INFLUENCE OF TIME OF SOWING ON THE CHEMICAL COMPOSITION OF FOUR COTTONSEED VARIETIES

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DECLARATION

I hereby declare that this thesis is written by me and that it is a result of my own research work. It has not been presented by any previous applicant for a higher degree.

K.M. ANIGO

18th December 1995

DATE

CERTIFICATION

This thesis entitled "Influence of time of sowing on the Chemical composition of four Cottonseed Varieties" by ANIGO, KOLA MATTHEW meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

TO

GOD ALMIGHTY

ABSTRACT

Four cottonseed varieties (TAMCOT-CABCS, TAMCOT-CAMD-E, TX-CDP.37-H-H-I-83 and SAMCOT-6) sown in May, June and July, 1991 were analysed to investigate the influence of time of sowing and variety on some chemical parameters.

Data obtained showed significant variation in some of these parameters due to time of sowing and variety. Time of sowing significantly increased ($P < 0.05$) gossypol and ester value of TAMCOT-CABCS, but decreases its crude fat and manganese contents. Iron and copper contents of TAMCOT-CAMD-E were increased but had its crude fat, magnesium and phosphorus contents decreased. There were decreases in free cyanide, sodium and manganese contents of TX-CDP, while for SAMCOT-6 there was an increase in total carbohydrate but decreased crude fat, ester and saponification values, manganese and free cyanide contents.

These cottonseed varieties sown in May showed significant effect ($P< 0.05$) of variety on the ester value, saponification value, calcium, sodium, phosphorus, manganese, iron and copper while those sown in June, varietal differences were reflected in their iron content. Those sown in July showed varietal effect on phytic acid, magnesium and manganese content.

Based on the findings of this study, these cottonseed varieties are good sources of oil, protein and roughage, and may be distributed for sowing ending of May to obtain higher cotton fibre and oil yields. Appreciable protein quantity

could be obtained from the cottonseed meal after the extraction of the oil which can be used as feed supplement to animals.

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CHAPTER ONE

1.0 INTRODUCTION

Cotton is grown primarily for its fibre. Cottonseed previously considered as a waste product of the ginning process is now industrially/commercially important (Smith, 1972). Of all the oilseeds, cottonseed has been reported to have the most uses (Abraham and Hron, 1992). Cottonseed which was either buried, dumped into streams, rivers or burnt is now processed for edible oil and cake which could be used in the livestock feed industry and the oil now ranks second in production to soyabean in world edible oilseed tonnage (Frank, 1987). According to Schmit (1984) the protein requirement of 200 million people could be satisfied from the 10 million ton press cake produced annually.

The yield of the products from cottonseed vary depending on the character of the seed, that is, the variety and this has a great influence on the composition of the cottonseed. Ikurior and Fetuga (1987) reported that the composition of cottonseed is quite variable due to the influence of variety and the environment of production.

Insect pests causes considerable damage to cotton plants hence high yield can only be obtained from cotton plant if the pests are kept below an economic level (Matthew, 1989). The low yield from cotton plant in Northern Nigeria have been attributed to among others insect pest and plant disease (Kumar et al 1990). Insect attack was also reported to be one of the factor that caused drastic reductions in the seed cotton yield between 1975-1977 (FRP, 1981). According to Sandhu (1976) amongst the measures to combat pest attack on cotton plant, the method of breeding resistant/tolerant varieties are the most effective and cheapest. An abrupt change from wet to arid condition associated with the harmattan was also recognised as an important factor affecting yield of cotton plant (King, 1951).

The insect pests, disease and drought adversely affect most of the cotton plants on the field and hence lowering the gains from plant. Attempts were then made to improve the genetic characteristics of cotton plant, these later resulted in the introduction of the multi-Adversity-Resistant (MAR) cottonseed varieties. These varieties which are under trial at the Institute for Agricultural Research, Zaria are high yielding, early maturing, drought, pest and disease resistant. Some of these varieties are already in large scale cultivation in the United States of America and several West African countries (Kumar, et al. 1990).

Weather conditions throughout the growing season has been reported to affect the quality of oilseed (Abraham and Hron, 1992). Jones (1968) reported that over half of the Northern Nigeria crops are planted at least a month later than the optimum date of mid-June to mid-July according to the area. It has also been reported by (Kumar et al, 1990) that cottonseed plant are sown late in the cotton growing areas of Nigeria. Cotton in the Northern cotton zone of Nigeria are planted late from mid-July to end of August (FRP, 1981). The gains from these MAR cottonseed varieties may be ultimately lost because of the late sowing of cottonseed in the cotton growing areas since Jones (1968) reported that planting date is the most important single factor affecting the plant and that early planting is a basic essential to this end. More reports (Duffus and Slaughter, 1980; Hui, 1992) have also revealed that environmental factors such as light, temperature, water availability and seed maturation can greatly influence the protein and lipid contents of oilseeds. Present study was therefore, designed to prospectively observe the possible effects of time of sowing and varieties on the nutrient composition of cottonseed.

There is need to establish the true chemical composition of these cottonseed varieties in our environment and to standardize the time of sowing with variety to determine the time the varieties can be sown to derive maximum level of nutrients and lowest level of antinutritional factors for animal feed and high quality oil.

Clearly define objectives of the study are:

1) Determination of the effect of sowing time on the proximate and mineral composition of the four cottonseed varieties.
2) Investigation of the effect of sowing time on the level of some antinutritional factors in the cottonseed varieties.
3) Determination of the effect of sowing time on some of the physicochemical characteristics of the oil of the cottonseed varieties.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 BOTANY OF COTTON PLANT

Cottons are malvaceious plants which belong to the genus Gossypium. Of the 33 species recognised by Fryxell (1969), all but four are wild shrubs of no commercial worth. One or more species are native to every continent of the world that lies within the tropical zone. The four cultivated species are distinguished from the wild species by relatively long, convoluted spinnable seed hairs. The wild species have short, rod-shaped seed hairs that cannot span. Lewis and Richmond (1972) reported that the cultivated species are Gossypium arboreum L., Gossypium herbaceum and Gossypium hirsutum L.

It has been observed by Prentice (1972) that cotton is a warm weather plant and neither the wild nor cultivated species survive hard freeze and the cultivated cottons do not grow well below 18°C. However, within thermal limitations, agricultural varieties have shown great adaptability to widely differing rainfall, soil and cultural conditions. The climate of the temperate zone as well as the strong breeding pressure for earliness of crop maturity has forced cotton to be grown as an annual crop.

The cotton plants yield the most beautiful fibre (lint) and seeds yielding both oil and feed, which was neglected for a long time, is now estimated to worth one-sixth as much as the fibre (Smith, 1972). It is therefore, possible that cotton plant may be grown as much for the cottonseed by-product as for the fibre.

2.2 COTTONSEED

The cottonseed are by-products of the fibre crop and according to King and Leffler (1979) they constitute more than 60% of the harvested yield. Cottonseed store oil as the major energy source and it was reported (Martinez et al., 1970) that it could be a multiple source of edible products, protein and oil. The present world production of cottonseed is in excess of 20 million tons (TPQ, 1970) representing a protein potential of about 6 million tons per annum (Shemer, et al., 1973).

2.2.1 COTTONSEED PRODUCT

Lewis and Richmond (1972) described cottonseed as a product of the cotton plant comprising two principal parts namely the hull from which the staple cotton and cotton linters arises, and the kernel from which oil and meal are obtained. These two principal parts can be separated into three economic fractions namely the residual lint (linters), seed coats (hulls) and embryo (kernels). The linters are seed hairs left after ginning while hull is the fibrous seed coats left after the kernel is extracted. The kernels constitute the seed fraction of greater value. The two main products of the kernels are oil and meal. In general, there are four primary products produced by the cottonseed processing plants namely cottonseed oil 16%; cottonseed meal 45%; cottonseed hulls 26% and cottonseed linters 9% (Hui, 1992).

Cottonseed oil has long been recognised as the most valuable of the products of cottonseed and on the average it accounts for slightly more than half of the total value of the four products

(Smith, 1972). The oil was used quite extensively both as an illuminant and as a lubricant (Moloney, 1940). The increase in the production of cottonseed oil led to the development of shortening in the United States of America (Bailey, 1948). The most important characteristics of cottonseed oil is its stability. The cottonseed oil contains oleic acid (25.7%) and linoleic acid (48.5%) as its major unsaturated fatty acids (Abraham and Hron, 1992). During hydrogenation a large part of the linoleic acid is converted to oleic acid or stearic acid and the stability is further increased.

Cottonseed meal is the second most valuable product from cottonseed accounting for about 30 to 35% of the total value. Ensminger (1967) reported that cottonseed meal contains between 36 to 45% protein. Glandless or degossypolized cottonseed flour may contain over 60% protein (Shemer et al., 1973). In a study, Bourely and Besancon (1986) reported the protein efficiency ration of cottonseed oilmeal in growing rats to be 3.2 compared to 2.7 for soyabean oilmeal and 3.6 for casein. In Northern Nigeria cottonseed is commonly soaked in water (Oyenuga, 1968) which is fed to cattle and sheep as supplementary food. Schmit (1984) reported that cottonseed press cake has been well received in recipes in Tchad and Cameroon. Result from nutritional experiments in several American, Asian and African countries have shown that cottonseed flours are of very good nutritional value for infants (Bourely, 1990).

It was also reported (El-minyawi and Zabik,1981) that sensory data indicated that bread that contains 12% cottonseed flour was acceptable. A major breakthrough is the ability to produce edible cottonseed flour by a process involving liquid cyclones and a processing plant in India was reported to be producing three tons of such flour daily (Gastrock and D'Aquin, 1971). Cottonseed flour is a highly concentrated source of protein of excellent biological quality and of minerals and vitamins of the 8-group it has certain unique physical properties (Black, 1948). It is remarkably stable in storage and is free of any tendency toward so called "Flavour reversion."

Cottonseed hulls are a major source of roughage for cattle in areas of cotton production and hulls are used widely in both growing and fattening rations. Hulls are often incorporated in the mud used in the drilling of oil wells and are also used in the production of synthetic rubber, in petroleum refining and in the manufacture of certain types of plastics (Smith, 1972). Cottonseed hulls are also used in soil conditioning (Hui, 1992).

Linters are the short residual fibre on the cottonseeds before extraction of oil (Becker and Pfeffer, 1978). Linters are used in the preparation of high quality bond paper and as felts for pads, cushions, comforters, and mattresses (Hui, 1992). They can be processed (NCPA, 1989) so that the cellulose can be used in such diverse products as plastics, food casings, X-ray films and many other industrial products.

2.3 CHEMICAL COMPOSITION

Early reports of cottonseed composition are subject to some speculation in regard to the methods of analyses and the exact strain or variety under consideration (Tharp, 1948).

2.3.1 PROXIMATE COMPOSITION

Complete analyses of cottonseed and each of its parts have been reported. Guthrie et al. (1944) showed the proximate composition to be 9.9% moisture, 19.5% oil, 19.4% protein, 22.6% crude fibre and 4.7% Ash. He cautioned that the values listed are average values for air-dry samples, and that individual values are quite variable due to the influence of variety, stage of maturity, environment of production, and mode of processing. The cottonseed - Gossypium species Linn., contains 5.44% moisture, 28.47% crude protein, 14.05% lipid, 21.61% crude fibre and 4.75% Ash (Oyenuga, 1968). Commercial cottonseed contains approximately 8% moisture, 16-20% protein, 18-24% oil, 22% crude fibre and 30% carbohydrate (Brown and Ware, 1958). Surendranath et al., (1975) reported an oil yield varying from 15 to 18% for cottonseed. The cottonseed variety Reba B50 contains 34.6% protein, 39.3% oil (Forma and Ngeka, 1985). Three Nigerian commercial cottonseed varieties and composite cottonseed from 3 locations were assayed (Ikurior and Fetuga, 1987) for proximate and mineral composition. The mineral values were relatively high and phosphorus was the most abundant, average 1.34% and 1.28% in the varieties and composite seed, respectively. The oil content in the varieties studied by Rakhimov (1980) ranged from 18 to 29%.

2.3.2 CHARACTERISTICS OF THE COTTONSEED OIL

The saponification value of 189-198 was reported (Hui, 1992) for cottonseed oil and also a range of 99-113 Iodine value. Fernando and Akujobi (1987) reported cottonseed oil from Gusau to contains 0.48 acid value, 195.0 saponification value and 77.7 Iodine value. Oil of highest quality expressed from American cottonseed as reported (Bailey, 1948) have a free fatty acid content of 0.5-0.6%. Although, an unfavourable climatic condition may cause the oil from an entire cotton growing state to average 5.0% or higher in free acids while extremely bad oil may contain 15-25% of free fatty acid (Bailey, 1948).

2.3.3 ANTINUTRITIONAL FACTORS

It has long been known that seeds generally contain a wide range of substances which, if not destroyed or removed will have an adverse effect on their nutritional value (Udoessien and Ifon, 1992).

2.3.3.1 GOSSYPOL

The use of cottonseed products (oil, meal and protein) by animals and human was reported to be limited by the presence of a toxic compound called gossypol (Lewis and Richmond, 1972). It's presence in cottonseed makes the by-product undesirable for eating or as feeds when compared to other oilseed meals. Gossypol is a pale yellow pigment produced by the pigment glands of the kernel of which it constitutes about 30-50% of the weight of the pigment gland (Smith, 1972). It has been observed (Admasu and Chandravanshi, 1984) that the amount of gossypol present in the pigment glands varies with the varieties of the plant and method of extraction of the oil. It also varies with the genetic type of the cotton plant and environmental condition during the development of the cottonseed. Gossypol is present in the cottonseed either as bound gossypol or in the free form (Panigrahi, 1990). It is present in larger quantity in the free or unbound form than in the bound form . Bound gossypol is relatively non-toxic and it was postulated that the inactivation of gossypol is due to combination of the gossypol with some of the cottonseed protein (Damaty and Bertran, 1979). However, it was reported (Zhuge et al., 1988) that the processes of extrusion, drying and fine grinding can be used to reduce the amount of gossypol in cottonseed meal.

Gossypol can be inactivated by cooking (Frank, 1987). Panigrahi (1990) reported that when hens were fed with cottonseed meal, the free gossypol in the meal was deposited in the yolk where it combines with iron to produce a brown coloured complex. The toxicity of gossypol can be prevented by the addition of iron salts to the diets (Cunha, 1977). Pigs dying from gossypol toxicity are reported (Wallace et al., 1955) to exhibit some symptoms which include excessive quantities of fluid in the pleural and peritoneal cavities, flabby and enlarged hearts, congested and endamatous lungs and a general congestion of other organs such as liver, spleen and lymph glands.

The precise mechanism of action of gossypol in susceptible animals is not known. However, intoxication may arise from one or a combination of the following effects:

i) Gossypol increases the rate of passage of food through the gut thereby reducing the time of exposure of the diet to digestion processes.

ii) Gossypol inhibits proteolytic enzymes by reacting with epsilon amino ($E-NH_2$) group of lysine in the pepsinogen, pepsin and trypsin molecules thus hindering their action in digestion processes (Dharmagrogartana et al., 1973).

iii) Gossypol interferes with amino acids absorption to varying extents. These actions could combine to produce a negative nitrogen balance in animal consuming gossypol containing meals (Damaty and Bertran, 1979).

iv) It was also postulated that the fundamental mechanisms of the observed lesions of gossypol poisoning may possibly be through interference with oxidative processes (Smith, 1957).

v) Similarly, it was suggested that gossypol may act and produce toxicity by preventing the release of oxygen from oxyhaemoglobin and lysis of red blood cells (Radeleff, 1970).

Gossypol is one of the major factors that influence the genotypic susceptibility to spotted bollworm. Bollworm resistant cotton varieties has been characterised by high amount of gossypol (Lee and Smith, 1970). It has been observed (Fu and Reiser, 1962) that gossypol does not apparently harm adult ruminants like sheep and cattle that have their rumen fully developed. This was attributed to the action of some micro-organisms in the rumen that degrade the gossypol.

Free gossypol in pig diet had no effect on its performance when iron was included in the diets on a 1:1 weight ration to free gossypol (Knabe et al., 1979). It was reported (Nzekwe and Olomu, 1979) that the use of cottonseed as ingredient in poultry rations is limited due to its gossypol level. Oyenuga (1968) reported 300 to 3000 mg/100g gossypol for cottonseed oil. The gossypol of 13 varieties, commercial and experimental lines in Colombia was estimated (Arias and Hernandez, 1977) and they reported that the gossypol ranged from 0.72 to 1.89% and that the result is influenced by environmental factors. The amount of gossypol in a moisture-free kernel varied for different varieties and growing conditions (Berardi and Golbatt, 1980) and ranged between 0.39 and 1.7%.

2.3.3.2 PHYTIC ACID

Phosphorus is very important to plant nutrition and a large proportion of the total phosphorus in plants is present as phytic acid (Inositol hexaphosphoric acid) or its salts (Khan et al., 1986). Most of the phosphorus in cottonseed meal as in most other oilseeds had been observed to occur in the form of phytic acid (Altscul, et al., 1958). Fernandez and Phillips (1982) reported that phytic acid has 12 replaceable hydrogen atoms and can form insoluble salts with calcium, magnesium and iron. The calcium-magnesium salt of inositol hexaphosphoric acid is called phytin.

The formation of insoluble salt with metal ions make them unavailable to the body except in circumstances where fermentation favours the activity of phytase, an enzyme which hydrolyses phytic acid into phosphoric acid and inositol (Tewell et al., 1973). Phytic acid is important for animal and human nutrition because of its ability to chelate several metals and thereby reduce their availability (Khan et al., 1986). Iron and zinc deficiencies were reported to occur in populations that subsist on unleavened whole grain bread and rely on it as a primary source of these minerals (Reinhold et al., 1973). These deficiencies have been attributed to the presence of phytate. However, it has been reported that phytic acid content is reduced during the process of bread making (Tersarkissian et al., 1974; Harland and Harland, 1980). Beal and Mehta (1985) also reported that there was 13% reduction in the phytate content of cooked peas. Charkraborty and Eka (1978) reported 101.33 and 110.00mg/100g phytic acid for maize and cowpea respectively. The cottonseed oil cake yielded according to sagdullaeu et al. (1979) 5% phytin of the weight of the initial oil cake. Oke (1967) reported cereals, grains and tubers found in the southern part of Nigeria to contained high amount of phytic acid. The phytate content of four yam species was reported to ranged between 3.70 to 9.70mg/100g dry matter (Udoessien and Ifon, 1992).

2.3.3.3 OXALIC ACID

Oxalates are naturally occurring nutritional stress factor that interferes with the absorption of the essential nutrients calcium, iron and to a certain extent zinc (Teutonico and Knorr, 1985). Oxalate when taken into the body, not only combines with calcium as reported (Davidson et al., 1975) but also combined with magnesium to form insoluble salts which are not available to the body. Teutonico and Knorr (1985) reported that oxalate are found in appreciable quantities in spinach (5.6% dry matter), rhubarb (7.8%), swiss chard (5.5%) and amaranta (7.2%). In Plants, oxalic acid is found in two forms, water soluble and water insoluble forms. The soluble oxalates are mainly present as salt of sodium and potassium ($NaHC_2O_4$ and KHC_2O_4). The insoluble oxalate occurs mainly as calcium salt. Free oxalic acid rarely occurs in plants and it is only the soluble salt of oxalic acid that are toxic (Dye, 1956). The lethal does of soluble oxalate for man range from 2 to 5g (Oke, 1966). Schuphah and Weihman (1958) reported that if normal diets contain enough calcium then soluble oxalate would have no remarkable toxic effect on children or adults. It has been found that ruminants can consume a high amount of high oxalate plants while non-ruminants cannot. This might be due to the presence in the intestine of ruminant micro-organism that break calcium oxalate to carbon dioxide and water (Watts, 1959). Zea may was reported by Ayatse et al. (1983) to contain 22.6mg/100g dry matter soluble oxalate. The soluble and total oxalate content of four yam species reported by Udoessien and Ifon (1992) were 5.30 to 11.60mg/100g and 43.80 to 49.50mg/100g dry matter respectively.

2.3.3.4 TANNIN

Tannins are plant polyphenols of relatively high molecular weights. They are stringent components of many foods and their ability to cause coagulation of proteins is the basis for their use as "tanning agents" in the Leather Industry. Tannin was observed to exert its adverse effect by binding onto protein and reducing its nutritional value (Ford and Hewitt, 1979). Tannin has also been shown to inhibit iron availability (Fernandez and Phillips, 1982). They are localised primarily in the pigmented layers of the cottonseed coat and in seed linters with lesser quantities in the nucleus and in the palisade parenchyma of embryo cotyledons where they act as chemical barrier against infection by fungi and physical barrier against water absorption (Halloin, 1982). Elkin et al. (1978) reported that chicks fed sorghum grains containing high levels of tannin had a higher incidence of leg abnormalities than those fed low tannin sorghum diets. Also high tannin sorghum depressed chick growth feed-efficiency. Some sorghum elite cultivars are low in tannin and their content as catechin equivalent from 0.075 to 0.215% of dry matter (Okoh et al., 1982). Obilana et al., (1982) observed that 16 improved Nigerian varieties showed little difference in ash, fat and carbohydrate contents but the crude protein and tannin showed considerable variations, with those high in crude protein values advantageous in terms of human nutritional requirement. The tannin contents reported for four yam species range from 20.00 to 75.00 mg/100g dry matter compared to sorghum 260-2370 mg per 100g dry matter (Udoessien and Ifon, 1992).

2.3.3.5 HYDROCYANIC ACID

Hydrocyanic acid is a deadly poisonous liquid whose effect has been attributed to its affinity for metal ions like iron and copper (Smith, 1991). It combines with haemoglobin which is an oxygen carrier. It may also combine with copper of the cytochrome oxidase which inhibits its function as an oxidative enzymes in electron transfer (Smith, 1991). It has been found that due to the medical significance of cyanide and the relative ease of its detection and determination most research data were given in terms of potential yields of cyanide rather than the glycoside content itself. Quisunbine (1947) established that many species of plants contain Hydrocyanic acid usually in the form of cyanogenic glycosides and listed 300 species of plants (74 families) containing Hydrocyanic acid with 52 species in the family of Leguminasae and 25 in Gramineae. The toxicity and release of Hydrocyanic acid is influenced by many factors like conditions of drought or wilting, stage of growth and soil fertility (Oke, 1969). Different animals react differently to glycoside due to the differences in their anatomical structure and detoxifying ability. It was observed (Dykstra, 1952) that ruminants were more susceptible than non-ruminants. Cyanide tended to decrease feed intake and growth rate in growing rats given diets with different amounts of cyanide (Tewe and Maner, 1982). Jackson (1988) reported that rats treated with cyanide results in significant decreased dominance behaviour, vocalisation, fighting, aggressive feeding patterns, pica and increased victimisation, distratibility from eating, anaesthesia recovery time, limping, limb stiffness, increase vomiting and shivering. Heat or hot water treatment of sorghum during processing according to Ikediobi et al. (1988) helps to detoxify the Hydrocyanic content of sorghum based food products and beverages. Studies on the etiology of human atoxic neuropathy in Nigeria (Osuntokun, 1969) and in Tanzania (Makene and Wilson, 1972) have led to the hypothesis that this condition was caused by chronic exposure to cyanide or cyanogens ingested in cassava.

Eka (1983) reported the Hydrocyanic acid lethal dose of 50-60 mg for an adult human. It was found that 25 mg/100g and 100-500mg/100g Hydrocyanic acid was contained in peeled plantain and peeled cassava respectively (Chakraborty and Eka, 1978). The Hydrocyanic acid of four yam species varied between 1.08 to 1.89 mg/100g dry matter (Udoessien and Ifon, 1992).

2.3.4 MINERAL ELEMENTS

The term mineral elements could be used for all those chemical elements found in foodstuffs which when traced back to source, enter the plant food from the soil (Nelson, 1951). A number of these elements are present in trace amounts in food and are known to be essential in human nutrition (Mertz, 1983). Humans require at least 18 minerals (Osborne and Voogt, 1978) and when in the body may be incorporated into the body structure, or functions as cofactors for enzymes, or are required as electrolytes.

Manganese is required by mammals for normal growth and reproduction (Underwood, 1977; Leach and Lilburn, 1978). Deficiency of manganese according to Underwood (1966) leads to low levels of alkaline phosphatase and liver arginase in the body. A daily intake of 2.5 - 5.0mg manganese had been recommended as adequate for adult humans (Lecos, 1983).

Zinc is an essential nutrient being a component of a large number of zinc metallo-enzymes such as carbonic anhydrase, carboxyl peptidases A and B, and alcohol dehydrogenase (NRC, 1980). Zinc deficiency leads to growth retardation, delayed sexual maturation, abnormal feather, skin lesions and skeletal abnormalities in chicks.

Copper is another essential nutrient and is present in a number of enzymes involved in oxidation and reduction reactions in the body. For example, in the absence of copper, cytochrome oxidase is completely inhibited and the animal or plant is unable to metabolise food effectively. Copper deficiency results in anaemia, abnormal bones, poor growth, defective connective tissues and death (Venugopal et al., 1978).

Iron is a component of myoglobin and the cytochromes. Hui (1992) observed that the availability of iron is dependent on the chemical form of the iron and its interaction with various components. The availability of iron is enhanced by protein

(Klavins and Kirney, 1962), vitamin C (Hallberg, 1981) and citric acid (Gillooly et al., 1983) whereas the availability of iron is inhibited by phytate (Hussain and Patwardhan, 1959), tannins (Disler et al., 1975) and fibre (Fernandez and Phillips, 1982). Cereal grains contain between 30 to 60 ppm iron (Miller, 1958).

Sodium and potassium occur largely in the fluids and soft tissues where they function in maintaining osmotic pressure, acid-base equilibrium, in controlling the passage of nutrients into cells. Aldrich and Leng (1969) also reported that potassium is essential for vigorous growth, lack of which decreases the utilisation of digested protein and energy while the deficiency of potassium causes heart lesions, tubular degeneration of the kidneys and other pathological changes (NRC, 1980).

Nugara and Edwards (1963) reported that there were interrelationship between magnesium, calcium and phosphorus and that, hormones and enzymes involved in bone metabolism may be related to magnesium metabolism. The magnesium contents of plant materials had been shown by Kempt et al. (1961) to increase with increase in their maturity. Underwood (1966) observed that only 20-30% of the magnesium present in ordinary diets are absorbed. High levels of calcium and phosphorus have been shown to depress magnesium absorption in sheep (Chicco et al., 1973; Pless et al., 1973).

Thomas and Smythe (1973) observed high value of Zn, Cu, Mn and Fe in plant materials. The values of Zn ranged from 2.5 - 17.4 mg/100g. Cu ranged from 0.5 - 9.2 mg/100g. Mn ranged from

1.1 - 6.3 mg/100g, while Fe ranged from 5.9 - 35.8 mg/100g. According to Guthrie et al. (1944), whole cottonseed contains 1270, 1170, 550, 250, 200 and 70 mg/100g of P, K, Ca, Na and Fe respectively.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 EXPERIMENTAL DESIGN

The four cottonseed varieties used in this study are the Multi-Adversity-Resistance (MAR) varieties. They are high yielding, early maturing, drought, pest and disease resistant varieties.

The cottonseed varieties were:

1) TAMCOT - CABCS
2) TAMCOT - CAMD-E
3) TX-CDP.37-H-H-I-83
4) SAMCOT-6

Samples of the cottonseed were planted on 27th May, 15th June and 8th July, 1991, and were correspondingly harvested on 28th November, 19th December, 1991 and 8th January, 1992 respectively.

The harvested cottonseed samples were collected from the Fibre Research Programme of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Samaru, Zaria. Each sample was milled using the Thomas-Wiley laboratory mill Model-4 with 1mm sieve. The resulting samples were mixed thoroughly and kept in clean dry corked plastic bottles until required.

3.2 PROXIMATE COMPOSITIONS

The method of AOAC (1975) were used for the determination of moisture, ash, ether extract, crude protein, crude fibre and total carbohydrate.

Total carbohydrate content was determined by difference from the following relationship.

Total Carbohydrate (% dry wt.)

= 100 - (%Ash + %Crude fat + %Crude protein + %Crude fibre)

3.3 PHYSICOCHEMICAL CHARACTERISTICS OF THE ETHER EXTRACT

The percent free fatty acid, Acid value, Iodine value, ester value and saponification value were determined by the method of AOAC (1975). Ester value was determined by the following relationship: Ester value = saponification value - Acid value.

3.4 ANTINUTRITIONAL CONSTITUENTS

Free gossypol content was determined using the method of Mathur *et al*. (1972) which is based on the quantitative reduction of ferric into ferrous ions by gossypol and subsequent estimation of the ferrous bipyridyl complex spectrophotometrically at 510 nm.

The vanillin-hydrochloric acid method by Burns (1971) was used for the determination of Tannin. An acid catalysed addition of vanillin to flavanols and their polymers as well as addition to other polyphenolic compounds such as dihydrochalcone and flavones and then determined colorimetrically at 500 nm.

Phytate phosphorus was determined by the colorimetric method of Stewart (1974). Phytin present in the sample, dissolved in the acidified extract. Phytic acid was then isolated as iron (II) phytate. It was recovered, digested and estimated as phytate phosphorus.

The method used for free cyanide content was that developed by Ikediobi et al. (1980).

The soluble and total oxalates were determined by the method of Abaza et al. (1968), whereby oxalic acid was extracted and precipitated as the calcium salt. The concentration of oxalate was determined by titration with potassium permanganate solution.

3.5 MINERAL ELEMENTS

3.5.1 WET DIGESTION OF SAMPLES

The method employed was that of the Analytical Methods Committee (1960), which used nitric and perchloric acids as decomposition reagents for organic matters. These acids have the advantage of not producing insoluble sulphates which absorb a considerable proportion of trace metals.

Two grams of the dried ground sample was accurately weighed into 200-ml kjeldahl flask. To it was added 25ml of concentrated nitric acid and glass beads. The mixture was boiled slowly for 30 minutes in a fume chamber. This was cooled and 15ml of perchloric acid added. The mixture was then boiled very gently for about one hour until it became colourless and dense white fumes evolved. The mixture was allowed to cool and quantitatively transferred to a 25-ml volumetric flask and diluted to volume with distilled water. The digests and blank were then transferred to plastic reagents bottles and stored in the refrigerator until ready for use.

3.5.2 DETERMINATION OF MINERAL ELEMENTS

The flame photometric method described by Osborne and Voogt (1978) was adopted for the determination of sodium and potassium using sodium and potassium filter respectively.

Phosphorus was determined as phosphate by Vanado Molybdate spectrophotometric method as described by Peason (1976). The stable orange-yellow coloured complex of Vanadi-Molybdi-phophoric acid (H_3PO_4 . VO_3 . $HMoO_3$. nH_2O) formed was determined at 440 nm.

Atomic Absorption Spectrophotometric method described by Osborne and Voogt (1978) was used at specific wavelength 213.8, 248.3, 279.5, 285.2, 324.7 and 422.7 nm for zinc, iron, manganese, magnesium, copper and calcium respectively.

3.6 STATISTICAL ANALYSIS

The statistical analysis was carried out using the t-test method described by Lewis (1966).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

Environmental factors affects plant growth and yield. Macro-environmental variations are easily recognised variation such as year, location, fertility, plant density and planting dates whereas micro-environmental variations arise from plant to plant variations (Odiemah, 1991). The effect of sowing time and variety on the nutrient composition of cottonseed is presented.

4.1 PROXIMATE COMPOSITION

On Table 1, is presented the effect of time of sowing on proximate composition of the four cottonseed varieties:- TAMCOT-CABCS, TAMCOT-CAMD-E, TX-CDP.37-H-H-1-83 and SAMCOT-6. Moisture content ranged between 3.04 to 3.68%. The highest moisture was observed in TAMCOT-CABCS sown in June. Generally, varieties sown in June tended to be lower in moisture than those of other two months. TX-CDP and SAMCOT-6 moisture content were lower than those of TAMCOT-CABCS and TAMCOT-CAMD-E sown in May. Moisture contents of TAMCOT-CABCS for each of the three sowing times were significantly different ($P<0.05$) from each other. These cottonseed varieties were observed to have lower moisture contents compared to the 4.70 to 5.44% moisture levels previously reported for other cottonseed varieties (Oyenuga, 1968; Abraham and Hron, 1992). These results showed that time of sowing affected the dry matter content of TAMCOT-CABCS. Ash is a measure of total mineral components of grain which enters the plant food chain from the

Table 1. Effect of time of sowing on the proximate composition of cottonseed varieties (percent dry matter)

Proximate composition	Varieties											
	TAMCOT-CABCS			TAMCOT-CAMD-E			TX-CDP.37-H-H-1-83			SAMCOT-6		
	May	June	July	May	June	July	May	June	July	May	June	July
MOISTURE	a*** 3.68 ±0.05	* 3.06 ±0.02	** 3.44 ±0.03	a 3.42 ±0.18	3.04 ±0.04	3.40 ±0.04	b 3.19 ±0.21	3.12 ±0.07	3.40 ±0.01	b 3.26 ±0.01	3.21 ±0.01	3.42 ±0.17
ASH	c 3.59 ±0.01	3.86 ±0.05	4.01 ±0.17	a 4.07 ±0.03	3.91 ±0.03	3.89 ±0.27	b 3.72 ±0.14	3.95 ±0.04	3.82 ±0.02	a 3.92 ±0.01	3.97 ±0.05	3.99 ±0.08
CRUDE PROTEIN	17.57 ±0.20	18.74 ±0.51	19.14 ±0.54	18.87 ±0.68	20.55 ±0.55	20.51 ±0.31	19.27 ±0.50	18.86 ±0.39	18.76 ±0.90	* 18.07 ±0.25	** 20.87 ±0.30	** 20.21 ±0.40
CRUDE FAT	***c 18.59 ±0.13	**b 16.69 ±0.01	*b 13.67 ±0.04	***a 21.31 ±0.01	**a 18.30 ±0.11	*b 13.70 ±0.10	**b 19.72 ±0.70	*b 15.40 ±0.20	*a 14.55 ±0.40	***a 20.44 ±0.18	**b 15.90 ±0.15	*b 13.25 ±0.25
CRUDE FIBRE	52.89 ±0.53	50.92 ±0.99	47.28 ±0.62	50.18 ±2.44	49.49 ±0.23	46.62 ±0.34	52.47 ±0.40	49.31 ±2.72	48.81 ±0.80	53.40 ±1.94	49.49 ±0.56	47.37 ±0.70
TOTAL CARBOHYDRATE	* 7.36 ±1.27	* 9.79 ±1.12	** 15.83 ±1.63	* 5.59 ±1.75	* 7.85 ±1.02	** 15.27 ±0.45	* 4.83 ±0.70	** 12.49 ±2.94	** 14.03 ±0.58	* 4.14 ±2.35	** 9.78 ±0.38	*** 15.19 ±1.56

Results are expressed as mean±SD of eight determinations

Values in the same horizontal row at the same time of sowing with different superscript (a, b, c, d) are significantly different ($P<0.05$)

Values in the same horizontal row at different time of sowing for each variety with different superscript (*, **, ***) are significantly different ($P<0.05$)

soil, therefore, a plant from soil deficient in mineral elements will have a decrease in ash content. Amount and nature of ions of element in the vicinity of plants was reported to affect the ash content of plant sample (Hamilton, 1979). Ash content of the cottonseed varieties studied varied from 3.59 to 4.07% (Table 1). The TAMCOT-CAMD-E and TAMCOT-CABCS varieties sown in May contained the highest and lowest ash respectively. Time of sowing had no significant effect (P>0.05) on ash content of each of these varieties of cottonseed. Varietal differences was noticed for the May sowing time with TAMCOT-CAMD-E and SAMCOT-6 having significantly (P<0.05) higher ash contents than TAMCOT-CABCS and TX-CDP.

Results of crude protein varied from 17.57 to 20.87%. SAMCOT-6 sown in June contained highest level of nitrogen while TAMCOT-CABCS sown in May had the lowest value. Variations in nitrogen content of plants of two varieties was attributed to differences in feeding power between the two varieties (Koyama and Snitwongse, 1971). Correspondingly, those sown in May gave lower crude protein values compared to those of June and July for each variety except TX-CDP which had slight but insignificantly (P>0.05) higher crude protein value for May sowing. Although, the crude protein value for SAMCOT-6 showed significant difference (P<0.05) compared to the other varieties. Varietal differences for each sowing times had no significant (P>0.05) effect on the crude protein content of the cottonseed varieties. Soil moisture was reported (Mali and Varade, 1981b) to cause significant effect on the nitrogen content of plants as a result of variation in the mineralization of nitrogen which leads to accumulation of ammonia thereby affecting the nitrogen content. Higher protein content were obtained for the months of June and July compared to the low crude fat content for same months for each variety. This observation according to Bailey (1948) is as a result of the fact that protein has a greater comparative opportunity for reaching a high level under unfavourable condition than oil during cotton plant maturation.

High kernel content of cottonseed was associated with high oil content among varieties (Tharp, 1948). Therefore, seeds that are well filled with kernel have highest oil contents while those poorly filled with kernel have low oil content. Crude fat content obtained in this work ranged from 13.25 to 21.31% with highest value in TAMCOT-CAMD-E sown in May and lowest in SAMCOT-6 sown in July. Significantly ($P<0.05$) decrease in fat content was observed when TAMCOT-CABCS, TAMCOT-CAMD-E and SAMCOT-6 sown from May were compared to July sowing. Among those sown in May TAMCOT-CAMD-E and SAMCOT-6 gave significantly ($P<0.05$) higher crude fat than TAMCOT-CABCS and TX-CDP. Those sown in June showed TAMCOT-CAMD-E to be significantly ($P<0.05$) different from the other varieties while for July TX-CDP also differed from the rest varieties significantly ($P<0.05$). The degree with which these cottonseed are filled by kernel may be responsible for the differences in the crude fat content of these cottonseed varieties analysed. Bailey (1948) and Taira et al (1986) reported that temperature and soil moisture during cotton plant growth has great effect on the oil content of cottonseed.

Crude fibre contents obtained (Table 1) varied from 46.62 to 53.40%. The crude fibre content of each variety, decreased with sowing time from May to July, although these differences in the time of sowing and variety had no significant effect ($P>0.05$) on the crude fibre content. cottonseed hulls, which consists primarily of cellulose, hemicellulose and lignin may comprise about 26 to 40% of the weight of whole cottonseed (Dollear and Markley, 1948; Cherry, 1983). The cottonseed hull may have contributed greatly to the high crude fibre content obtained in this study. Moreover, drought resistance is a function of many morphological, physiological and biochemical characteristics which lead to increases in dessication tolerance. Hence, the high crude fibre obtained could be associated with resistance mechanism in these cottonseed varieties since they are multi-Adversity-Resistant varieties.

Carbohydrates constitute important components of the plant nutrients in addition to oil and protein which make up the main components of cottonseed kernel. Results obtained showed the total carbohydrate content of between 4.14 to 15.83%. The TAMCOT-CABCS variety sown in July had the highest carbohydrate content while SAMCOT-6 sown in May had the lowest. Those sown in July recorded higher total carbohydrate content for all varieties. Total carbohydrate content of SAMCOT-6 showed significant ($P<0.05$) increase when those sown in May were compared to those of July.

Variety had no significant effect ($P>0.05$) on the total carbohydrate content for each sowing times. Abdallah and Khalifa (1980) reported that cotton plants generally tended to accumulate carbohydrate under draught conditions as a result of the retardation in utilization of such materials and that differences between cotton cultivars in their response to drought conditions can be interpreted mainly to their genotypic differences. Decrease in crude fat may have led to the net increase in total carbohydrate content of these cottonseed varieties because the total carbohydrates was deduced by difference.

Results of this study indicate the influence of time of sowing on most of the proximate parameters. Generally, the moisture content of these cottonseed varieties are low compared to other cottonseed varieties. Varieties sown in May and July gave higher oil and protein contents respectively. The amount of these two parameters are of nutritionally significant if the oil is to be used for food and the protein for animal feed after defatting. Carbohydrate content of the varieties sown in July recorded higher amounts, which may be as a result of the decrease in the oil content. Variety had no effect on the amount of crude fibre and total carbohydrate content for the different sowing times.

4.2. PHYSICOCHEMICAL PROPERTIES OF THE CRUDE FAT

Results showing effect of time of sowing and variety on the physicochemical properties of the crude fat are shown in Table 2. Free fatty acid ranged from 1.61 to 2.30%. Highest value was obtained in TAMCOT-CAMD-E sown in July while SAMCOT-6 sown in May had the lowest. Free fatty acid content of TAMCOT-CABCS, TAMCOT-CAMD-E and SAMCOT-6 increased with time of sowing from May to July, although, only those of SAMCOT-6 was significantly different ($P<0.05$). Sowings in July indicated TAMCOT-CABCS and TAMCOT-CAMD-E to have significantly ($P<0.05$) higher free fatty acids compared to TX-CDP and SAMCOT-6. Acid value is another way of expressing the amount of free fatty acids in an oil and it varied from 3.22 to 4.49; showing similar pattern as was observed for free fatty acids. Bailey (1948) reported that environmental factors leads to variations in free fatty acid content while Taira et al 91986) also reported that changes in environmental temperature result in variation in free fatty acid content.

Iodine value of a fat or oil is a measure of its degree of unsaturation. Results obtained for Iodine value (Dam's method) ranged from 43.72 to 61.00. TAMCOT-CABCS sown in May gave highest iodine value while TAMCOT-CAMD-E sown in July gave the lowest value. Cottonseed sown in May and June gave significantly ($P<0.05$) higher iodine values for each of the varieties except TX-CDP which was not affected by time of sowing. This shows that sowing in May and June with the exception of TX-CDP produces higher amounts of unsaturated fatty acid.

Table 2. Effect of time of sowing on the physicochemical properties of the ether extract of cottonseed varieties

Characteristics	TAMCOT-CABCS			TAMCOT-CAMD-E			TX-CDP.37-H-H-1-83			SAMCOT-6		
	May	June	July	May	June	July	May	June	July	May	June	July
Percent free fatty acid	2.05 ±0.07	2.15 ±0.14	2.24^{a} ±0.00	1.88 ±0.11	2.16 ±0.01	2.30^{a} ±0.05	2.02 ±0.07	2.26 ±0.06	2.11^{b} ±0.01	1.61^{*} ±0.06	2.00^{**} ±0.04	2.15^{**b} ±0.01
Acid value (mg/g)	4.08 ±0.14	4.28 ±0.28	4.46^{a} ±0.00	3.73 ±0.21	4.30 ±0.03	4.58^{a} ±0.11	4.02 ±0.14	4.49 ±0.13	4.20^{b} ±0.03	3.22^{*} ±0.20	3.97^{**} ±0.07	4.28^{**b} ±0.02
Iodine value (g/100g)	61.00^{**a} ±1.41	54.72^{**a} ±1.32	45.28^{*} ±2.37	56.00^{**b} ±1.41	51.75^{**b} ±0.53	43.72^{*} ±1.30	49.00^{c} ±2.83	46.05^{c} ±0.07	44.37 ±0.02	58.00^{**b} ±2.83	50.99^{**b} ±0.28	47.59^{*} ±0.28
Ester value (mg/g)	186.3^{*d} ±5.2	220.2^{**b} ±5.8	251.8^{***b} ±1.2	247.4^{**b} ±1.3	280.7^{***a} ±3.2	225.8^{*c} ±2.3	266.5^{*a} ±2.4	281.1^{**a} ±1.3	279.1^{**a} ±2.4	208.4^{*c} ±1.5	271.6^{**a} ±3.6	283.5^{***a} ±2.2
Saponification value	190.3^{*d} ±5.0	224.5^{**b} ±5.5	256.3^{***b} ±1.2	251.1^{**b} ±1.6	285.0^{***a} ±3.2	230.3^{*c} ±2.2	270.5^{*a} ±2.3	285.6^{**a} ±1.4	283.3^{**a} ±2.4	211.6^{*c} ±1.7	275.5^{**a} ±3.6	287.8^{***a} ±2.7

Results are expressed as mean±SD of eight determinations
Values in the same horizontal row at the same time of sowing with different superscript (a, b, c, d) are significantly different ($P<0.05$)
Values in the same horizontal row at different time of sowing for each variety with different superscript (*, **, ***) are significantly different ($P<0.05$)

Among those sown in May and June, TAMCOT-CABCS and TX-CDP were significantly ($P<0.05$) different from TAMCOT-CAMD-E and SAMCOT-6 in Iodine value. These results revealed that time of sowing and variety affected the amount and type of fatty acid synthesized by the cottonseed varieties. This differences could be as a result of differences in temperature during growth of the cotton plant, since some plants have been reported to produce more highly unsaturated fat when grown at lower temperature (Taira et al, 1986). AbdelRahman et al (1980) reported that early sowing caused an increase in unsaturated fatty acid content which was collaborated by the results obtained in this study because those sown in May and June had higher unsaturated fatty acid (based on the iodine number) than those of July.

Ester value, a measure of the glyceride content of the crude fat, ranged from 186.3 to 283.5 for the cottonseeds (Table 2). TAMCOT-CABCS variety sown in May gave lowest ester value while SAMCOT-6 sown in July had the highest value. Time of sowing led to significant ($P<0.05$) increase in the glyceride content of TAMCOT-CABCS and SAMCOT-6 grown from May to July. Variety also accounted for significant ($P<0.05$) variations in the glyceride content of those sown in May. For July sowing, TX-CDP and SAMCOT-6 gave significantly ($P<0.05$) higher glyceride content compared to TAMCOT-CABCS and TAMCOT-CAMD-E.

Saponification value, a measure of the molecular weight of fat or oil obtained in this study ranged between 190.3 for TAMCOT-CABCS sown in May and 287.0 for SAMCOT-6 grown in July. Increase was observed in the Saponification values of TAMCOT-CABCS and SAMCOT-6 grown from May to July. Variety also had significant effect ($P<0.05$) on the saponification value for the three sowing times (Table 2). The physical and chemical properties of oil are essentially determined by the fatty acid composition of their triglyceride (Fernando and Akujobi, 1987). These are in turn affected by the genetic constitution of the oilseed plant, environment in which the plant are grown and extent of refining. The crude fat of these four cottonseed varieties sown between May and July contain low molecular weight fatty acid since their saponification value are higher than 200 (Terry et al., 1992) except TAMCOT-CABCS sown in May.

4.3 ANTINUTRITIONAL FACTORS

A look at the effect of time of sowing on the antinutritional constituents of the four cottonseed varieties is in consonant with (Table 3) earlier reports that antinutritional factors vary in amounts depending on environmental and genetic factors (Hui, 1992). This study, therefore indicates the presence in these cottonseed varieties of appreciable amounts of such toxicants as free gossypol, Tannin, phytic acid, free cyanide and oxalate. Gossypol in food leads to loss of appetite, retarded growth and death (Osaniyi and Eka, 1978). Free gossypol content ranges from 210mg/100g for TAMCOT-CAMD-E sown in June and 1960mg/100g for TX-CDP of July. There was significant ($P<0.05$) increase in the free gossypol content of TAMCOT-CABCS sown in May compared to those

Table 3. Effect of time of sowing on some antinutritional factors in cottonseed varieties (mg/100g)

Antinutritional factors	TAMCOT-CABCS			TAMCOT-CAMD-E			TX-CDP.37-H-H-1-83			SAMCOT-6		
	May	June	July	May	June	July	May	June	July	May	June	July
Free gossypol	*b 880 ±60	**a 1200 ±140	*** 1600 ±170	**c 420 ±30	*b 210 ±10	*** 1600 ±400	**a 1740 ±350	*b 440 ±20	** 1960 ±340	b 1040 ±100	a 1220 ±540	1200 ±10
Tannin	***a 565 ±28	*a 327 ±11	**a 445 ±95	**b 308 ±32	*b 162 ±14	*b 141 ±11	**b 315 ±42	*b 125 ±29	*b 130 ±10	**c 190 ± 3	*c 90 ± 3	*c 100 ± 5
Phytic acid	*d 130 ±10	***a 439 ±22	**b 363 ±11	**a 285 ±20	***a 438 ±22	*d 130 ±10	*b 207 ±11	*b 207 ±11	**a 440 ±14	*c 155 ± 4	***a 439 ±22	**c 304 ±25
Free cyanide	** 146 ±25	* 109 ± 8	* 97 ± 1	** 145 ± 7	* 119 ± 7	* 98 ± 3	*** 150 ± 7	** 123 ± 2	* 95 ± 1	*** 160 ± 7	** 131 ± 6	* 101 ± 1
Soluble oxalate	** 475 ±64	***a 605 ±64	* 375 ±35	400 ±42	b 390 ±28	375 ±35	* 305 ±35	*b 305 ±37	** 445 ±64	395 ±35	b 440 ±42	400 ±14
TOTAL oxalate	690 ±70	a 790 ±71	645 ±64	620 ±28	a 695 ±64	535 ±35	** 700 ±28	*b 490 ±28	* 510 ±28	510 ±57	a 610 ±42	490 ±28

Results are expressed as mean±SD of eight determinations
Values in the same horizontal row at the same time of sowing with different superscript (a,b,c,d) are significantly different (P<0.05)
Values in the same horizontal row at different time of sowing for each variety with different superscript (*, **, ***) are significantly different (P<0.05)

grown in June and July. Time of sowing therefore had some effect on the free gossypol content of the cottonseed varieties with the exception of SAMCOT-6.

High tannin content of feed reduces the availability of proteins and amino acids and act as an antioxidant (Fache, 1988). Hence tannin influence digestibility and utilization of protein by man and animals. Tannin content ranged from 90 to 565mg/100g, with TAMCOT-CABCS sown in May having the highest value while SAMCOT-6 sown in June had the lowest. May sowing gave significantly ($P<0.05$) higher tannin contents for each of the cottonseed varieties. The TAMCOT-CAMD-E and TX-CDP varieties differed significantly ($P<0.05$) from TAMCOT-CABCS and SAMCOT-6 in terms of tannin contents irrespective of sowing time. Although, the major role of phenolic compounds is in the defence mechanism of plant tissues in response to infections or injuries by forming a physical barrier which is stronger in resistant plant varieties, these compounds are of nutritional importance because of their antinutritional activities.

TX-CDP sown in July gave highest phytic acid content (440mg/100g) while TAMCOT-CABCS and TAMCVOT-CAMD-E sown in May and July respectively gave the lowest values (130mg/100g). TAMCOT-CABCS, TAMCOT-CAMD-E and SAMCOT-6 all sown in June gave significantly ($P<0.05$) higher phytic acid content compared to other months of sowing. Most of the phosphorus in cottonseed as in most oilseeds had been observed to occur in the form of phytic acid (Altschul et al., 1958). The amount of this toxicant is some what variable and is dependent upon the amount and relative proportions of mineral constituents present in the seed (Bailey, 1948).

Results obtained for free cyanide content shows that SAMCOT-6 sown in May had the highest value (160mg/100g) while TX-CDP sown in July had the lowest+ (90mg/100g). Free cyanide content of TX-CDP and SAMCOT-6 varieties sown in May were significantly ($P<0.05$) higher than those sown in July, indicating the influence of sowing time on the level of this toxicant. Variety had no significant effect ($P>0.05$) on the free cyanide content for each of the sowing times. Oke (1969) reported that the amount of hydrocyanic acid in plant is influenced by many factors like conditions of drought or wilting, stage of growth and soil fertility. Variations in the soil moisture may be partially responsible for the variation of the cyanide content with sowing time.

Time of sowing significantly affected ($P<0.05$) the soluble oxalate content of TAMCOT-CABCS and TX-CDP (Table 3). Among those sown in June, TAMCOT-CABCS had significantly higher ($P<0.05$) soluble oxalate than the other three varieties sown in the same month. Total oxalate values ranged from 490 to 790mg/100g with TAMCOT-CABCS sown in June having the highest value while SAMCOT-6 sown in July had the lowest. Time of sowing also had significant effect ($P<0.05$) on the total oxalate content of TX-CDP. TX-CDP sown in June had significantly ($P<0.05$) lower oxalate than the other varieties sown in that month. Singh (1974) reported light intensity to be one of the factors that influence oxalic acid formation of some plants and the differences could arise as a result of the de novo synthesis of oxalic acid or transportation of the acid from one tissue to another.

4.4 MINERAL ELEMENTS

The mineral content of the cottonseed varieties is shown on Table 4. Phosphorus, potassium and magnesium occurred at very high levels (ranging from 211.9 to 587.5mg/100g dry weight). These cottonseed meals therefore present apparently good sources of these minerals whose roles in animal nutrition and feed/ration formulation are important. Copper, manganese, zinc, sodium, iron and calcium were present at very low levels in all the cottonseed varieties (0.5 to 50.5mg/100g). Time of sowing caused significant ($P<0.05$) variation in the mineral profile of the four cottonseed varieties. The mineral levels of these cottonseed varieties are important because cottonseed meal could serve as a constituent of fertilizer and the seed meal is also a nutritionally valuable feed and food.

The TAMCOT-CABCS sown in July had highest calcium content (50.8mg/100g) while TAMCOT-CAMD-E sown in May had the lowest value (24.4mg/100g). There was significant difference ($P<0.05$) between the calcium content of all four varieties sown in May (Table.4). Howeler (1973) reported that soil moisture affects calcium content in plant. High level of ion in the soil could be an important factor leading to the retardation of calcium absorption by plants.

Table 4. Effect of time of sowing on some mineral elements in cottonseed varieties (miligram per one hundred grammes dry weight)

Mineral element	Varieties											
	TAMCOT-CABCS			TAMCOT-CAMD-E			TX-CDP.37-H-H-1-83			SAMCOT-6		
	May	June	July	May	June	July	May	June	July	May	June	July
Calcium	*c 29.3 ±0.4	*c 25.9 ±0.2	**a 50.8 ±1.8	*d 24.4 ±0.1	**b 39.3 ±0.4	*c 26.3 ±1.8	*b 37.5 ±0.1	*b 40.3 ±1.1	**a 50.5 ±1.4	**a 48.0 ±0.7	**a 45.0 ±1.4	*c 37.3 ±0.4
Magnesium	***a 275.4 ±0.5	*c 224.7 ±0.4	**a 245.0 ±1.4	***a 275.2 ±0.3	**b 227.5 ±0.7	*d 211.9 ±0.2	**c 240.5 ±0.7	*a 234.9 ±0.2	*b 234.7 ±0.5	**b 247.0 ±1.4	*c 224.8 ±0.4	*c 221.4 ±0.5
Potassium	*a 503.5 ±5.0	* 504.5 ±5.0	**a 587.5 ±10.6	*a 482.3 ±2.5	** 512.0 ±5.7	**b 530.0 ±14.1	*b 473.0 ±4.2	** 518.0 ±8.5	**b 503.0 ±4.2	*b 478.0 ±2.8	** 502.5 ±3.5	**b 527.5 ±10.6
Sodium	*c 11.4 ±0.3	**a 73.5 ±5.0	*b 8.4 ±0.6	b 18.6 ±0.9	b 16.8 ±0.6	a 20.0 ±0.6	***a 24.8 ±1.1	**b 15.4 ±0.9	*c 5.5 ±0.7	*d 8.1 ±0.1	**b 17.1 ±0.2	*b 8.0 ±0.1
Phosphorus	***a 542.2 ±3.9	*c 373.6 ±5.0	**a 422.8 ±9.2	***b 515.8 ±7.7	**b 441.5 ±1.7	*c 347.4 ±8.5	*d 404.8 ±6.6	**a 460.1 ±0.7	*a 418.8 ±1.7	***c 473.6 ±5.0	**b 434.8 ±0.7	*b 382.6 ±3.6
Zinc	** 5.0 ±0.1	**a 4.7 ±0.1	* 4.1 ±0.3	4.9 ±0.3	a 4.6 ±0.1	4.4 ±0.04	4.9 ±0.2	c 3.6 ±0.3	4.6 ±0.1	4.6 ±0.2	b 4.2 ±0.2	4.5 ±0.1
Manganese	***b 2.9 ±0.1	**b 2.2 ±0.04	*d 1.1 ±0.1	**a 3.1 ±0.2	*a 2.4 ±0.04	*a 2.4 ±0.1	***d 2.3 ±0.1	**c 2.0 ±0.01	*c 1.6 ±0.1	c 2.5 ±0.2	a 2.4 ±0.02	b 2.0 ±0.03
Iron	**a 18.5 ±0.5	*a 8.4 ±0.5	*a 12.0 ±1.4	*d 2.0 ±0.1	**d 3.8 ±0.4	***c 6.1 ±0.1	*c 4.9 ±0.2	*c 4.9 ±0.1	**c 7.5 ±0.7	*b 6.8 ±0.3	*b 6.2 ±0.2	**b 10.3 ±1.1
Copper	*d 0.7 ±0.01	**a 2.4 ±0.1	*c 0.5 ±0.03	*b 0.7 ±0.01	**b 0.8 ±0.01	***a 0.9 ±0.01	*c 0.7 ±0.01	*c 0.7 ±0.04	**b 0.8 ±0.02	*a 0.8 ±0.01	**b 0.9 ±0.01	**a 0.9 ±0.03

Results are expressed as mean±SD of eight determinations.
Values in the same horizontal row at the same time of sowing with different superscript (a, b, c, d) are significantly different ($P<0.05$).
Values in the same horizontal row at different time of sowing for each variety with different superscript (*,**,***) are significantly different ($P<0.05$).

Magnesium content varied from 211.9 to 275.4mg/100g with TAMCOT-CABCS sown in May with the highest level while lowest is TAMCOT-CAMD-E sown in July. Those sown in May gave higher magnesium content for each variety. There was significant ($P<0.05$) decrease in the magnesium content of TAMCOT-CAMD-E sown in May compared to those of July. Variety also caused significant difference ($P<0.05$) in the magnesium content of those sown in July. TAMCOT-CABCS and TAMCOT-CAMD-E gave significantly ($P<0.05$) higher magnesium content than TX-CDP and SAMCOT-6 for those sown in May. Variations in the magnesium contents of plant materials was reported (Kempt et al., 1961) to increase with increase in maturity of the plant in addition to other factors such as climate and soil.

The TX-CDP cottonseed variety sown in May had the lowest potassium content (473.0mg/100g) while TAMCOT-CABCS sown in July had the highest value (587.5mg/100g). Both variety and sowing time conferred significant differences ($P<0.05$) on the potassium content of these cottonseed varieties. Soil moisture was reported to affect the potassium content in plant at all the stages of plant growth while low bicarbonate level along with low calcium and iron contents of the soil causes an increase in potassium uptake (Lian and Tanaka, 1972). In this study the low levels of calcium and iron may be related to the high potassium content of these cottonseeds.

Sodium content varied from 5.5 to 73.5mg/100g TAMCOT-CABCS sown in June had highest while TX-CDP sown in July had the lowest value. There was significant ($P<0.05$) decrease in sodium content of TX-CDP sown in May compared to those of July. Variety and time of sowing affected sodium content which agreed with Duckworth (1966) that same variety of plant species grown under different climatic and soil conditions, exhibit considerable variation in mineral contents.

Phosphorus content ranged from 347.4 to 542.2 mg/100g with TAMCOT-CABCS sown in May giving the highest while TAMCOT-CAMD-E sown in July had the lowest value. Phosphorus content of TAMCOT-CAMD-E and SAMCOT-6 decrease significantly ($P<0.05$) from May to July. TAMCOT-CAMD-E and SAMCOT-6 were both significantly ($P<0.05$) different from each of TAMCOT-CABCS and TX-CDP sown in June. Although, some workers (Mali and Varade, 1981a) have attributed the differences in the phosphorus content in plants to variations in the level of iron and manganese in the soil.

Data obtained for zinc content ranged from 3.6mg/100g for TX-CDP sown in June to 5.5mg/100g for TAMCOT-CABCS sown in May. Time of sowing and variety had significant ($P<0.05$) effects on the zinc levels of these cottonseed. The amount of zinc in plant was reported (Marinho and Igue, 1972) to be determined by the amount of zinc available in the soil and zinc absorption is also reduced by presence of phosphate and oxides of iron. It must be noted that the distribution of zinc between soil fractions are influenced by organic acids, types and concentration in the soil which in turns affect the availability of zinc to plant and hence the amounts of zinc in plant tissue (Evans, 1991).

The manganese content ranged from 1.1 to 3.1mg/100g. Manganese content of TAMCOT-CABCS and TX-CDP decreased significantly ($P<0.05$) from May to July. some workers have reported that Manganese occurs in the soil in variable quantities, and that the large differences in the manganese content of plants appear to be due to effect of several factors most prominent of which is the soil (Lassiter et al., 1972).

Iron content ranges from 2.0 to 18.5mg/100g. Those sown in July gave higher iron content for each variety with the exception of TAMCOT-CABCS. Increase occurred significantly ($P<0.05$) in the iron content of TAMCOT-CAMD-E sown in May compared to those of July. Varietal differences significantly ($P<0.05$) affected the iron contents irrespective of the time of sowing. According to Lingle and Tiffin (1963) a major factor affecting the absorption of iron by plants, is the interference of other metal ions (Nickel, cobalt, zinc, manganese and copper).

Copper content varied from 0.5 to 2.4mg/100g (Table 4). TAMCOT-CABCS sown in June and July gave highest and lowest levels of copper respectively. copper content of TAMCOT-CAMD-E increased significantly ($P<0.05$) from May to July. For July, TAMCOT-CAMD-E and SAMCOT-6 gave significantly ($P<0.05$) higher copper content compared to TAMCOT-CABCS and TX-CDP. Low level of copper and the interaction of other metal such as selenium in the soil had been observed as contributing to low copper content of plant material (Francis and Rush, 1973; Cary, 1981).

Despite variations in the mineral contents due to variety and time of sowing, these cottonseed varieties present potentially good sources of phosphorus, potassium and magnesium. However, the occurrence of oxalate and other antinutritional factors (Table 3) underscores the need to carry out extensive bioavailability studies before using the cottonseed meals as feed/food.

CHAPTER FIVE

5.0 CONCLUSION AND SUGGESTIONS

5.1 CONCLUSIONS

Results of this study indicate the influence of time of sowing on some chemical components of cottonseed varieties (TAMCOT-CABCS, TAMCOT-CAMD-E, TX-CDP.37-H-H-1-83 and SAMCOT-6). The results have shown that some nutritionally important components of cottonseed can be significantly affected by time of sowing and variety. Therefore, the use of time of sowing and variety for cottonseed production apart from increasing crop yield, bring about an increase in the nutritional value of the crop. Hence, samples sown in May gave higher cotton fibre and oil content among which TAMCOT-CAMD-E and SAMCOT-6 gave the highest oil content with TAMCOT-CAMD-E having lowest free gossypol level which is the main toxic oil-soluble polyphenolic compound found in cottonseed that could limits the use of the product by animals and human. The gossypol contents of TAMCOT-CABCS AND SAMCOT-6 are also comparably low thereby increasing the suitability of their oils for human consumption. The high gossypol content of TX-CDP makes it suitable for recommendation for breeding of new resistant varieties thereby contributing some increase in gossypol where this substance is needed to control bollworms, this agrees with the report of Lee and Smith (1970).

Tannin has an astringent effect on proteins and, by binding irreversibly to proteins, renders them indigestible and unabsorbable. However, SAMCOT-6 which had the highest protein content has on the average lowest tannin content, this makes it a good source of protein if used as animal feeds.

The crude fibre content of all the cottonseed samples are very high while this might limit their use by monogastric animals, they would be good source of supplement to ruminants if the crude fibre content are reduced by dehulling. High crude fibre causes less palatability and decrease in nutrient content of feeds which may result in poor feed intake and general performance of the animal. Processing like soaking and cooking can help to considerably reduce the levels of these toxicants gossypol, hydrocyanic acid, tannin, phytic acid and oxalate. Reduction and elimination of these toxicants could make these cottonseed varieties more useful as a source of inexpensive, nutritious oil for human and protein for animal consumption.

Based on the above finding, these cottonseed samples are good sources of oil, protein and roughage, and they may be distributed for sowing in May ending since samples sown in that month gave higher cotton fibre and oil. Appreciable amount of protein could be derived from the cottonseed meal after the extraction of the oil. The cottonseed cake could then be used as feed supplement for animals which will in turn be a good source of animal protein.

5.2. SUGGESTIONS FOR FURTHER STUDIES

Cotton is grown in many countries where malnutrition is encountered. The fact is overlooked that when the plant is well used it could be used to satisfy our protein requirement.

It is therefore suggested that:

(1) Further analyses be carried out which should include the amino acids and vitamins composition of the cottonseed.

(2) Feeding experiments be conducted using growing rats with the aim of selecting the best in performance.

(3) Separation of the cottonseed into its various fractions and the preparation of cottonseed flour suitable for human consumption in Nigeria.

(4) The limited supply of protein for man and animals is a major concern of nutritionists and efforts are being directed towards the most efficient use of the available protein. Cottonseed is an important source of protein but the actual utilization in this direction in Nigeria for human use is negligible. Hence, research should be conducted to isolate and fractionate the proteins so that it could be used a supplements in foods for human consumption.

REFERENCES

Abaza, R.H.; Blake J.I. and Fisher, E.J. (1968): Oxalate determinations: Analytical problems encountered with certain plant species J. Ass of Anal. Chem. 51,963.

Abdallah, M.M. and Khalifa, M.A, (1980): Effect of Drought conditions on some chemical constituents of cotton seedlings. J. Agron. Crop. Sci. 149(5):424-429.

Abdel-Rahman, A.Y. (1975): Production of margarine oil from cottonseed oil and corn oil. J. Oil Technol. Ass. India. 7(5):99-100.

Abdel-Rahman, K.A. Hassaballa, E.A. EL-Morshidy, M.A. and Khalifa, M.A. (1980): Physiological responses of sesame to sowing dates, Nitrogen fertilizer and hill spacings, Research Bull. Fac. Agric. Ani. Shams Univ. No. 1235. 13Pp.

Abdou, I.R. and Kasaim, I.A. (1965): Cottonseed protein. Bull Nutr.Inst. 1. 85.

Abraham, G, and Hron, R.J. (1992): In: "Encyclopedia of food, Science and Technology" Hui. Y. ed., Vol.3 1905=1906.

Admasu, A and Chandravanshi, B.S. (1984): Effect of variety on thegossypol content of cottonseed. Anal Chem. 56, 30-32.

Aldrich, S.R. and leng, E.R. (1969): In: Modern corn production. 4th ed., The farm quarterly, cincinnati, Ohio.

Altschul, A.M. Lyman, C.M. and Thurber, F.H. (1958): In: Processed plant-protein feedstuffs. Academic Pres Inc. New York, P.469.

Analytical methods committee (1960): Methods for the destruction of organic matter. Report Prepared by the metallic impurities in organic matter sub-committee, 85, 643-655

AOAC (1975): Official Methods of Analysis (12th edn). Association of Official Analytical Chemists, AOAC, Inc. Washington D.C.

Arias, F.J. and Harnandez, E. (1977): Estimation of gossypol in commercial and promising varieties of cotton in Columbia. Revista Institute Columbiano, Agropecuarra, 12(2):125-134.

Ayatse, J.O.; Eka, O.U. and Ifon, E.T. (1983): The effect of roasting on the nutritive value of maize. Food Chem. 12(2):135-147.

Bailey, A.E. (1948): In: "Cottonseed and cottonseed productis" Interscience, New York. 364-408.

Beal, L. and Mehta, T.O. (1985) Food Science, 50, 96, cited by Khan, N. Zaman, R., and Elahi, M. (1986): Effect of processing on the phytic acid contents of wheat products J. Agric Food Chem. 34. 1010-1012.

Beaker, K. and Pfeffer, E. (1978): Are cotton Lintes suitable as a Food for ruminants? Tropenlandwirt, 79. 13-21.

Berardi, L.C. and Goldbatt, L. Pr. (1980) In: "Gossypol", Liener, I.E. ed. Toxic, Press Inc. Orlando. Fla.

Black, H.C. (1948): In: "Cottonseed and Cottonseed products." Bailey, A.E. ed Wiley (Interscience) New York, 732-761.

Bourely, J. (1990): Development of glandless cotton as a food crop technology and Nutritional aspect. Sciences des Aliments (France) 10(2), 485-514.

Bourely, J, and Besancon, P. (1986): Cottonseed: a source of high quality protein for human consumption. In Les Malnutritionals dans Les pays du liersMonde, Paris France, Edition INSERM 561-567.

Brown, H.B. and Ware, J.O. (1958): In: "Cotton", McGran-Hill. 566Pp.

Burns, E.E. (1971): Method of estimation of tannins in grain sorghum, Agron. J. 63:511.

Cary, E.E. (1981): Effect of selenium and cadmium additions to soil on their concentrations in lettuce and Wheat. Agron J. 63:511.

Chakraborty, R. and Eka, O.U. (1978): Studies on hydrocyanic, Oxalic and phytic acid content of foodstuffs, W. Africa. J. Bio and App. Chem. 21:50-55.

Cherry, J.P. (1983): "Cottonseed oil", J. Amer. oil Chem. soc 60:360-367.

Chicco, C.F.; Ammerman, S.B.; Feaster, J.P. and Dunavart, B.G. (1973): Nutritional Interrelationship of Dietary Calcium, phosphorus and Magnesium in sheep. J. Anim. Sci. 36:986-990.

Cunha, J.J. (1977): In: Swine feeding and nutrition, 3rd ed., Academic Press, New York, 228-230.

Damaty. S.M. and Bertran, J.F.H. (1979): the Interaction between gossypol and cottonseed protein, J, Sci. Fd. Agric 30(11): 1050-1056.

Davidson, S.; Passmora, R.; Brock, J.F. and Truswell, A., (1975):In: "Human Nutrition and Dietetics" 6th ed. The English Language Book Society and Churchill, Livingstone, Edinburgh.

Dharmagrongartama, E.D.; Perimann, G.E. and Finlay, T,H. (1973): Mechanism of the gossypol inactivation of pepsinogen, J. Biol Chem 245-248.

Disler, P.B.; Lynch, B.R.; Charlton, R.W.; Rorrank, J.D.; Bothwell, T.M.; Waldner, R.B.; and Mayet, F. (1975). The effect of tea iron absorption. Gut. 16 193-260.

Dollear, F.G. and Merkley, K.S. (1948): Miscellaneous constituents of cottonseed. In: "Cottonseed and cottonseed products". Bailey A.E. Interscience 486-493.

Duckworth, R.B. (1966): In: "Fruits and vegetables:, Pergaman Press. Oxford. 1-20.

Duffus, G.H. and Slaughter, J.C. (1980): In: "Seeds and their uses" John Wiley and Sons. Chinchester, New York.

Dye, W.A. (1956): Studies on Halogeton glomerulus, Weeds 4, 50-60.

Dykstra, R.R. (1952): In: "Animal sanitation and disease control". Interstate, Danville III.445.

Eka, O.U. (1983): In: Udoessien and Ifon (1992): Chemical Evalulation of some antinutritional constituents in four species of yam. Trop. Sci. 32. 115-119.

Elkin, R.G.; Featherston, W.R. and Rogler, J.O. (1978): Investigation of leg Abnormalities in chicks consuming high sorghum grain diets, Poult, Sci, 57. 757-762.

El-Minyawi, M.A. and Zahik, M.E. (1981): Cottonseed figure functionality in Egyptian Baladi Bread, Cereal Chem, 58(5):413-417.

Ensminger, M.E. (1967): In: Swine science" 3rd edition. Anim. Agric series. Interstate. Danville.

Evans, A. Jr. (1991): Influence of low Molecular weight organic acids on zinc distribution within micronutrient pools and zinc uptake by wheat. J. plant nutrition 14(12):1307-1318.

Fache, S.J. (1988): Assessment of the Nigerian poultry feeds in relation to their nutritive value. M.Sc. Thesis, Ahmadu Bello University, Zaria, Nigeria. 83-85.

Fernando, C.E.C. and Akujobi, E.O. (1987): Chemical analysis of selected vegetable oils and fats of Sokoto state, Nig. J. Basic. App. Sci. 1:11-14.

Fernandez, R. and Phillips, S.F. (1982): Components of fibre Impair iron absorption in the dog. Amer. J. Clin. Nutr 35:107-112.

Fibre Research Programme (FRP, 1981): Cotton and other fibres improvements programme. In: Cropping Scheme meeting, IAR, Zaria, pp.1-26.

Ford, J.E. and Hewitt, D. (1979): Protein quality in Cereals and pulses. Brit. J. Nutr. 41.341-352.

Forma, N. and Ngeka, K. (1985): Oleagineux (France): 40(6) 335-337.

Francis, C.W. and Rush, S.U. (1973): Factors affecting uptake and distribution of cadmium in plants. In: Trace substances in Environmental Health-VII, ed. Hemphilli DD, Univ. of Missouri, Columbia, 75-81.

Frank, A.W. (1987): In: "Food uses of cottonseed proteins in development in food proteins -5". Hudston, J.E. ed. Elsevier Applied Sci. publishers. 31-80.

Fryxell, P.A. (1969): A classification of Gossypium L. (Malvaceae). Taxon, 18:585-591.

Fu. H.C. and Reiser, R. (1962): The mechanism of gossypol detoxification by ruminant animals. J. Nutr. 76. 215-218.

Gastrock, E.A. and D'Aquin E.L. (1971): U.S. Pat. 3. 615. 657. Cited by Caltschul, A.M. (1974). New protein foods, vol. I. Academic Press Inc. New York, pp.26.

Gillooly, M.; Bothwell, I.H.; Torrance, J.D.; Marphil, A.P. Derman, D.P.; Bexwoda, W.R.; Mills, W.; Charlton, R.W. and Mayet, F. (1983): The effects of organic acids, phytates and polyphenol on the absorption of iron from vegetables. Brit. J. Nutr 49:331-342.

Guthrie, J.D.; Hoffpaiur, C.I.; Steinen, E.I.; and Stanbury, M.R. (1944): Survey of the chemical composition of cotton fibres, cottonseed and sweet potatoes, processed Resease AIC-61, South, Reg, Res. Lab U.S. Dept. Agric Pp.20.

Hallberg, L. (1981): Effect of vitamin c on the bioavailability of iron from food. In: "Vitamin C". Cousell, J.M. Harring, D.H. eds.

Halloin, J.M. (1982): Localization and changes in catechin and tannins during development and ripening of cottonseed, New phytologist, 90(4): 651-657.

Hamilton, E.I. (1979): Diet In: Chemical elements and Man. Charles C. Thomas, Illinois publisher. Pp95-108.

Harbone J.B. and Van Sunere (1975): Plant proteins and phenolics In: The Chemistry and Biochemistry of Plant Proteins: Academic Press London, 247-248.

Harland, B.F. and Harland, J. (1980): Fermentative reduction of phytate in Rye, White and whole wheat Breads. Cereal Chem. 57(3):226.

Howeler, R.H. (1973): Iron reduced oranging disease of rice in relation to physico-chemical changes in a flooded oxisol. Soil Sci. Soc. Amer. Proc. 37:898-903.

Hui, Y.H. (1992): In: Encyclopedia of Food Science and Tech. Vol (2,3), 1805-1819, 1901-1902.

Hussain, R. and Patwardhan, (1959): The influence of phytate on the absorption of iron. Indian, J. med. Res. 47:676-682.

Ikediobi, C.O.; Olugboji, O. and Okoh, P.N. (1988): Cyanide profile of component parts of sorghum (sorghum bicolor L. Moench) Sprouts, Food Chem, 27(3):167-175).

Ikediobi, C.O.; Onyia, G.O.C. and Eluwah, C.E. (1980): A rapid and inexpensive enzymatic assay for total cyanide in cassava and cassava products. Agric, Biol. Chem. 44 (12):2803-2809.

Ikurior, S.A. and Fetuga, B.L.A. (1987): Composition of some recommended Nigerian commercial cottonseed varieties. food Chem 26(4): 307-314.

Jackson, L.C. (1988): Behavioural effects of chronic sub-lethal dietary cyanide in an animal model implication for humans consuming cassava. Human Biology 60(4), 597-614.

Jones, T.S. (1968): Cotton production in Nigeria and the possibility of a cotton Estate to produce longer staple cotton. Commonwealth Development Corporation 14-17.

Kalvins, J.V. and Kirney, R.D. (1962): The influence of dietary protein on iron absorption. Brit. J. Exp. Path, 43:172-180.

Kempt, A.; Deijis, W.B.; Hemkes, O.J. and Vans, J.A.H. (1961): In: underwood, E.J. (1966): Mineral Nutrition of Livestock Commonwealth Agric, Bureaux, Pp.75-81.

Khan, N.; Zaman, R. and Elahi, M. (1986): Effect of processing on the phytic acid content of wheat products. J. Agric. Fd. Chem. 34: 1010-1012.

King, A. (1951): The effect of climatic change. Empire cotton grow, Rev. 24. (3): 153-154.

King, E.E. and Leffler, H.R. (1979): Seed protein improvement in cereals and grain legumes. Proc. Symposium, Neuherberg, 2:385-391.

Knabe, D.A.; Tanksley, T.D. Jr. and Hesby, J.H. (1979): Effect of lysine, crude fibre and free gossypol in cottonseed meal on the performance of growing pigs. J. Anim. Sci. 49(1):134-142.

Koyama, T and Snitwongse P. (1971): Soil plant nutrition studies on tropical rice II. Soil sci. Plant Nutr. 17; 186-194.

Kumar. V.; Poswal, M.A. and Onu, I. (1990): Sowing dates and varieties and spray. Research programme 1990-91, IAR., ABU, Zaria.

Kutches, A.J.; Chalupa, W and Trei, J. (1987): "Delinted cottonseed improves lactation response" Feedstuffs 16-17.

Lassiter J.W.; Caston, M.L.; Miller, W.J. and Morris, H.D. ^{54}Mn Incorporation into plants and subsequent metabolism by Rats. Agron J. 64(1):339-341.

Leach, R.M. and Lilburn, M.S. (1978): Manganese metabolism and its function. World Rev. Nutr. Dietetic 32:123-213.

Lecos, C. (1983): Tracking trace elements. FAD consumer 17:16-21.

Lee, J.A. and Smith, F.H. (1970): Some chemical properties of Hybrid seed. Crop Science; 10:379-380.

Lewis, A.E. (1966): In: "Biostatistics" Reinhold Publisher, page 5.5.

Lewis, C.F. and Richmond, T.R. (1972): In: cotton improvement. cotton CIBA-GEIGY, AGROCHEMICALS, ETKS, C.E. ed. U.S.

Lian, S. and Tanaka, A. (1972): Calcareous soil in pingtung area in relation to the growth of lowland rice. Soil Sci. Plant Nutr. 18:15-22.

Lingle, C.J.; Tiffin L.O. and Brown, C.J. (1963): Iron uptake-transport of soybeans as influenced by other cations. Plant physiol. 38:71-76.

Makene, W.J. and Wilson, J. (1972): J, Neurol, Neurosurg, psychiat, 35: 31, Cited by charkroborty, R. (1976): Studies on hydrocyanic, oxalic and phytic acid content of foodstuffs, M.Sc. Thesis, Ahmadu Bello Unviersity, Zaria.

Mali, C.V. and Varade, S.B. (1981a): Response of Rice to varying soil moisture conditions in vertisols I. J. Agron. Crop. Sci. 150(2):129-139

Mali, C.V. and Varade, S.B. (1981b): Response of Rice to varying soil moisture conditions in vertisols. II. J. Agron. Crop. Sci. 150(2): 140-148.

Marinho, M.L. and Igue, K. (1972): Factors affecting zinc absorption by corn from volcanic ash soils. Agron. J. 64 (1): 3-8.

Martinez, W.H.; Berardi, L.C. and Goldbatt, L.A. (1970): Cottonseed protein products composition and functionality. J. Agr. Food Chem. 18, 961.

Marthur, J.M.S.; Sharma, N.D. and Singh, M. (1972): Rapid spectrophotometric method for determining free gossypol in cottonseeds. J. Food Sci. Technol., 9:138-140.

Mathew, G.A. (1989): In: "Cotton insect pests and their management", Longman Group, U.K. Limited.

McCay, C.M.; McCay, J.B. and Smith, O. (1975): Nutritive value of potatoes. In: "Potatoes processing." Tatburt, W.F. and Smith, O. (eds). 3rd ed. Avi Publishing Co. Westport.

Mertz, W. (1983): The significance of trace elements. Nutr. Today. Sept/Oct. 26-31.

Miller, D.F. (1958): Composition of cereal grains and forages. National Academy of Science, NRC Publication 585, Washington D.C.

Moloney, J.F. (1940): "Proceedings First Cotton Research Congress". Waco, Texas, pp. 231-242.

NCPA (1989): National Cottonseed Products Association. Cottonseed and its products, 9th ed. NCPA INC. Memphis, Tenn.

Nelson, A. (1951): In: Medical Botany: A handbook for medical men and all who are concerned in the use of plant. Nutritionist, Dieticians, Pharmacists and Veterinarians. E. and S. Livingstone, Edinburgh. 1-89.

NRC (1968): National Research Council: Nutrient Requirement of Domestic Animals (2): Nutrient Requirement of Swine. Nat. Acad. Sci. Publ., Washington D.C. 1599.

NRC (1980): National Research Council (NRC): Mineral Tolerance of Domestic Animals, Nat. Acad. Sci., Washington D.C., 162-163.

Nugara, D. and Edwards, H.M. (1963): Influence of dietary calcium and phosphorus levels on the magnesium requirement of the chick. J. Nutr. 80:181-194.

Nzekwe, N.M. and Olumu, I.M. (1979): Replacement value of cottonseed meal for groundnut meal in practical broiler diets: Annual Reports of Research in Animal Production, NAPRI, A.B.U., Shika. 63-64.

Obilana, A.T.; Njoku, P.C. and Okoh, P.N. (1982): Proximate analysis, amino acid composition and tannin content of improved Nigerian sorghum varieties. Animal Feed Sci. and Tech. 7(4): 365-384.

Odiemah, M. (1991): Seed traits, yield and environment in maize. Seed Sci. Technol., 19:25-32.

Oke, O.L. (1966): Chemical studies on the more commonly used leaf vegetables in Nigeria. J. West Africa Sci. Ass. 11(1&2):42-48.

Oke, O.L. (1967): Availability to plants of residual phosphorus in manure. W.A.J. Biol. Appl. Chem. 9:27-30.

Oke, O.L. (1969): Role of hydrocyanic acid in nutrition. World Review of Nutrition and Dietetics. 11:170.

Okoh, P.N.; Obilana, A.T.; Njoku, P.C. and Aduku, O.A. (1982): Proximate analysis, amino acid composition and tannin content of improved Nigerian sorghum varieties and their potentials in poultry feeds. Animal Feed Science and Tech. 7:359-364.

Osaniyi, C.B. and Eka, O.U. (1978): Studies on chemical composition and nutritive value of horse eye bean. W.A.J. Biol. Appl. Chem. 21(1-4):53-61.

Osborne, D.R. and Voogt, P. (1978): The analysis of nutrients in food (A series of monograph). Academic Press, London.

Osuntokun, B.O. (1969): Controlled trial of hydroxocobalamin and riboflavin in Nigerian atoxic neuropathy. Nig. J. Sci. 313.

Oyenuga, V.A. (1968): In: "Nigeria's foods and feedstuffs." Third edition. University of Ibadan Press, p.1-49.

Panigrahi, S. (1990): Ammonia and dietary cottonseed meal - Associated with brown yolk discolouration in hen's egg. Trop. Sci. 30:325-342.

Peason, D. (1976): The chemical analysis of foods. 7th edn. Churchill, Livingstone, Edinburgh, 1-119. 209-210.

Pless, C.D.; Fontenot, J.P. and Webb, K.E.(Jr.). (1973): Effects of dietary calcium and phosphorus on magnesium utilisation in sheep. Polytech. Inst. Stat. Univ. Res. Div. Rep. 153:104-110.

Prentice, A.N. (1972): In: "Cotton with special reference to Africa. Williams and Clowes, Longman.

Quisunbine, E. (1947): Phillipines J. Forestry. 4:145. Cited by Chakraborty, R. (1976); Studies on Hydrocyanic, oxalic and phytic acid contents of foodstuffs. M.Sc. Thesis, Ahmadu Bello University, Zaria, Nigeria.

Radeleff, R.D. (1970): In: "Veterinary Toxicology." 2nd edn. Lea and Febiger, Philadelphia, pp.98-99.

Rakhimov, A. (1980): Oil content of cottonseeds in relation to variety and fertiliser regime on newly irrigated light serozem soil. Tashkent, Uzbek, USSR. 151-152.

Reinhold, J.G.; Lahimgarzadeh, A.; Nasr, K. and Hedayat, H. (1973): Lancet, I. 283. Cited by Khan, N.; Zaman, R. and Elahi, M. (1986): Effect of processing on the phytic acid content of wheat products. J. Agric. Fd. Chem. 34:1010-1012.

Sagdallaev, S.S.; Turakhozhaev, M.T.; Zubkova, L.P. and Shakirov, T.T. (1979): Phytic production from cottonseed oil cake. 6:767-769.

Sandhu, A.S. (1976): Measures to combat insect on cotton in India. In: Cotton development published by Directorate of Cotton Department, Bombay.

Schmit, L.M.A. (1984): Cotton food resources rich in proteins. Agriculture (FRANCE). 5:24-26.

Schuphan, W. and Weihman, I. (1958): Qualities of plant material. Vegetables. 5.1.

Shemer, M.; Mizrahi, S.; Berka, Z. and Mokady, S. (1973): Effect of processing condition on isolation of cottonseed protein. J. Agric. Fd. Chem. 21(3):460-462.

Singh, P.P. (1974): Influence of light intensity, fertilisers and salinity on oxalate and mineral concentrations of two vegetables. Qual. Pl. Fds. Hum. Nutr. 24(1,2):115-125.

Smith, F.H. (1972): Effect of gossypol bound to cottonseed protein on growth of weanling rats. J. Agric. Fd. Chem. 20(4):803.

Smith, H.A. (1957): Poisoning of swine caused from feeding cottonseed oil containing gossypol. J. Pathology. 33:353.

Smith, J.P. (Jr.). (1991): In: "Encyclopedia of food science and technology." Hui, Y.H. (ed). John Wiley Inc. New York. 3:2114.

Stewart, E.A. (1974): In: "Chemical analysis of ecological materials." Blackwell Scientific Publ. Oxford, London. 298-312.

Street, H.E. and Cockburn, W. (1972): Absorption, secretion and translocation. In: "Plant metabolism." 2nd edition.186-211, 212-246.

Terry, D.E.; Agbaji, A.S. and Agbaji, E.b. (1992): Proximate composition of the seeds of Acacia nilotica. Adansonii (Bagaruwa) and extraction of its protein. Trop. Sci. 32:261-268.

Taira, H.; Akimoto, I. and Miyahara, T. (1986): Effect of seeding time on lipid content and fatty acid composition of buckwheat grains. J. Agric. Fd. Chem. 34:14-17.

Tar-Sarkissian, N.; Azar, M.; Ghavifaki, H.; Perguson, T. and Hadayat, H. (1974): J. Am. Dietetic Assoc. 65(6). cited by Khan, N; Zaman, R. and Elahi, M. (1986): Effect of processing on the phytic acid content of wheat products. J. Agric. Fd. Chem. 34:1010-1012.

Teutonico, A.A. and Knorr, D. (1985): Non destructive method for determination of water soluble oxalate in cultural Amaranthus tricolor cells. J. Agric. Fd. Chem. 33:60-62.

Tewe, O.O. and Manor, J.H. (1982): Cyanide, protein and iodine interaction in the physiology and metabolism of rats. Food Chemistry. 9(3):195-204.

Tewell, J.W.; Clark, H.E. and Howe, J.M. (1973): Phosphorus balances of adults fed rice, milk and wheat flour mixture. J. Am. Dietetic Ass. 63:530-535.

Tharp, W.H. (1948): In: Cottonseed and cottonseed products. Bailey, A.E. (ed.). Interscience. New York. 117-154.

Thomas, A.D. and Symthe, L.E. (1973): Rapid destruction of plant material with concentrated nitric acid vapour. Talanta, 20:469-475.

Tran, V.H; Peter, D.H.; Vivian, C.A.; William, S.A.K. and Richard, S.T.Y. (1987): Content and distribution of manganese in lupin flour, spray-dried powder and protein isolate prepared from the seeds. J. Sci. Fd. Agric. 41:131-139.

Tropical Products Quarterly (TPQ, 1970): 11,167: Cited by Shamer, M.; Mizrahi, S.; Barka, Z. and Mokady, S. (1973): Effect of processing condition on isolation of cottonseed protein. J. Agr. Fd. Chem. 21(3):460-462.

Udoessien, E.I. and Ifon, E.T. (1992): Chemical evaluation of some antinutritional constituents in four species of yams. Tropical Science. 32:115-119.

Underwood, E.J. (1966): Mineral nutrition of livestock. Commonwealth Agricultural Bureaux. 158-180.

Underwood, E.J. (1977): In: "Trace elements in human and animal nutrition." 4th edn. Academic Press. New York. pp.89-208.

Venogopal, B. and Luckery, T.D. (1978): Metal toxicity in mammals-2. Chemical toxicity of metals and metalloids. Platinum Press, New York. pp.25-32.

Wallace, H.D.; Cunha, T.J. and Combs, G.E. (1955): Gossypol toxicity in pig. Fla. Agric. Expt. Statn. 566.

Watts, P.B. (1959): Effect of oxalic acid ingestion by sheep. J. Agric. Sci. 52:244.

Zhuge, Q.; Posner, E.S. and Devoe, C.W. (1988): Production study of low-gossypol product from cottonseed meal. J. Agric. and Food Chem. 36(1):153-155.