)	BREAST BONE (g)	BREAST FAT (g)	BREAST CUT (g)	NECK MUSCLE (g)	NECK BONE (g)	NECK FAT (g)	NECK CUT (g)
MOB	5	237.5	115.0	50.0	442.5	175.0	90.0	5.0	270.0
	10	147.5	120.0	0	267.5	105.0	130.0	0	235.0
	15	118.0	79.0	0	197.0	156.0	144.5	0	300.5
MEAN		167.67	104.67	16.67	302.33	145.33	121.50	1.67	268.50
RBB	5	80.0	132.5	0	212.5	120.5	165.0	0	285.5
	10	199.0	143.0	0	342.0	293.5	195.0	0	434.5
	15	82.0	135.0	0	217.0	137.5	113.5	0	251.0
MEAN		120.33	136.83	0	257.17	165.83	157.83	0	323.67
	10	137.5	130.0	0	267.5	45.0	80.0	0	125.0
	15	88.0	121.5	0	209.5	97.5	151.5	0	249.0
MEAN		122.17	122.17	0	244.33	103.33	113.00	0	216.33

TABLE 4:10.6 WEIGHTS OF CARCASS CUTS AND TISSUES CONTD

FACTOR TYPE	UREA LEVEL (%)	FLANK MUSCLE (g)	FLANK BONE (g)	FLANK FAT (g)	FLANK CUT (g)	DRESSING PERCENTAGE (%)
MOB	5	97.5	5.0	30.0	132.5	41.6
	10	65.0	0.0	0.0	65.0	36.8
	15	87.0	0.0	23.0	110.0	36.9
MEAN		83.17	1.67	17.67	102.50	38.43
RBB	5	65.0	7.5	0.0	72.5	35.3
	10	62.5	4.0	8.0	74.5	40.4
	15	59.0	7.0	0.0	66.0	35.1
MEAN		62.17	6.17	2.67	71.00	36.93
GCSGB	5	70.0	5.0	0.0	75.0	36.7
	10	83.0	5.0	0.0	88.0	32.5
	15	55.0	5.5	0.0	60.5	37.7
MEAN		69.33	5.17	0.0	74.5	35.63

TABLE 4.12: PRICES AND PER CENT COMPOSITION OF CONSTITUENTS OF MOLASSES-UREA BLOCK

Constituent	Description	*Price N K	%Composition
Mineral/Vitamin Premix	25kg bag	2334. 50	0.168
Maize Offal	1 ton	1000. 00	43.0
Rice bran	1 ton	300. 00	43.0
Guinea corn spent grain	1 ton	1000. 00	43.0
Urea	50kg bag	48. 00	5,10 or 15
Local Sulphur	55.5kg bag	900. 00	0.336
Local Potash	100kg bag	150. 00	1.0
Molasses	1 drum (111kg)	116. 00	26,31 or 36
Carbide oxide	1 ton	300. 00	3.0
Cement	1 ton	800. 00	6.0
Bone meal	1 ton	1600. 00	2.832
Common salt	25kg bag	90. 00	2.664

*Prices were as at February, 1990.

TABLE 4.13: MATERIAL AND LABOUR COST OF PRODUCING MOLASSES-UREA BLOCKS

	COST (N) BLOCKS/10Kg WEIGHT								
CONSTITUENTS	1	2	3	4	5	6	7	8	9
Mineral/vitamin Premix	1.50	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57
Maize Offal	4.30	4.30	4.30	-	-	-	-	-	-
Rice Bran	-	-	-	1.29	1.29	1.29	-	-	-
Guinea corn spent grain	-	-	-	-	-	-	4.30	4.30	4.30
Urea	4.48	0.96	1.44	0.48	0.96	1.44	0.48	0.96	1.44
Local Sulphur	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86
Local potash	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Molasses	3.76	3.24	2.72	3.76	3.24	2.72	3.76	3.24	2.72
Carbide oxide	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Cement	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Bone meal	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Common salt	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Labour	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Total	14.65	14.61	14.57	11.64	11.60	11.56	14.65	14.65	14.57

TABLE 4.14 ECONOMIC INDEX OF MOLASSES - UREA BLOCK UTILIZATION BY RAMS

BLOCK	COST OF DAILY BLOCK INTAKE(K)	TOTAL COST (N)/ 10Kg BLOCK	FEED CONVERSION RATION	ECONOCMIC INDEX	RANKING INDEX
1	77	14.65	0.0438	0.64	1st
2	35	14.61	-0.0133	-0.19	2nd
3	22	14.57	-0.0541	-0.79	6th
4	39	11.64	-0.0022	-0.26	3rd
5	27	11.60	-0.0459	-0.53	4th
6	20	11.65	-0.0894	-1.03	8th
7	38	14.65	-0.0686	-1.00	7th
8	29	14.61	-0.0503	-0.74	5th
9	16	14.57	-0.0926	-1.36	9th

Block 1 = 5% Urea Maize Offal Block
Block 2 = 10% Urea Maize Offal Block
Block 3 = 15% Urea Maize Offal Block
Block 4 = 5% Urea Rice Bran Block
Block 5 = 10% Urea Rice Bran Block
Block 6 = 15% Urea Rice Bran Block
Block 7 = 5% Urea Guinea Corn Spent Grain Block
Block 8 = 10% Urea Guinea Corn Spent Grain Block
Block 9 = 15% Urea Guinea Corn Spent Grain Block

TABLE 4.01 ANALYSIS OF VARIANCE FOR SORGHUM INTAKE

Source	Df	Mean - Square	F - Ratio	P
Weeks	8	116441.251	104.706	0.000
Types	2	46738.234	42.028	0.001
Levels	2	1202.656	1.081	0.334
Weeks x Types	16	5797.696	5.213	0.000
Weeks x Levels	16	1633.643	1.469	0.102
Types x Levels	4	2520.390	2.266	0.060
Weeks x Types x Levels	32	3806.358	3.423	0.000
Error	2061	1112.074		

TABLE 4.02 ANALYSIS OF VARIANCE FOR SUPPLEMENT INTAKE.

Source	Df	Mean - Square	F - Ratio	P
Weeks	8	208256.250	13.185	0.000
Types	2	2830228.232	179.181	0.000
Levels	2	0.110832E+08	701.676	0.000
Weeks x Types	16	55608.971	3.521	0.000
Weeks x Levels	16	178501.280	11.301	0.000
Types x Levels	4	1099641.045	69.618	0.000
Weeks x Types x Levels	32	40094.279	2.538	0.000
Error	2061	15795.389		

TABLE 4.03 ANALYSIS OF VARIANCE FOR TOTAL DRY MATTER INTAKE

Source	Df	Mean - Square	F - Ratio	P
Weeks	8	499178.642	28.578	0.000
Types	2	3536902.388	202.487	0.000
Levels	2	0.0108871+08	623.282	0.000
Weeks x Types	16	59420.439	3.402	0.000
Weeks x Levels	16	192505.701	11.021	0.000
Types x Levels	4	1071376.312	61.336	0.000
Weeks x Types x Levels	32	43286.043	2.478	0.000
Error	2061	17467.304		

TABLE 4.04 ANALYSIS OF VARIANCE FOR LIVEWEIGHT CHANGE.

Source	Df	Mean - Square	F - Ratio	P
Weeks	8	1.274	2.333	0.020
Types	2	1.564	2.864	0.059
Levels	2	1.492	2.733	0.067
Weeks x Types	16	0.870	1.593	0.072
Weeks x Levels	16	0.512	0.937	0.528
Types x Levels	4	0.227	0.415	0.797
Weeks x Types x Levels	32	0.458	0.838	0.718
Error	225	0.546		

TABLE 4.05 ANALYSIS OF VARIANCE FOR PERCENT SORGHUM INTAKE

Source	Df	Mean - Square	F - Ratio	P
Weeks	8	995.224	6.191	0.000
Types	2	14377.171	89.432	0.000
Levels	2	86911.407	540.623	0.000
Weeks x Types	16	504.929	3.141	0.000
Weeks x Levels	16	1431.231	8.903	0.000
Types x Levels	4	4215.805	26.224	0.000
Weeks x Types x Levels	32	541.520	3.368	0.000
Error	2061	160.762		

TABLE 4.06 ANALYSIS OF VARIANCE FOR PERCENT SUPPLEMENT INTAKE

Source	Df	Mean - Square	F - Ratio	P
Weeks	8	995.224	6.191	0.000
Types	2	14377.171	89.432	0.000
Levels	2	86911.407	540.623	0.000
Weeks x Types	16	504.929	3.141	0.000
Weeks x Levels	16	1431.231	8.903	0.000
Types x Levels	4	4215.805	26.224	0.000
Weeks x Types x Levels	32	541.520	3.368	0.000
Error.	2061	160.762		

TABLE 4.07 ANALYSIS OF VARIANCE FOR DAILY WEIGHT CHANGE

Source	Df	Mean - Square	F - Ratio	P
Weeks	8	0.026	2.333	0.020
Types	2	0.032	2.864	0.059
Levels	2	0.030	2.733	0.067
Weeks x Types	16	0.018	1.593	0.072
Weeks x Levels	16	0.010	0.937	0.528
Types x Levels	4	0.005	0.415	0.797
Weeks x Types x Levels	32	0.009	0.838	0.718
Error.	225	0.011		

Trends of stover intake by weeks
Intake as influenced by level of urea
in maize block

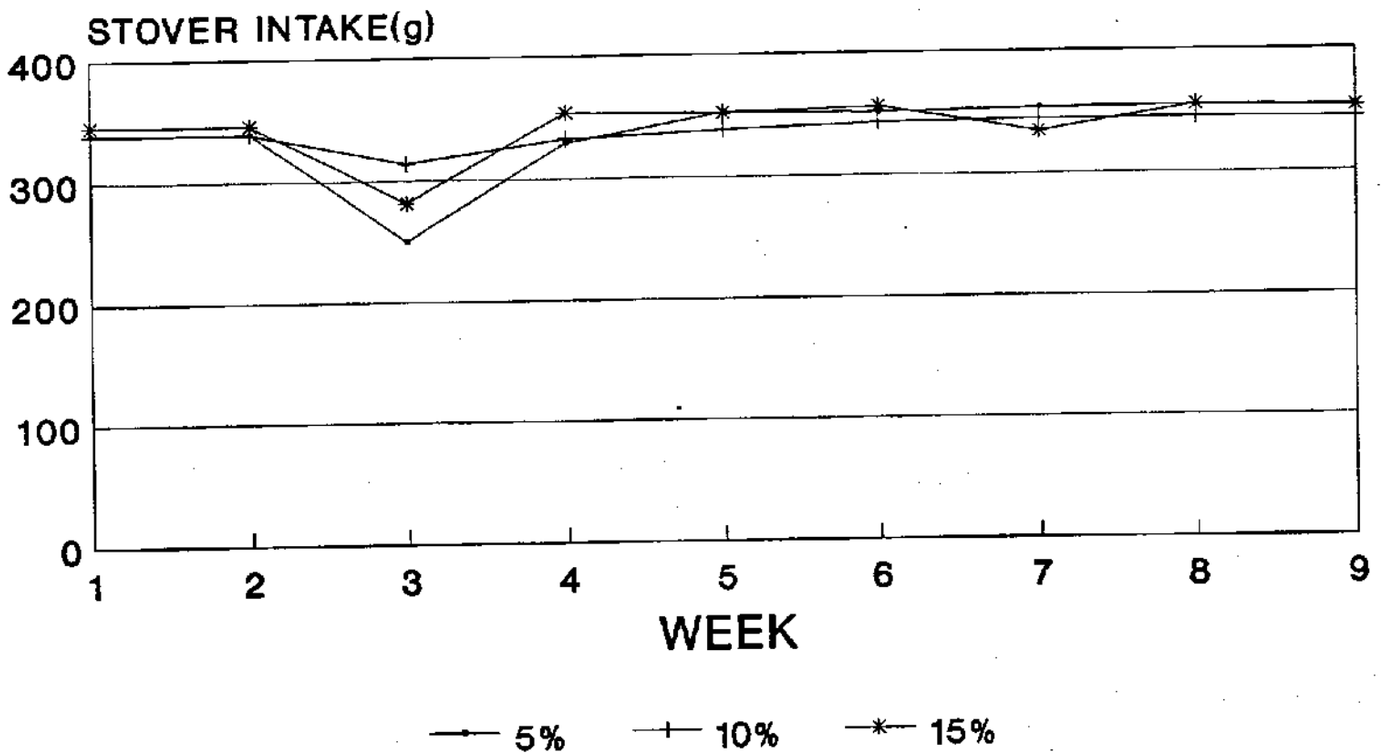


FIGURE 4.7.1

Trends in stover intake by week

Intake of stover as influenced by urea level in rice bran block

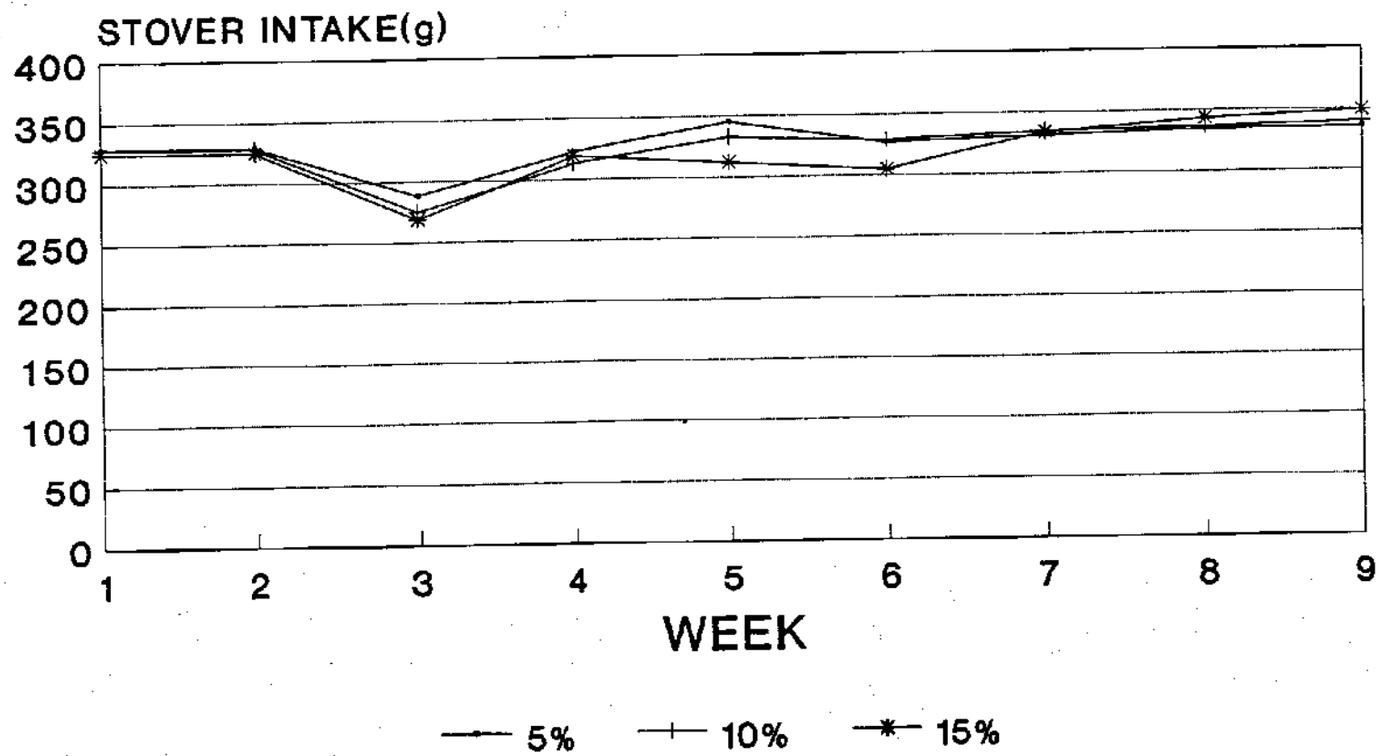


FIGURE 4.7.2

Trends in stover intake by week

Intake of stover as influenced by urea level in g/corn block

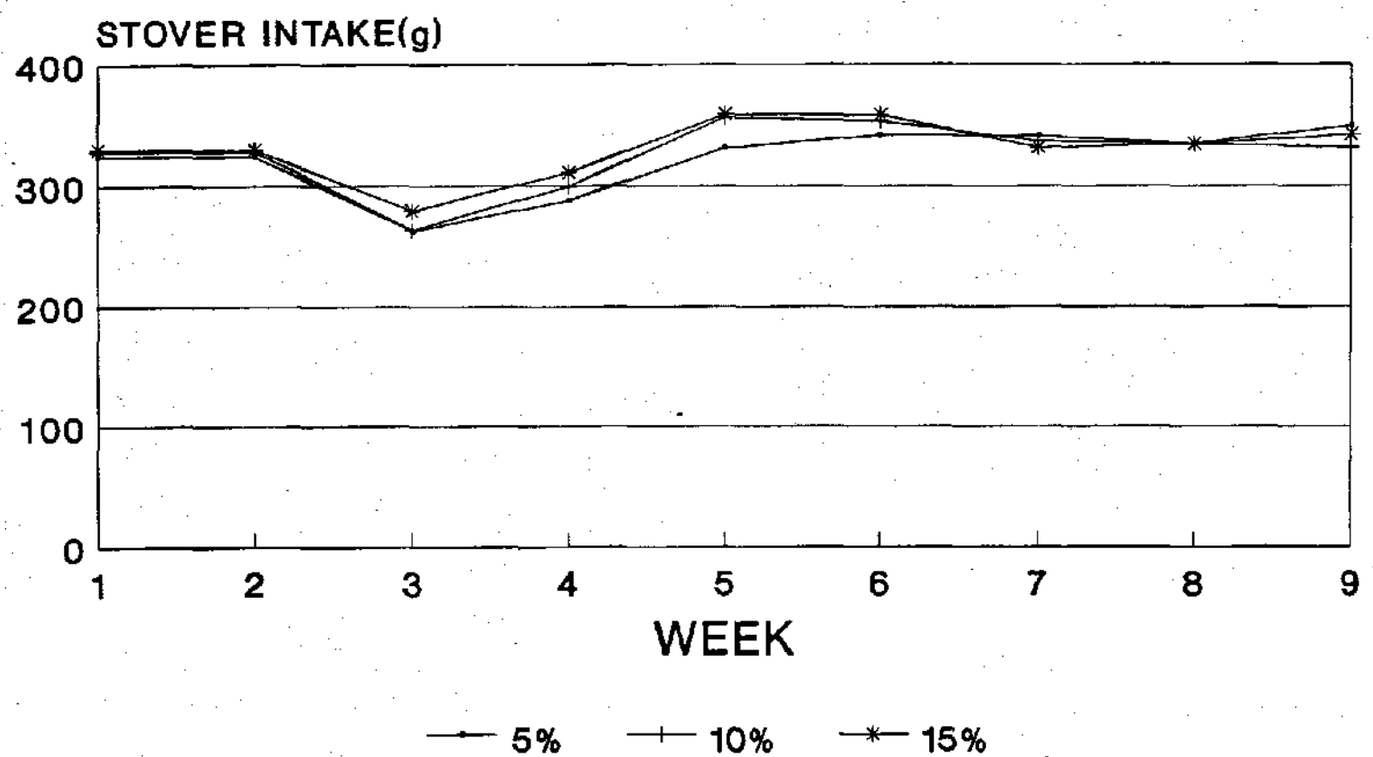


FIGURE 4.7.3

PERCENT STOVER INTAKE/TOTAL

PERCENT STOVER INTAKE/TOTAL

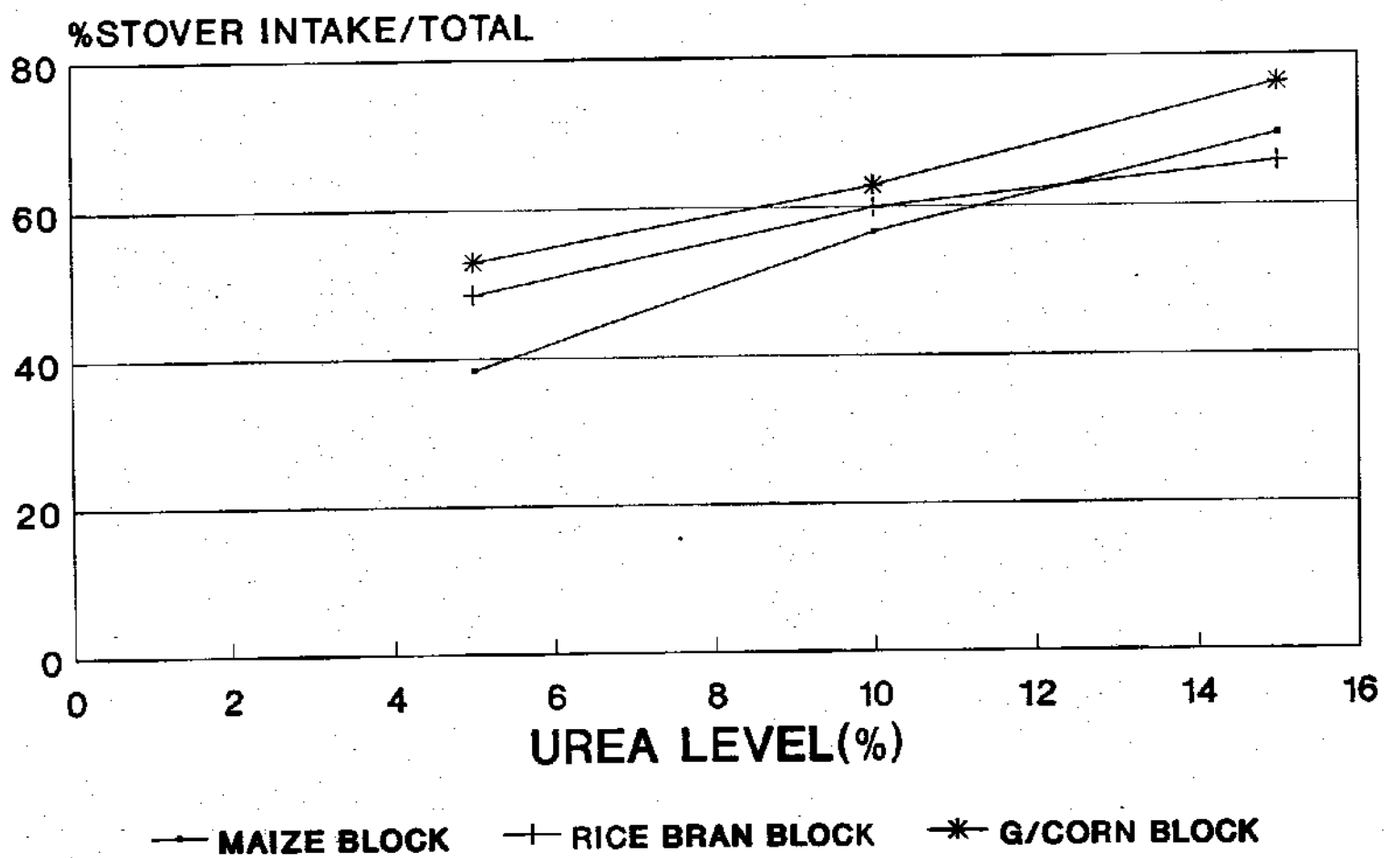


FIGURE 4.7.4

Trends in supplement intake by week Intake of supplement as influenced by urea level in maize block

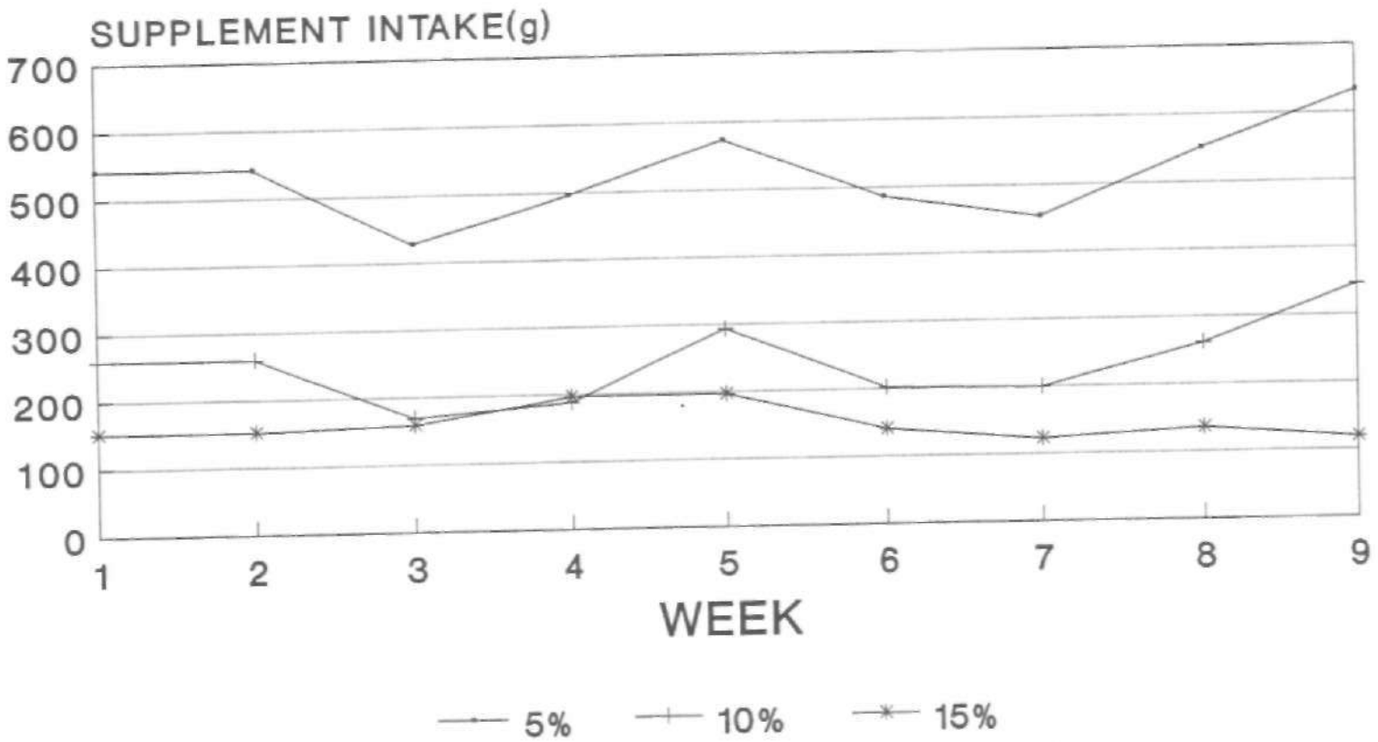


FIGURE 4.7.5

Trends of supplement intake by week

Intake of supplement as infuenced by urea level in rice bran block

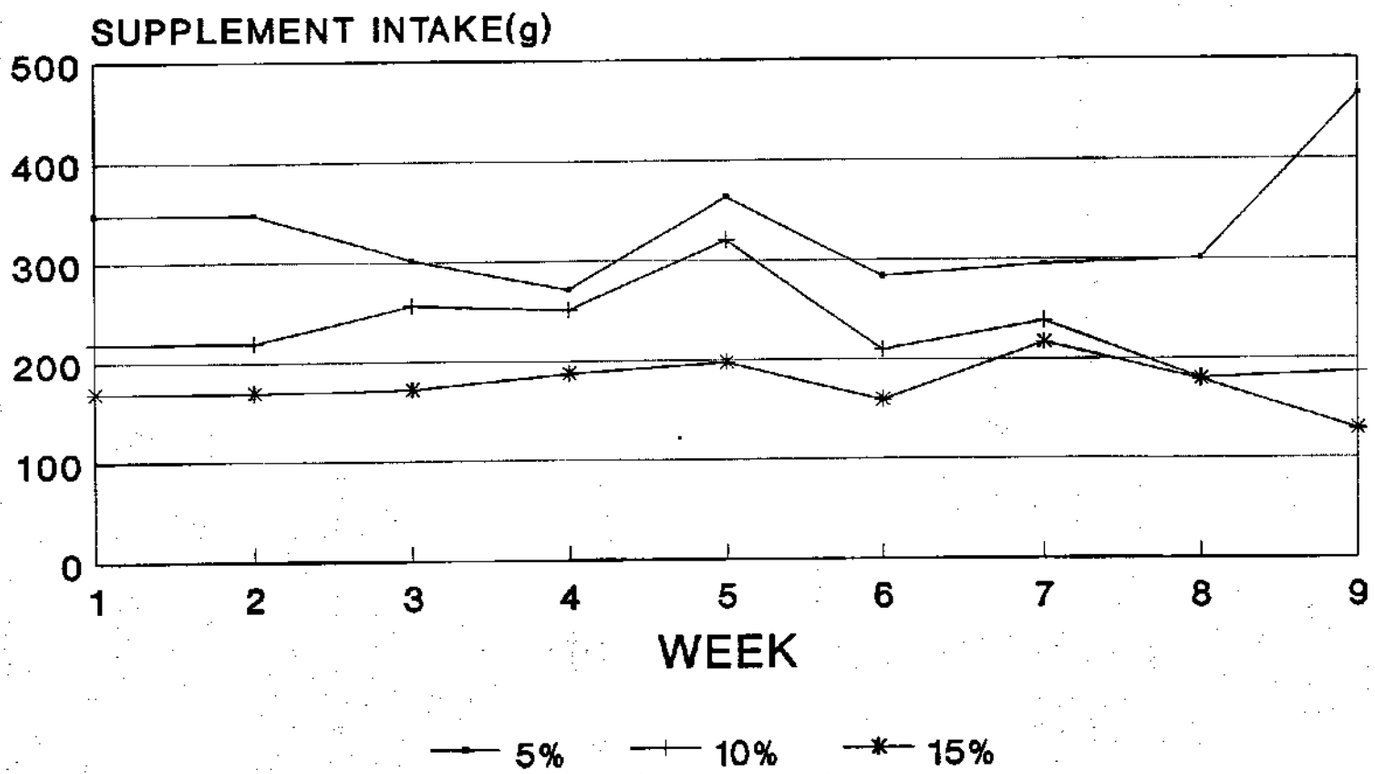


FIGURE 4.7.6

Trends of supplement intake by week

Intake of supplement as influenced by urea level in g/corn block

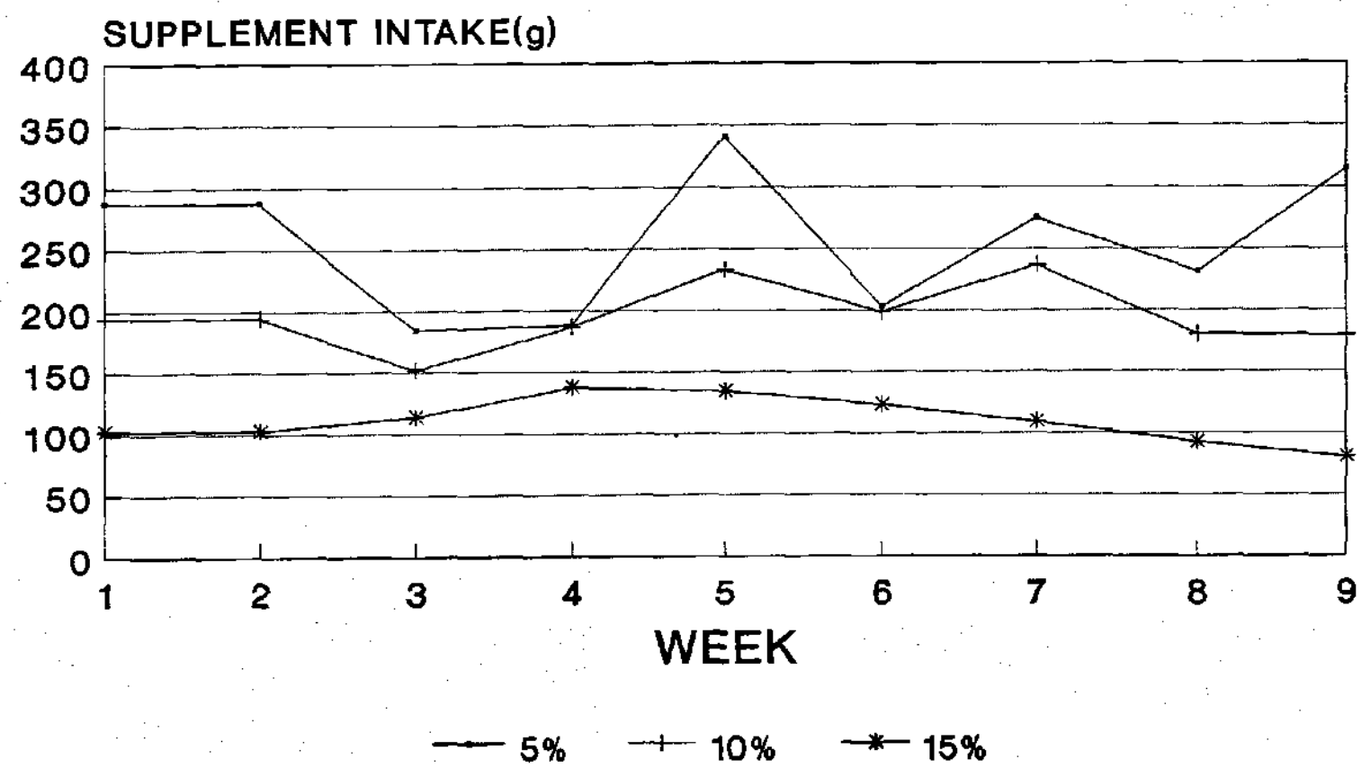


FIGURE 4.7.7

Trends in total intake by week

Total intake as infuenced by urea level in maize block

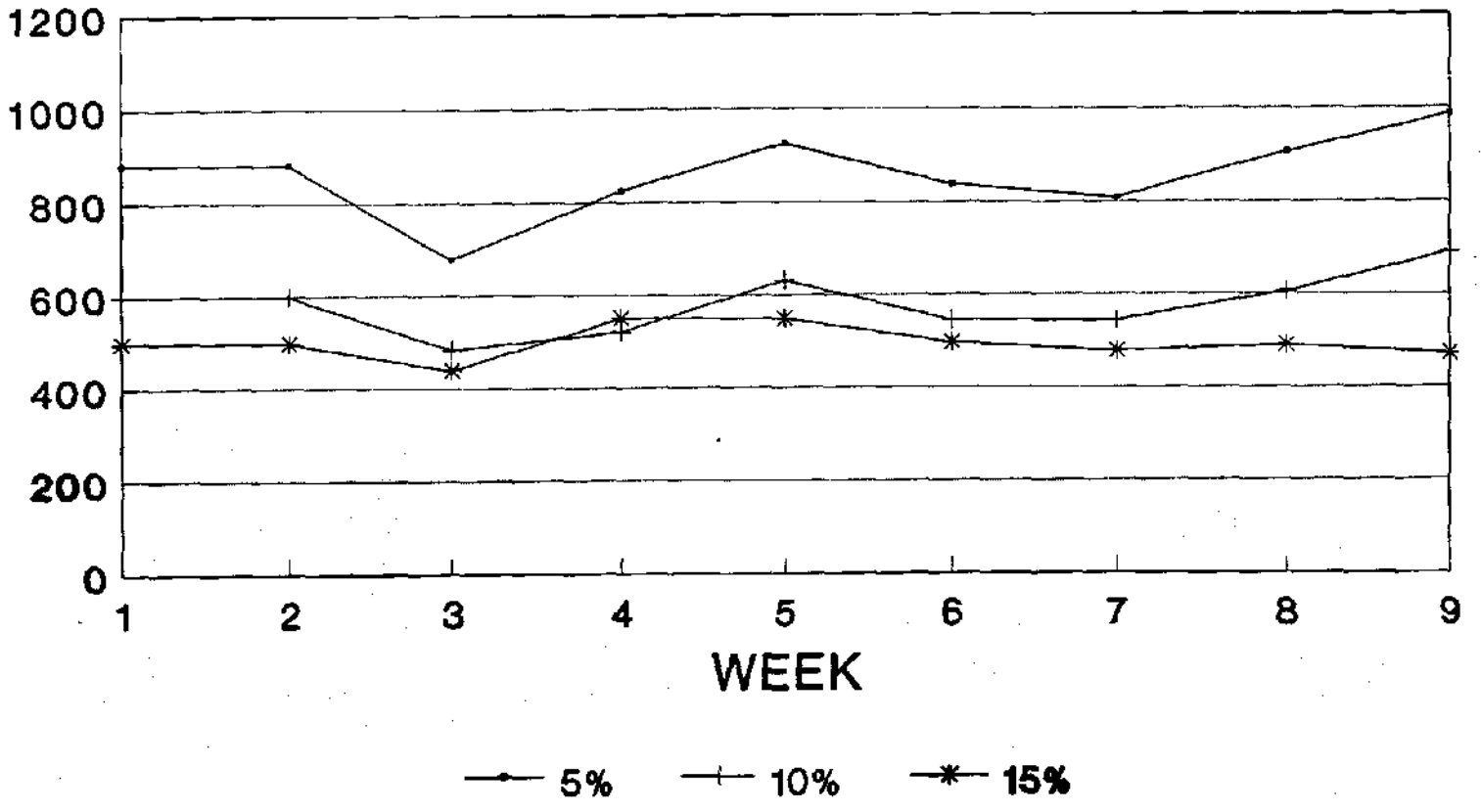


FIGURE 4.7.8

Trends in total intake by week

Total intake as influenced by urea level in rice bran block

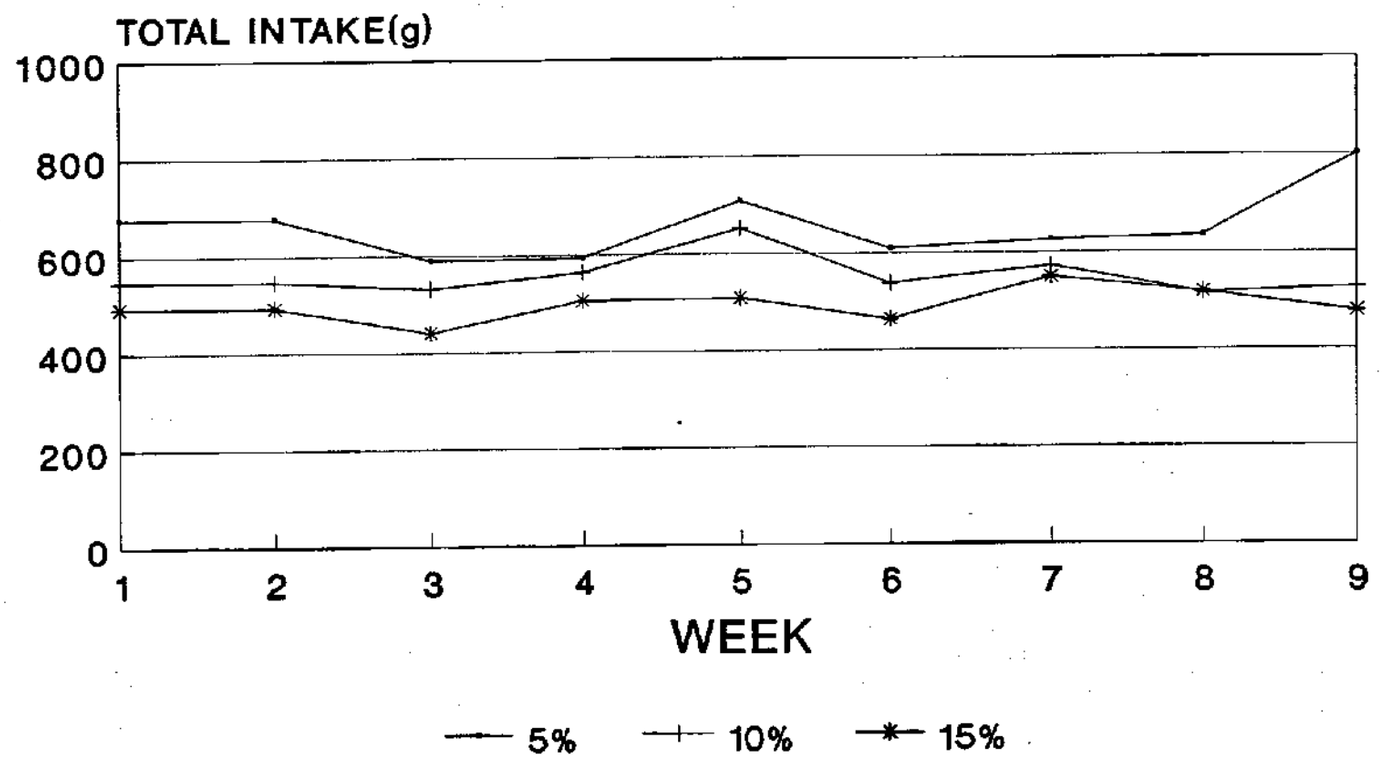


FIGURE 4.7.9

Trends in total intake by week
Total intake as influenced by urea level in g/corn block

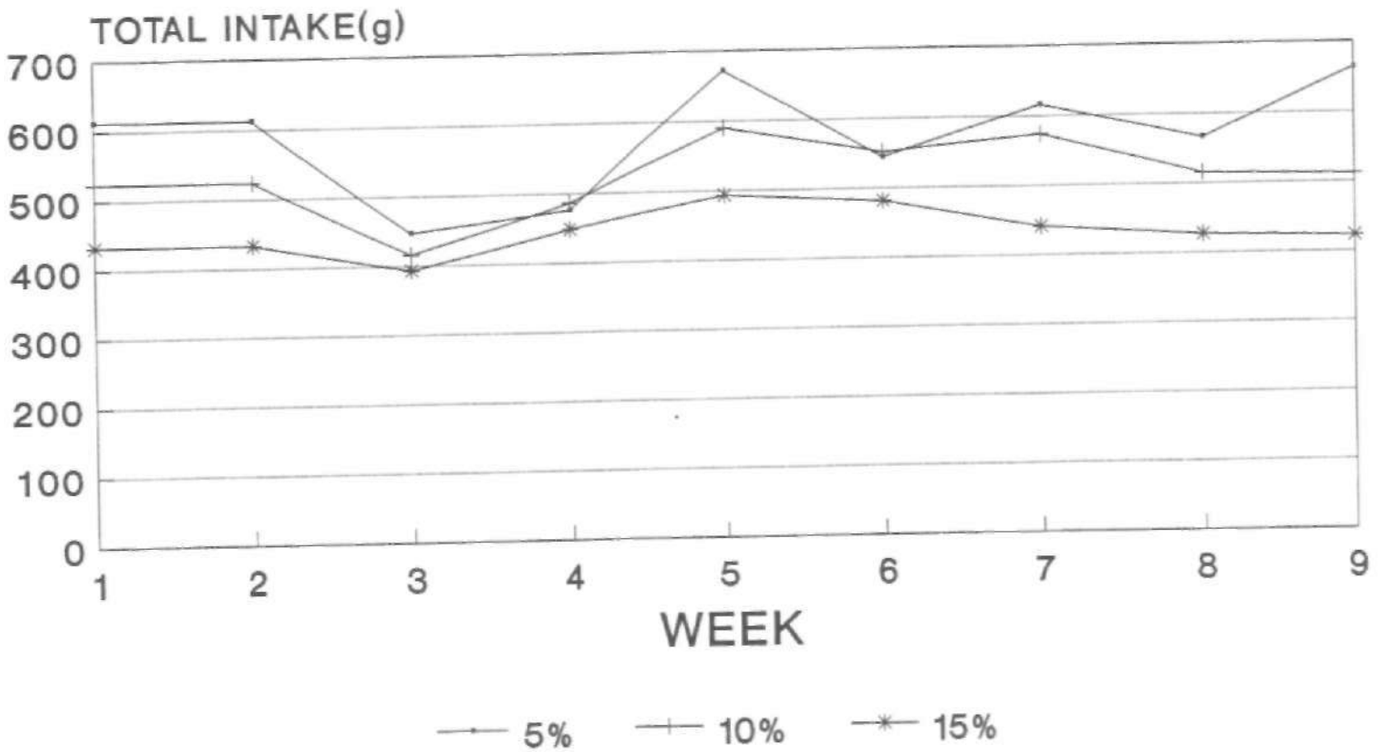


FIGURE 4.7.10

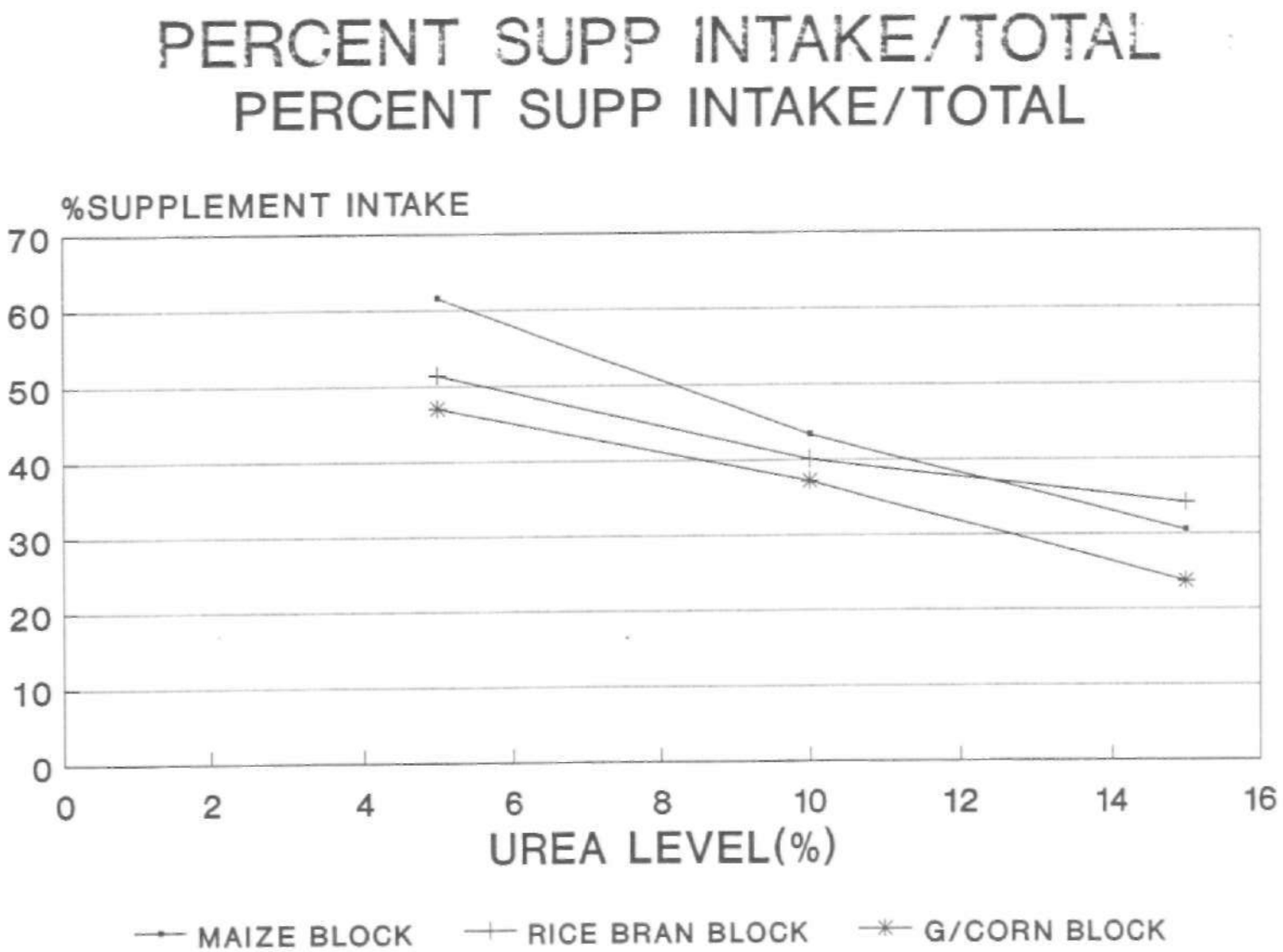

PERCENT SUPP INTAKE/TOTAL
PERCENT SUPP INTAKE/TOTAL
%SUPPLEMENT INTAKE
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
UREA LEVEL(%)
MAIZE BLOCK
RICE BRAN BLOCK
G/CORN BLOCK

FIGURE 4.7.11

Daily supplement intake
Intake response to urea level blocks

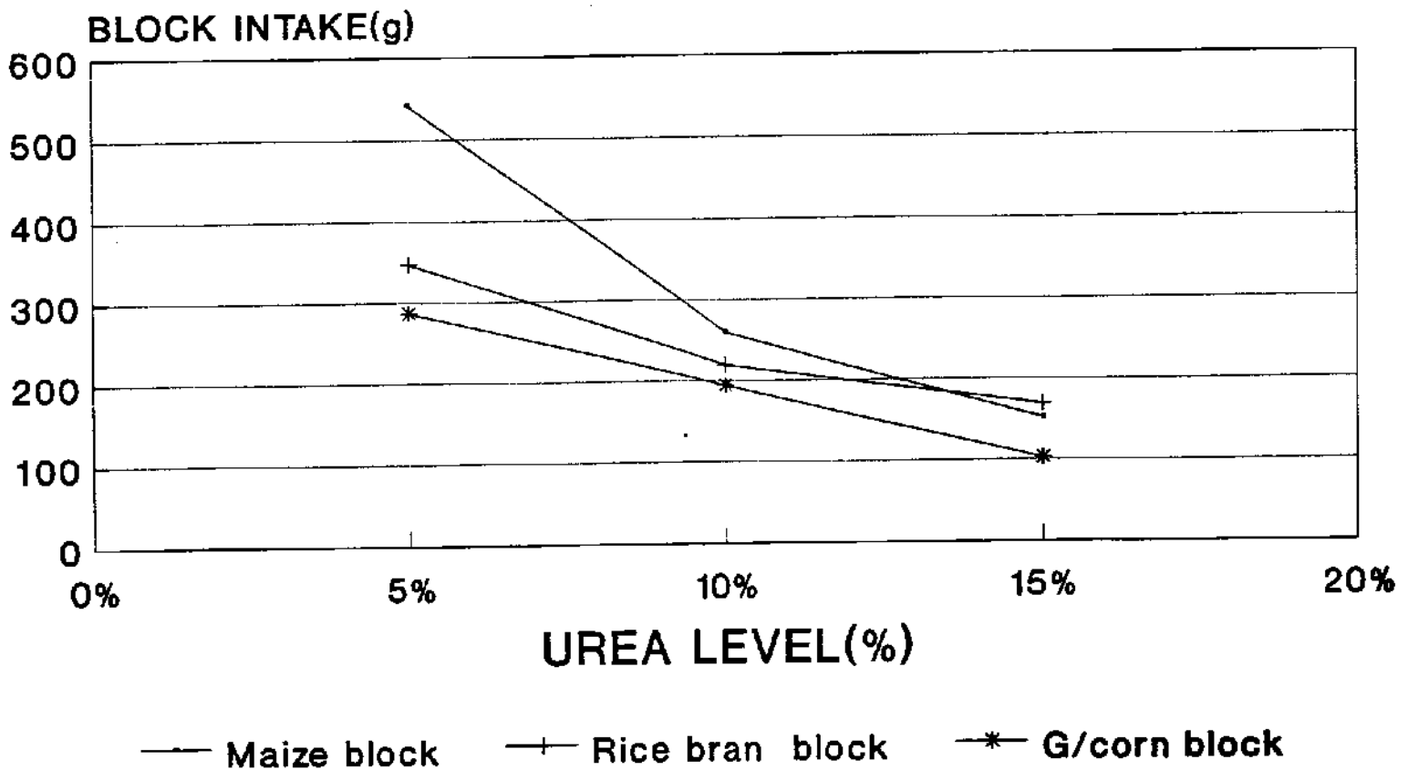


FIGURE 4.7.12

Total intake

Total intake in response to urea level in block

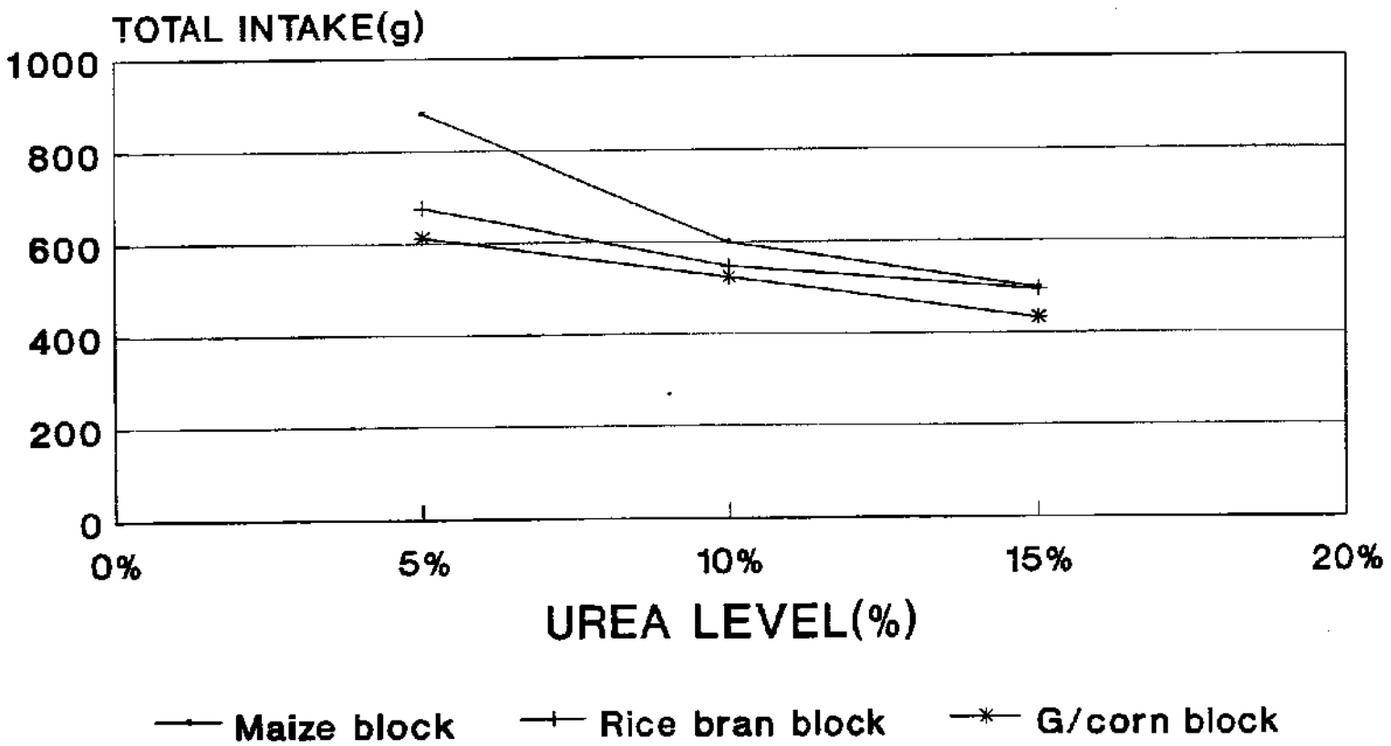


FIGURE 4.7.13

EXPECTED NITROGEN INTAKE IN SUPPLEMENT

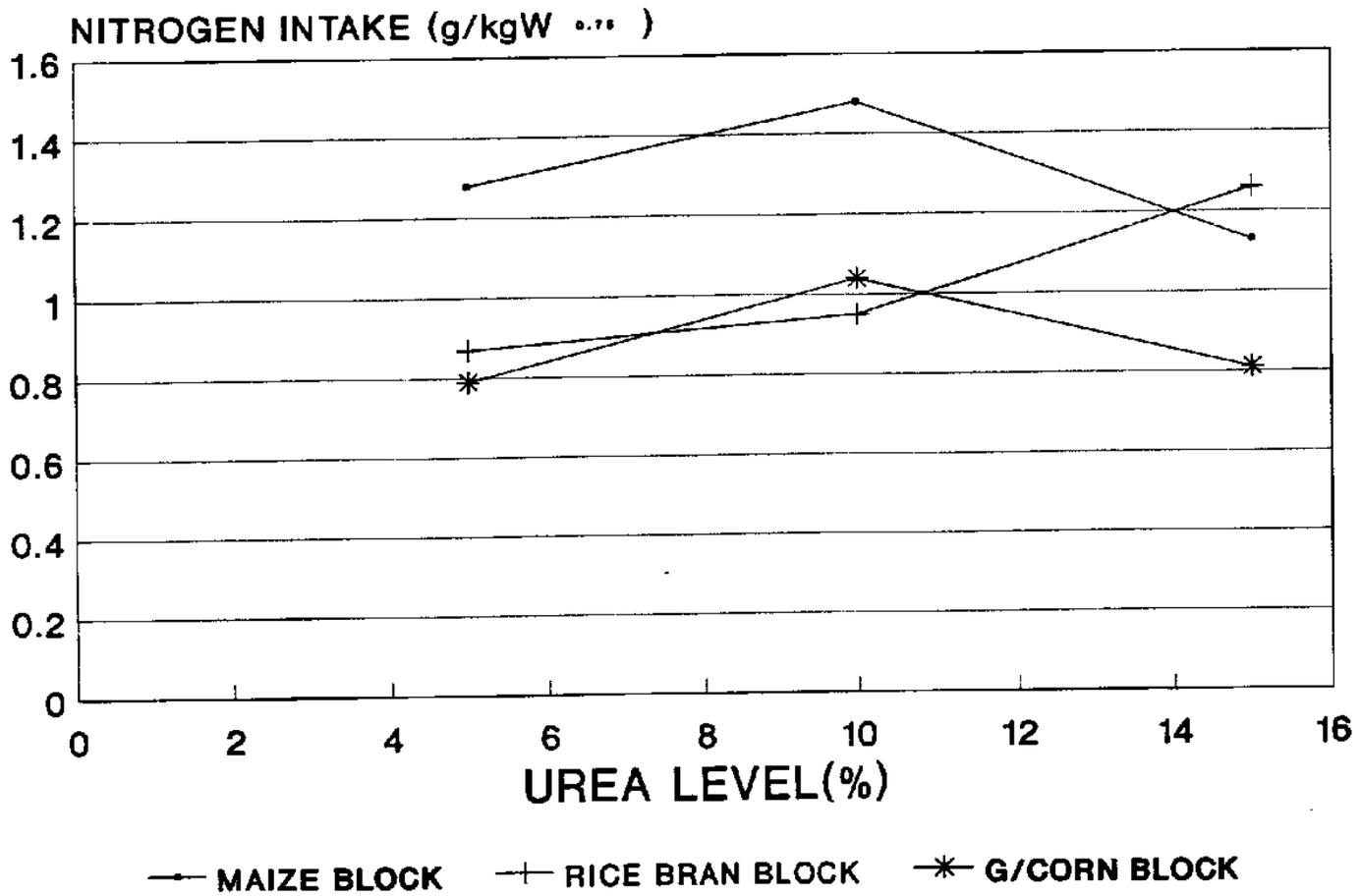


FIGURE 4.7.14

ACTUAL NITROGEN INTAKE IN SUPPLEMENT

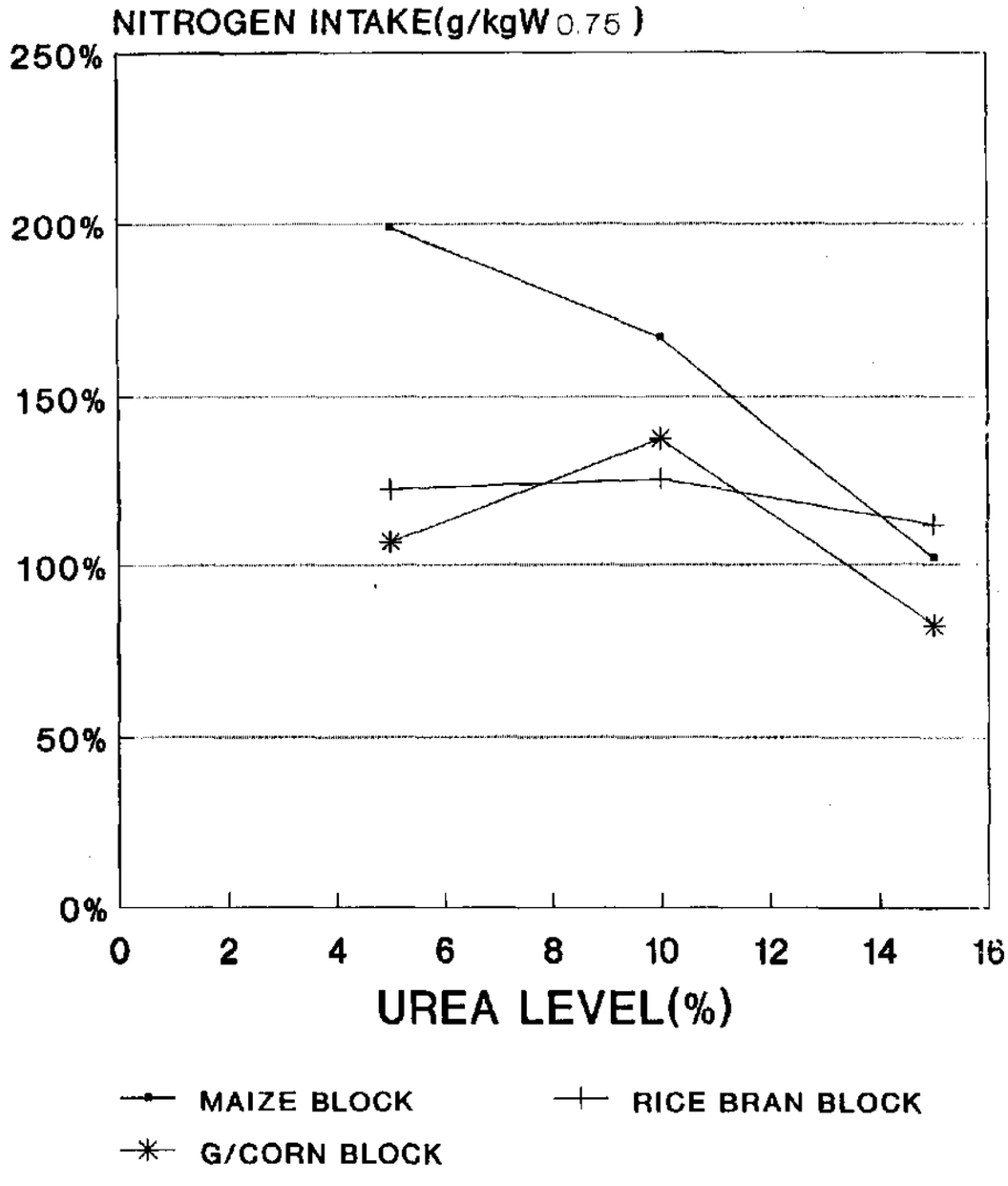


FIGURE 4.7.15

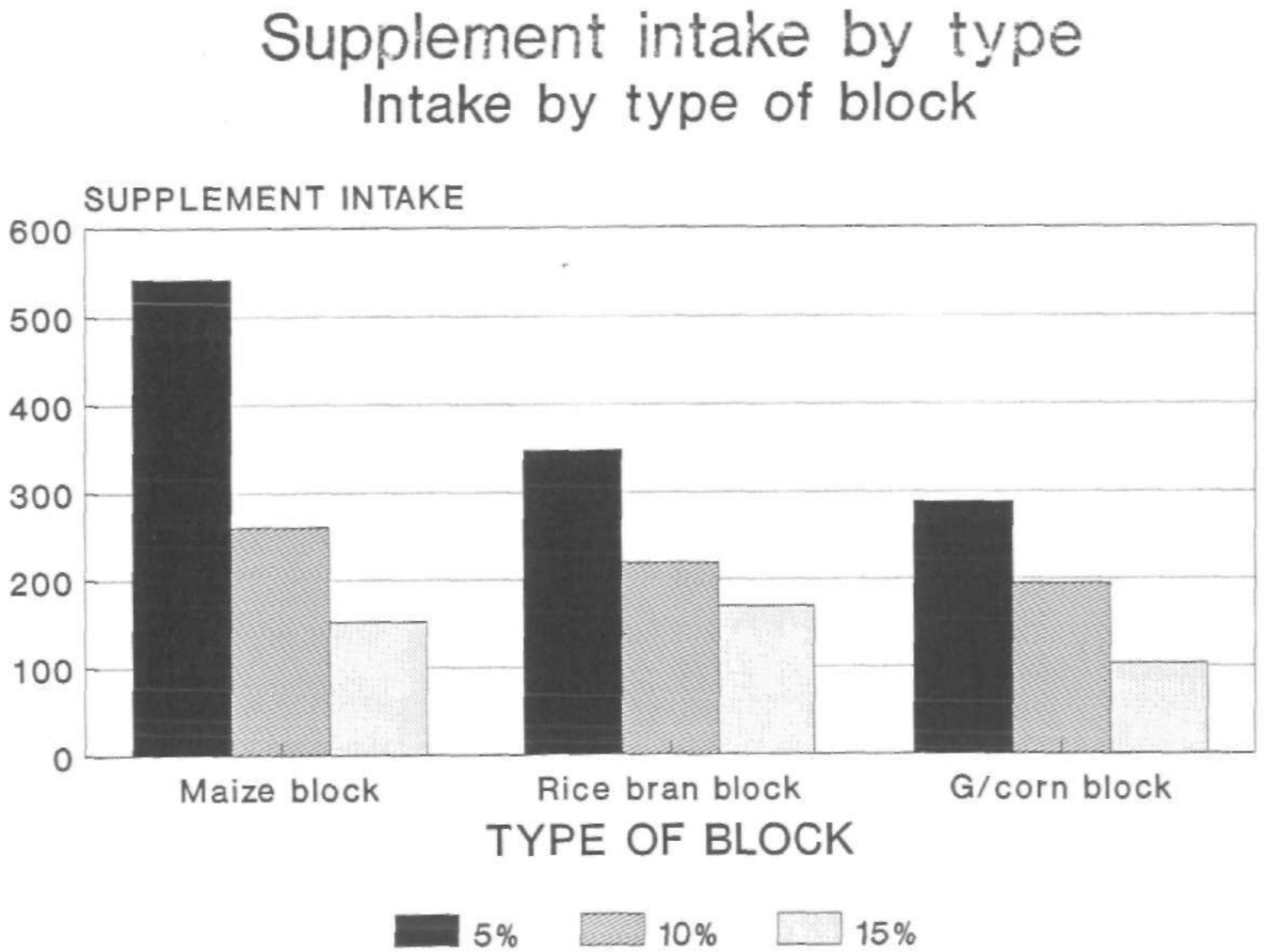

Supplement intake by type
Intake by type of block
SUPPLEMENT INTAKE
600
500
400
300
200
100
0
Maize block
Rice bran block
G/corn block
TYPE OF BLOCK
5%
10%
15%

FIGURE 4.7.16

PERCENT TOTAL INTAKE /(kgW$^{0.75}$)

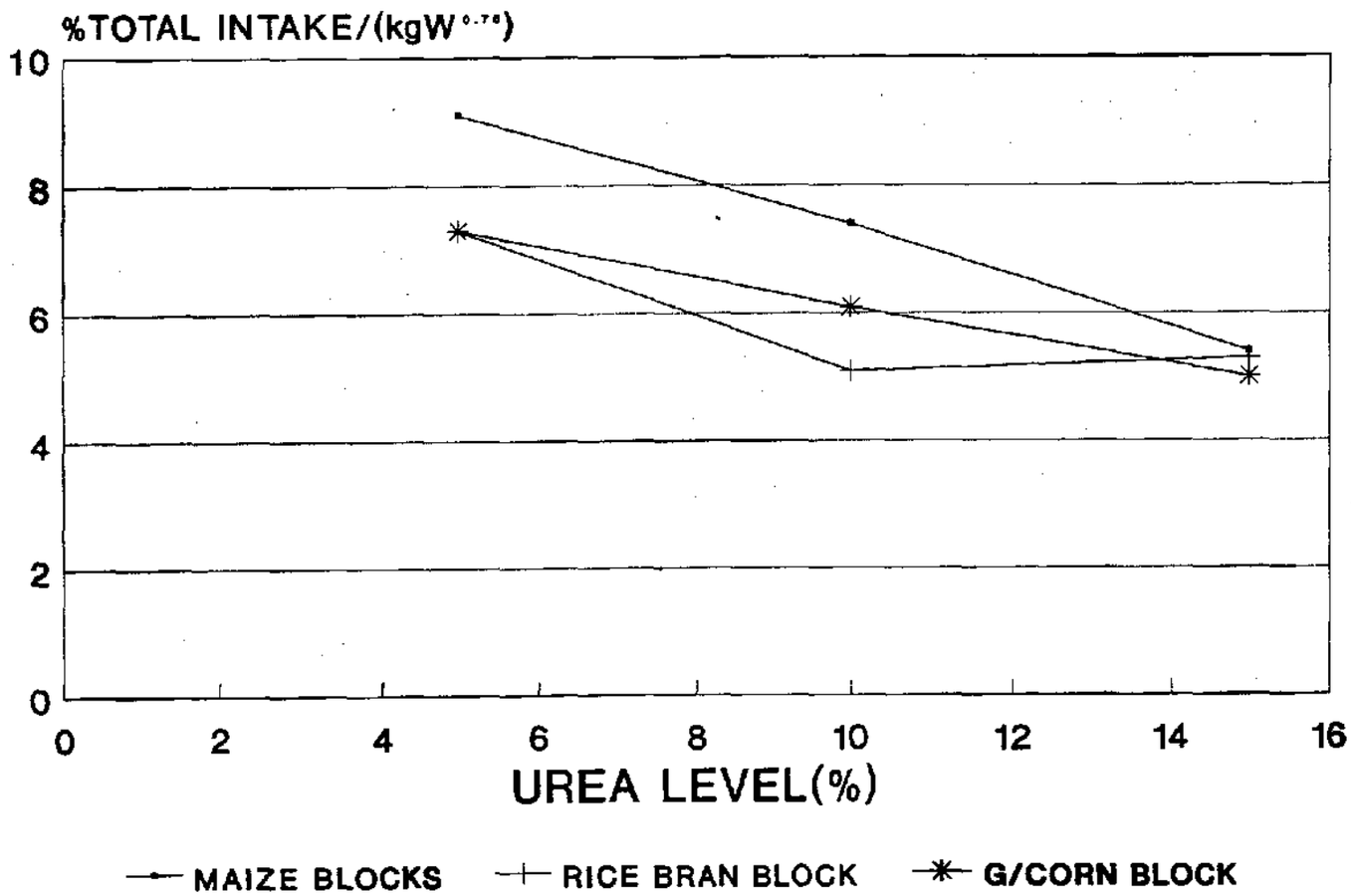


FIGURE 4.7.17

Daily weight change(g)

Weight response to urea level in block

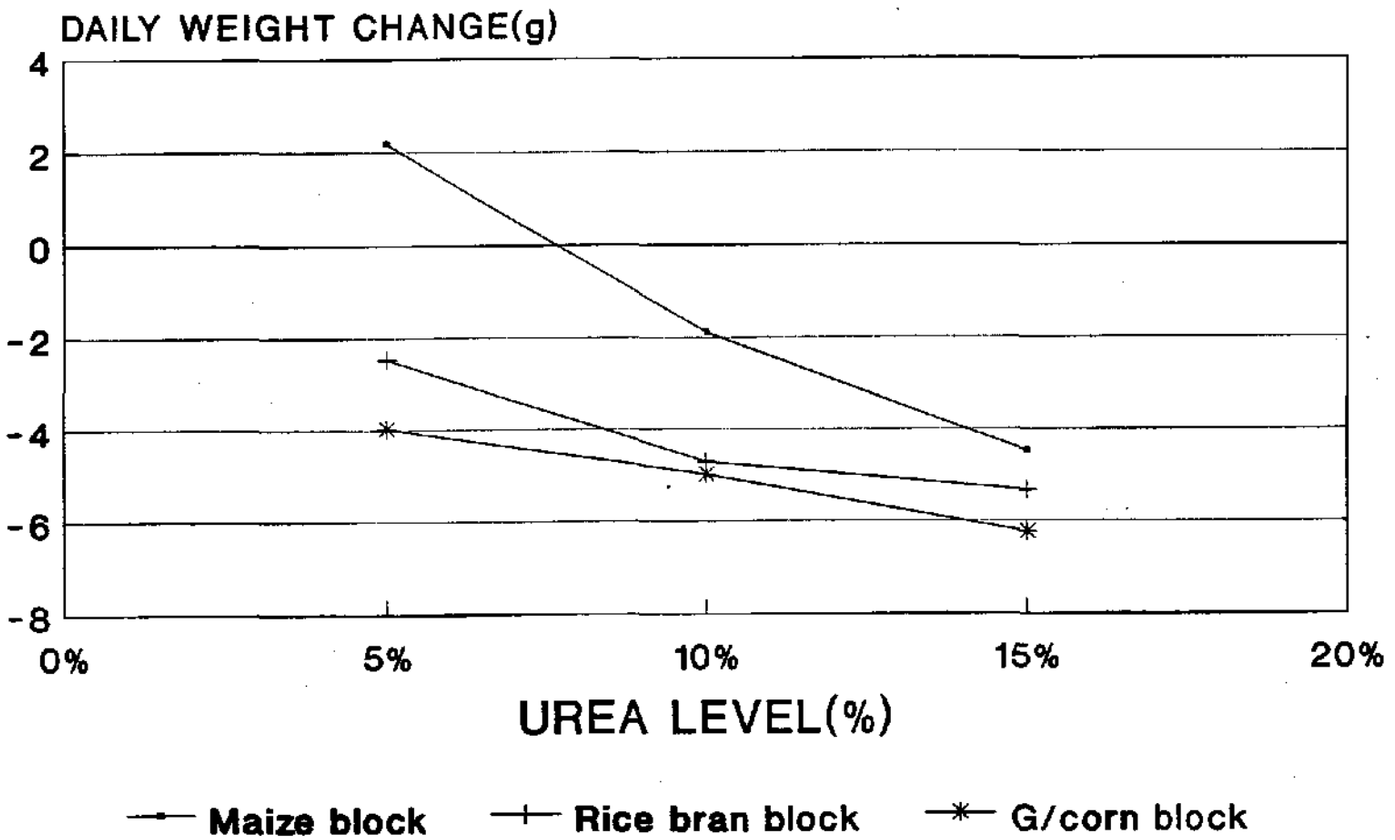


FIGURE 4.7.18

DAILY LIVEWEIGHT CHANGE(g) BY WEEK

Liveweight change(g) for maize block

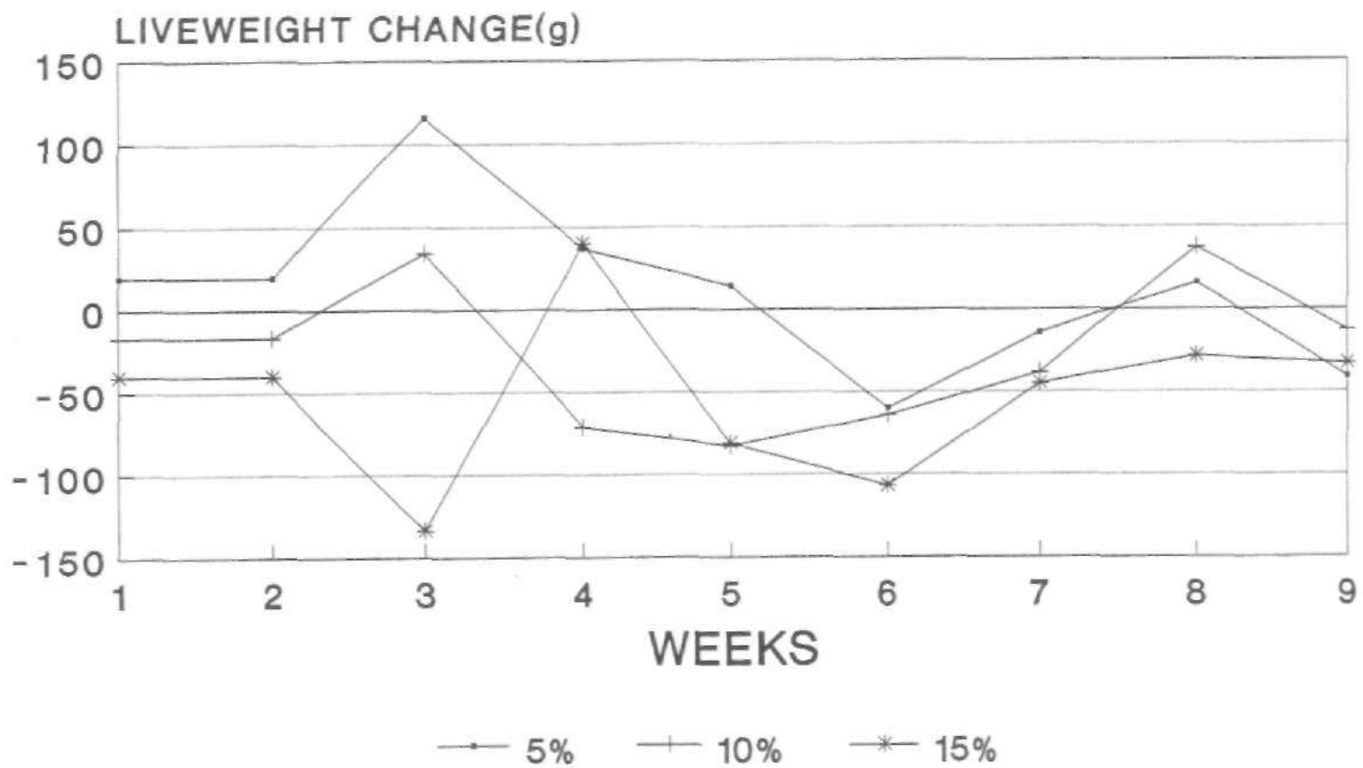


FIGURE 4.7.19

LIVEWEIGHT CHANGE(g) BY WEEKS

LIVEWEIGHT CHANGE(g) FOR RICE BRAN BLOCK

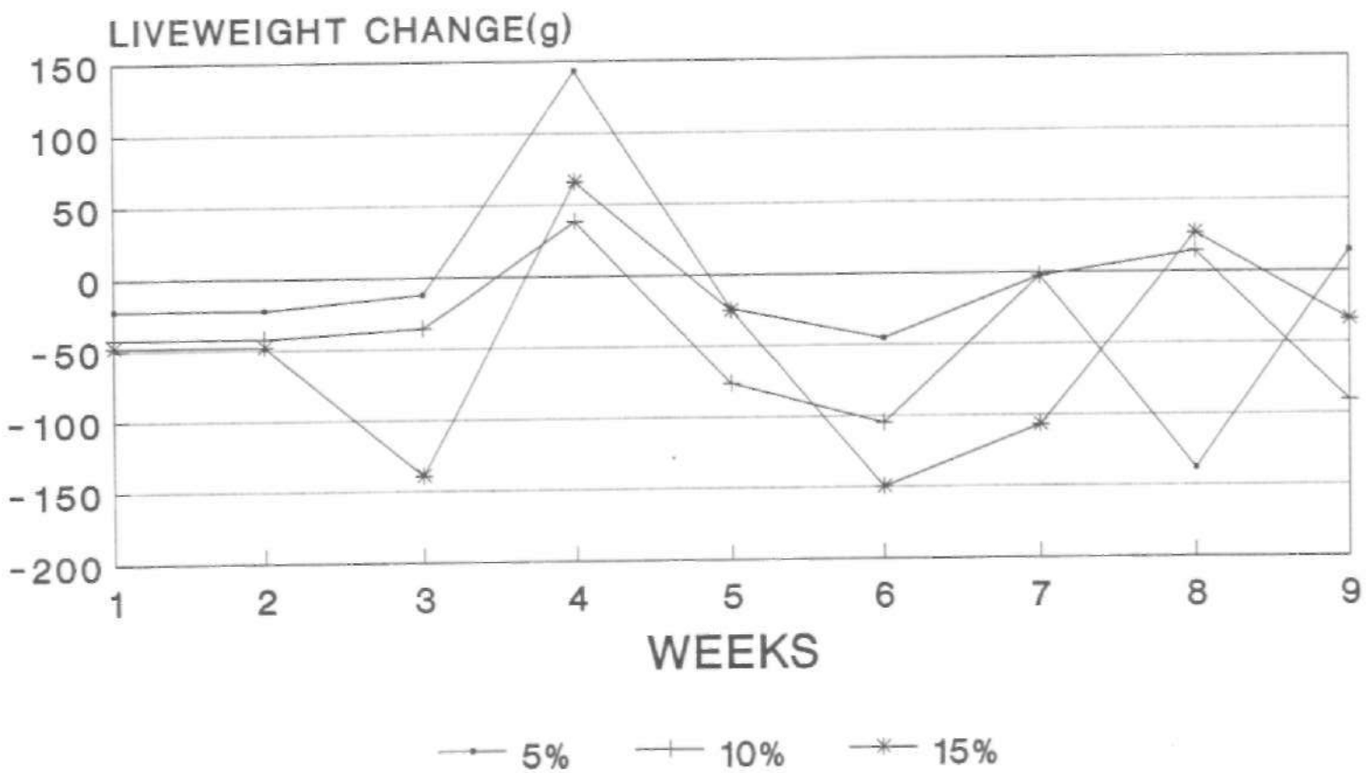


FIGURE 4.7.20

LIVEWEIGHT CHANGE(g) BY WEEKS

LIVEWEIGHT CHANGE (g) FOR GUINEA CORN BLOCK

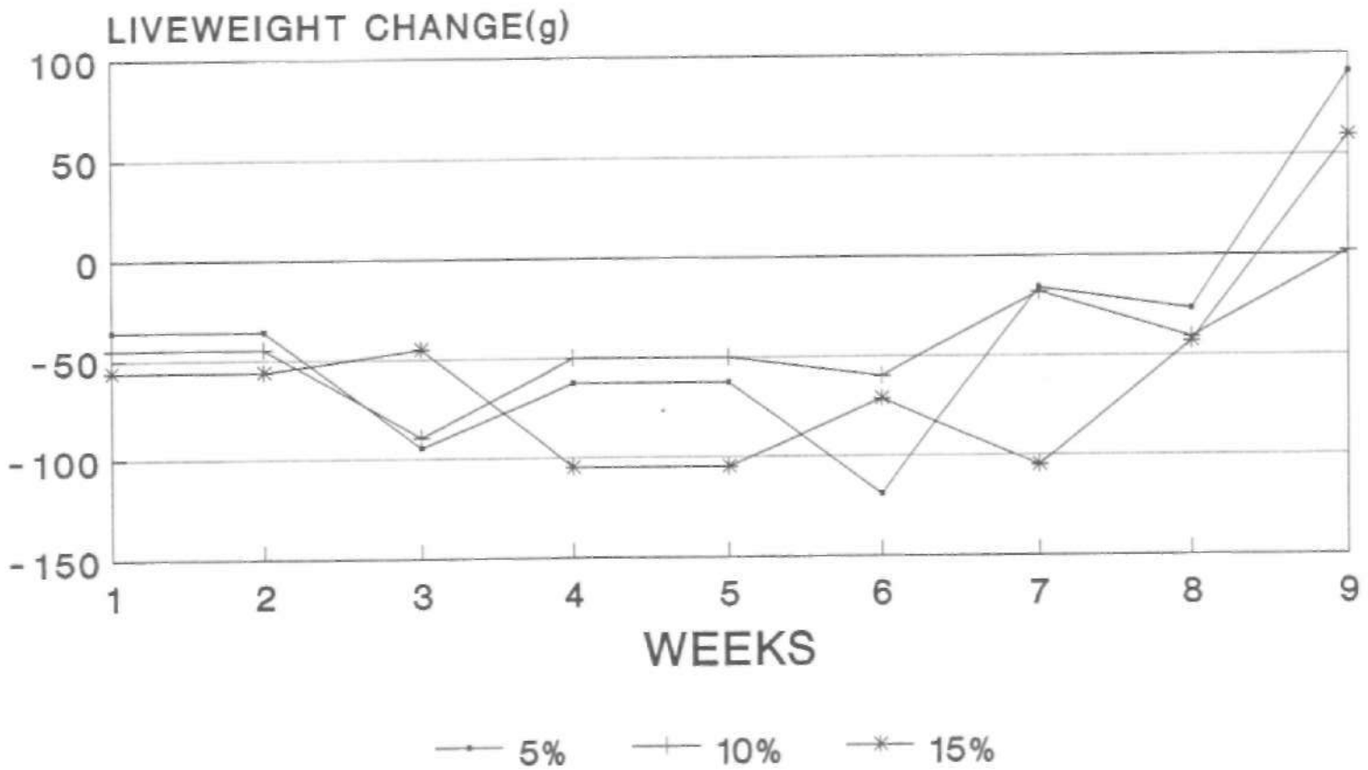


FIGURE 4.7.21

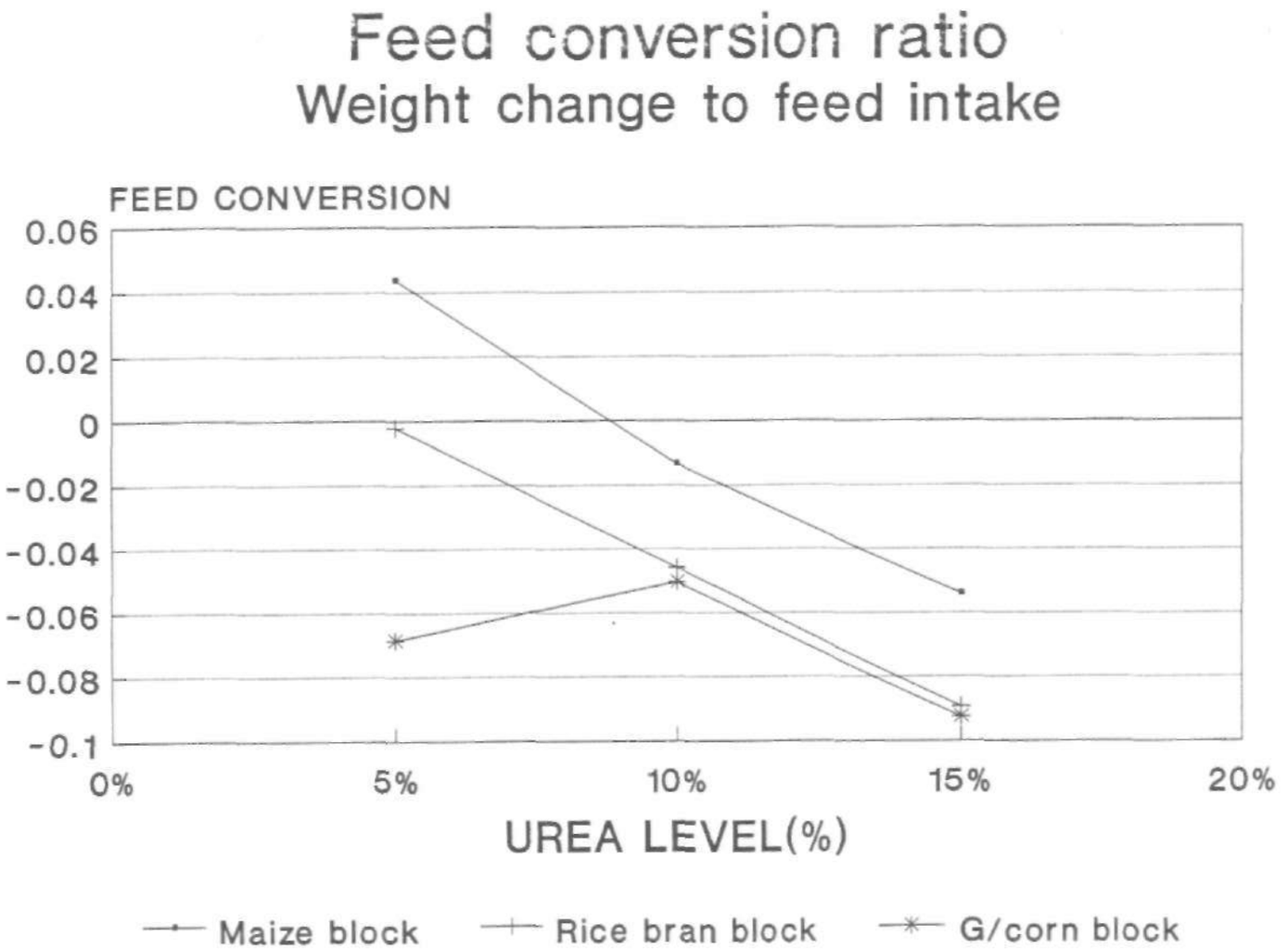

Feed conversion ratio
Weight change to feed intake
FEED CONVERSION
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
0%
5%
10%
15%
20%
UREA LEVEL(%)
Maize block
Rice bran block
G/corn block

FIGURE 4.7.22

FEED CONVERSION RATIO BY WEEKS

FEED CONVERSION RATIO FOR MAIZE BLOCK

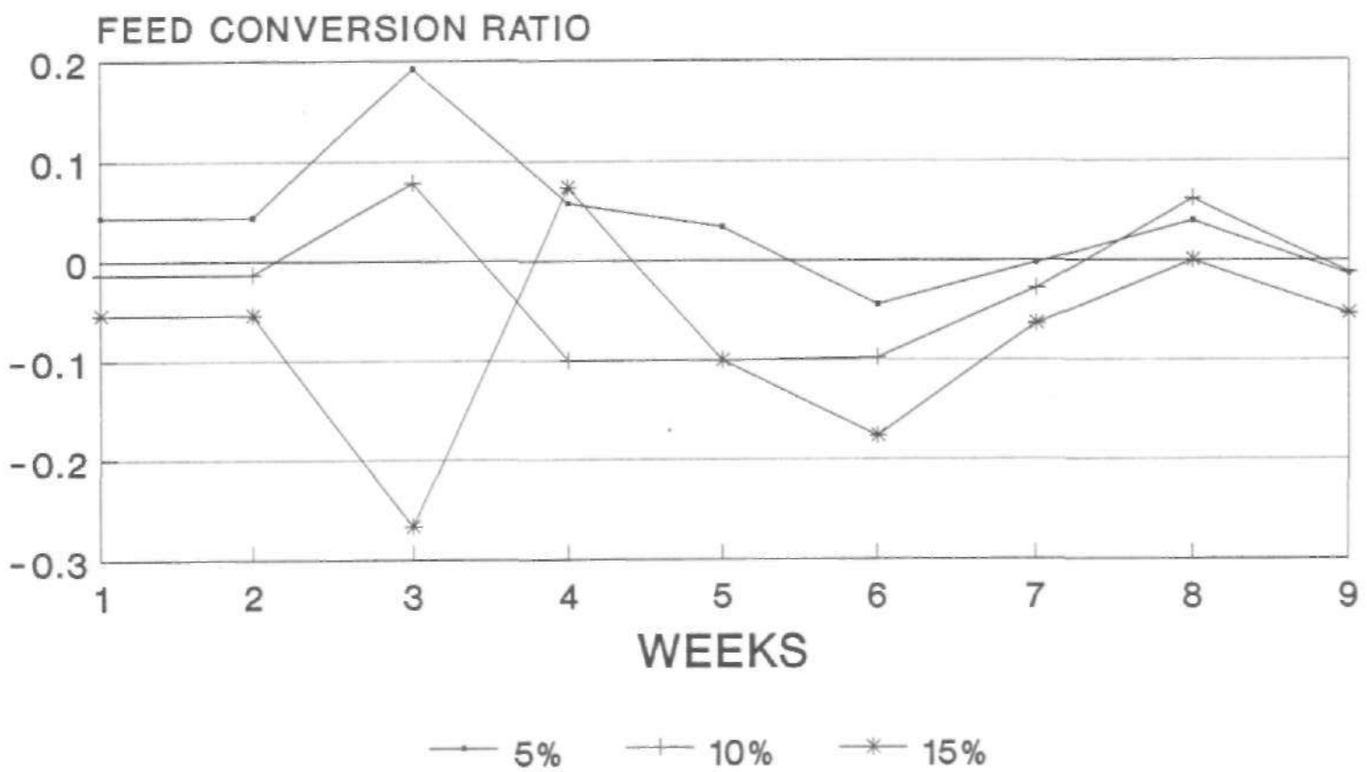


FIGURE 4.7.23

FEED CONVERSION RATIO
FEED CONVERSION RATIO FOR
RICE BRAN BLOCK

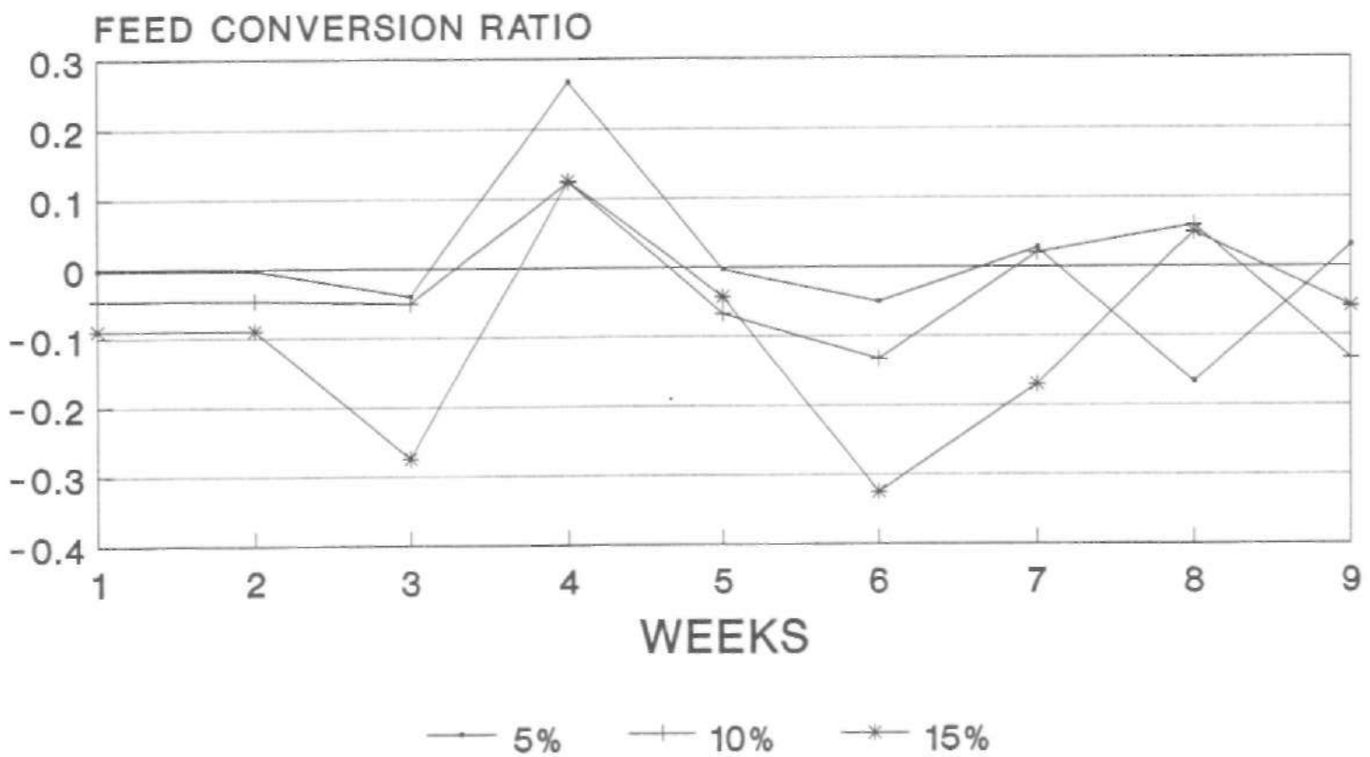


FIGURE 4.7.24

FEED CONVERSION RATIO

FEED CONVERSION RATIO FOR GUINEA CORN BLOCK

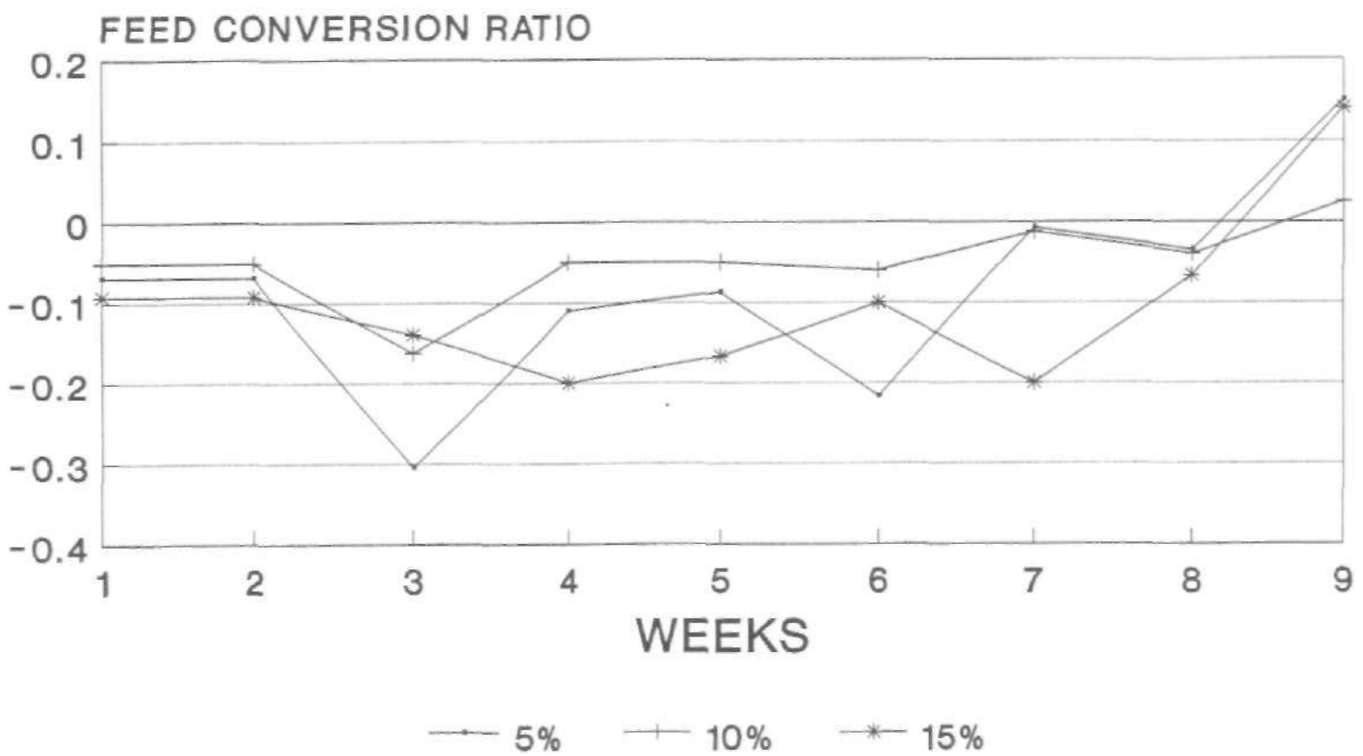


FIGURE 4.7.25



PLATE 1: STEEL MOULD

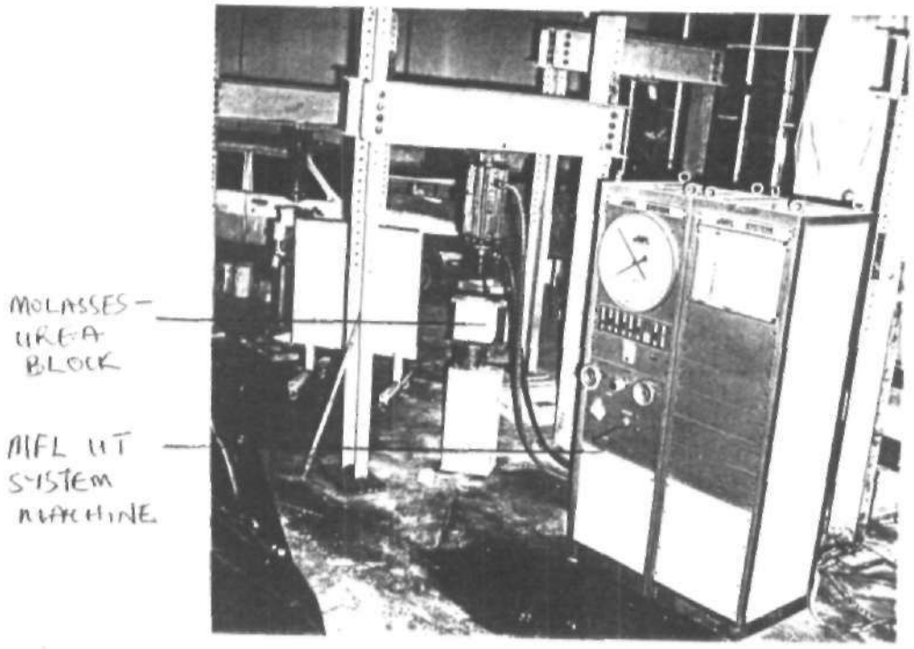


PLATE 2: MFL UT SYSTEM MACHINE

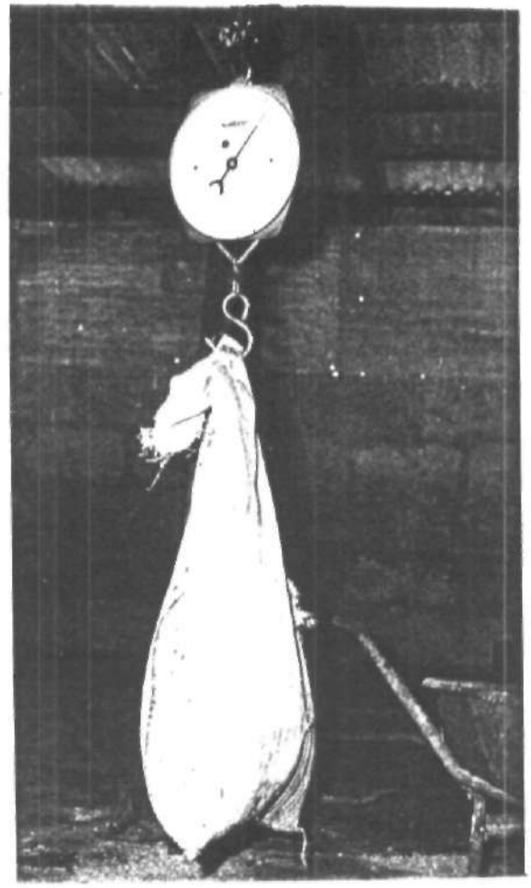


PLATE 3: WEIGHING OF FILLER

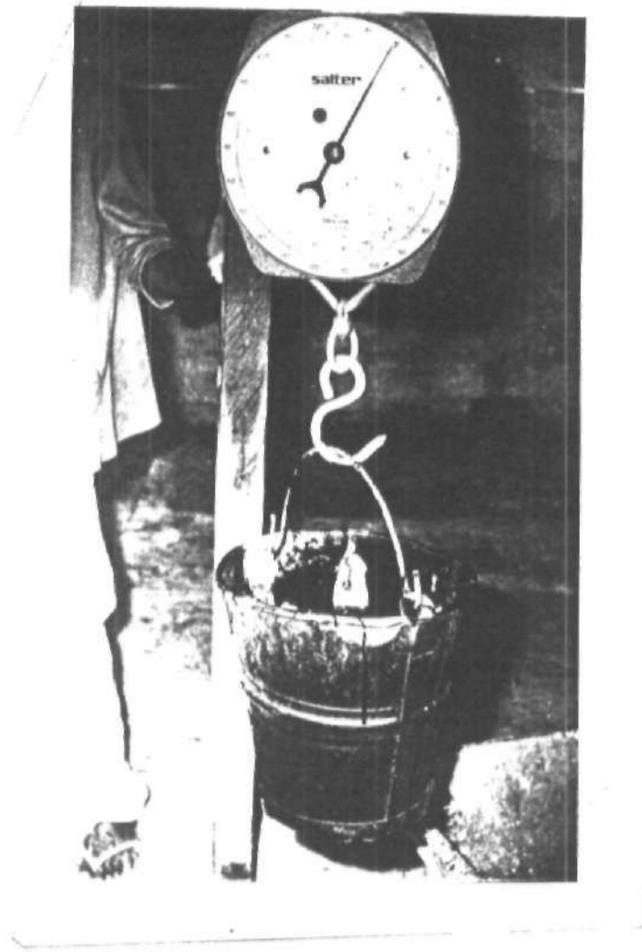


PLATE 4: WEIGHING OF MOLASSES



PLATE 5: WEIGHING OF BINDER



PLATE 6: TAKING TEMPERATURE
OF BIOLING MOLASSES

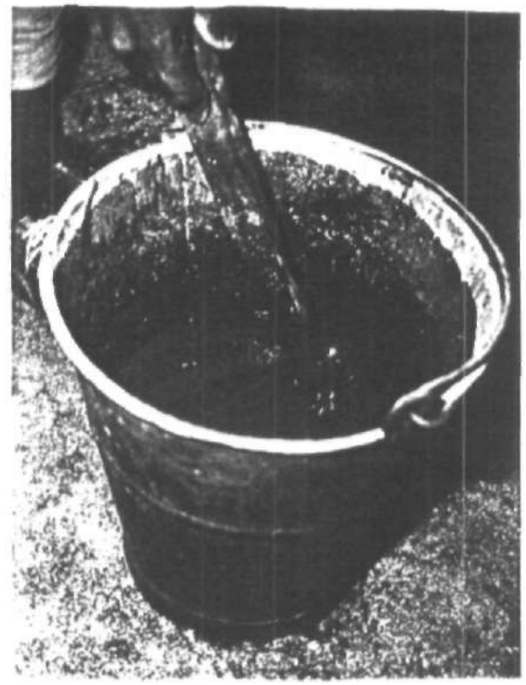


PLATE 7: MIXING OF BIOLED UREA, BINDER AND MINERAL/VITAMIN PREMIX

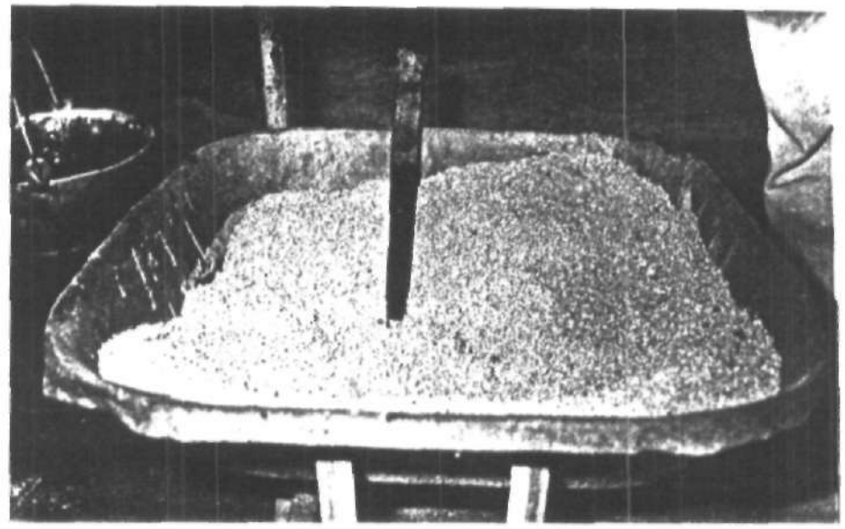


PLATE 8: MEASURED FILLER
IN WHEEL BARROW



PLATE 9: MIXING MOLASSES WITH
UREA, BINDER AND
MINERAL/VITAMIN PREMIX
MIXTURE SOLUTION.



PLATE 10: ADDING MIXED SOLUTION
OF MOLASSES, UREA
BINDER AND MINERAL/
VITAMIN PREMIX TO
FILLER



PLATE 11: FURTHER ADDITION OF MIXED SOLUTION OF MOLASSES, UREA BINDER AND MINERAL/VITAMIN PREMIX TO FILLER.



PLATE 12: KNEADING OF MIXED FORMULATED COMPONENTS.



PLATE 13: MANUAL POUNDING
OF FILLED MOULD
USING WOODEN PESTLE



PLATE 14: EXTRUSION OF MOULDED MOLASSES - UREA BLOCK.