The Effect of Dietary Pigeon pea (*Cajanus cajan)* Seed on Growth and Some Blood Parameters of Desert Goats

By
Fatima Mohamed Ahmed Fadl Elmula
B.Sc. (Honours)
Faculty of Natural Resources and Environmental Studies
University of Kordofan
Department of Animal Science
June 1999

Supervisor
Dr. Khadiga Abbas Abdel Ati

A thesis submitted in fulfillment of the
requirements for the degree of M.Sc. Animal Production.

Department of Animal Nutrition
Faculty of Animal Production
University of Khartoum

September - 2003

DEDICATION

To my father,
my mother,
my brothers and my sisters

ACKNOWLEDGEMENTS

Praise to Allah, who gave me the strength and patience to complete this work.

Next, I would like very much to thank and gratitude to my supervisor Dr. Khadiga Abbas Abdelati, Head of Department of Animal Nutrition, Faculty of Animal Production, University of Khartoum for her continuous supervision, patience and unlimited support throughout the period of the research. Thanks very much to all staff and technicians of the Departments of Animal Nutrition, Faculty of Animal Production, also my thanks extended to Nasr El Din Abdel Rahim, for his help in experiments.

My thanks extend to Mrs Rauda Hassan, Technician of Biochemistry on Veterinary Research Laboratory, Soba. I am grateful to Dr. Mohammed Elsir, Faculty of Veterinary Science, Department of Physiology for his cooperation during practical period.

Finally especial thanks extend to my family, Al Eleaser, and all the member of my family for their financial support and continuous encouragement.

ABSTRACT

The experiment was conducted in the Faculty of Animal Production, University of Khartoum, at Shambat during period from 3rd July (2002) to 20th August (2002) for 6 weeks. The study aims to examine the effect of the dietary *C. cajan* on the growth of desert goat kids, chemical blood serum cholesterol, calcium (Ca), inorganic phosphorus (i.P), glucose, total protein, iron (Fe) and blood haemoglobin (Hb).

The sample taken in this experiment was twenty four male kids of ages ranging from 3.5 – 4 months and the animal average weight (10.27 ± 0.69 kg), such sample was divided into four equal groups of six animals each. The four groups were provided with basic ration consisting of sorghum grain, wheat bran and groundnut cake that supply male kids with all nutrients. The ration of isolcaloric and isonitrogenous NRC (1981) was almost of the same results. In this experiment four treatments of *C. cajan* were added to the basic ration with percentage of (0, 3, 6 and 9%) in group A, B, C and D.

Results showed that there was a significant effect (P< 0.05) on growth and consumed feed when using *C. cajan,* the group who was provided with the ration containing 9% of *C. cajan* had a significant increase in the growth rate. In addition, such group had the larger amount of the consumed feed as well as the best feed conversion ratio (FCR). Chemical blood measurements showed that there is ascending increase in blood indices such as (Hb), the group who was fed with the ration containing 9% of *C. cajan* scored the significant increase, however, higher level of serum cholesterol observed on animal fed 6% *C. cajan*, but serum total protein, glucose, Ca, i.P and Fe were not affected by *C. cajan*. Feeding 9% of *C. cajan* has no adverse effect on animal health and no bloat symptoms.

Π

ملخص الأطروحة

أجريت هذه التجربة بجامعة الخرطوم – كلية الإنتاج الحيـواني – شـمبات فـي الفترة من 3 يوليو 2002 – 20 أغسطس 2002م لمدة ستة أسابيع بهدف تـأثير إضـافة بذور اللوبيا العدسي علي مستوي الأداء العام لجداء الماعز الصحراوي وكيميـاء مصـل الدم يشمل الكلسترول والكالسيوم والفسفور الغير عضوي والجلكوز والبـروتين الكلـي والحديد والهيموقلوبين.

24 من جداء الماعز الصحراوي يتراوح عمرها من 5ر3 – 4 أشهر ومتوسـط وزن الحيوان 27ر10 ± 69ر0 كجم استخدمت في هذه التجربة ولقد قسمت إلى أربعـة مجموعات متساوية (ستة حيوانات لكل معاملة) كما استخدمت عليقة أساسية تكونت مـن الذرة وردة القمح وامباز الفول بحيث تقابل احتياجات الماعز كما تساوت نسـبة الطاقـة والبروتين والكالسيوم والفسفور غير العضوي فـي الأربعـة علائـق (1981) NRC. أضيفت أربعة معاملات من اللوبيا العدسي بنسبة (صفر، 3، 6، 9%) في المجموعات أ، ب، ج، د علي التوالي.

أوضحت النتائج أن هناك تأثير معنوي (P< 0.05) لاستعمال اللوبيـا العدسـي علي معدل النمو والغذاء المستهلك وسجات الحيوانات التي تغذت علي عليقـة بهـا 9% لوبيا عدسي زيادة معنوية (P< 0.05) في معدل النمو بالإضافة إلى ذلك سـجلت هـذه المجموعة اكبر كمية من الغذاء المستهلك وافضل كفاءة تحويلية. كما أن مقاييس كيميـاء الدم أظهرت أن هناك فروق معنوية في مصل الكلسترول في المجموعات المضاف إليهـا اللوبيا العدسي كما أن هناك زيادة تصاعدية في مكونات الدم مثل الهيموقلوبين وسـجلت المجموعات التي تغذت علي عليقة بها 9% لوبيا عدسي اعلي زيادة معنوية كما ان هنالك زيادة معنوية في مصل الكلسترول في المجموعات التي تغذت علي عليقة بها 6% لوبيا عدسي. كما أظهرت النتائج أن مقاييس كيمياء مصل الدم مثل البروتين الكلي والجلوكوز والكالسيوم والفوسفور غير عضوي والحديد لم تتأثر بإضافة اللوبيا العدسي.

كما أوضحت النتائج أن تغذية جداء الماعز الصحراوي علي عليقة تحتوي نسبة 9% لوبيا عدسي ليس لها أضرار علي صحة الحيوان ولم تظهر علي الحيوانات أعراض نفاخ.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE
INTRODUCTION

Goat are the most widely distributed domestic livestock, and mainly found in tropical and subtropical regions, they can survive in areas with low quality vegetation. They are important to tropical farmers because they provide them with milk, meat and skin (Devendra and Burns, 1983).

In Sudan goats are mainly kept for milk production in the riverain areas in the towns and in rural areas. In the vast area of Western Sudan goats are occasionally kept in association with cattle, sheep and camels.

The population of goats in Sudan is approximately 38.5 million (M.A.R., 2001). This huge number of animal wealth formulates the considered of Sudanese economy and is expected to play an important role as a source of human food. However, about 90% of the animal resource in the Sudan are possessed by nomads with their seasonal migratory habits in search of water and pasture, consistently the Sudanese livestock are mostly raised under open range grazing conditions, where tropical grass are known for their early maturity, high fibre, high lignin and low protein contents this has adversely affected livestock reproductive and productive performance.

C. cajan contain high level of protein (21 – 28) (Fialho, *et al.,* (1985); Sibarani (1982); Tangtaweewipat and Elliot (1989) and Hamad, (2000). With high level of lysine (Singh and Eggum (1984) and good source of minerals (Meiners *et al.,* (1976), the value of *C. cajan* seed for animal feeding has not been investigated.

In the Sudan *C. cajan* has been considered as human diet, but up to our knowledge two studies have been conducted by (Magboul, 1998 and Hamad, 2000) on broiler chicks.

The main objectives of this work is to investigate the effect of feeding *C. cajan* seed on desert kids performance, and assessing the effect of *C. cajan* on some blood parameters of desert kids.

CHAPTER TWO

LITERATURE REVIEW

C. cajan ”pigeon pea” is a member of the subtribe *cajaninae*, tribe *phaseoleae* and family *leguminosae*, although it is often stated to be *amonotypic genus* (Vander Maesen, 1986). It is of importance as a source of high protein food in many countries in the semi arid tropics but particularly so in India, where it is the second most important pulse after chickpea (Sheldrake *et al*., 1979). India accounts for more than 90% of the world’s pigeon pea production. Other countries where *C. cajan* is an important legume are Kenya, Uganda, Malawi, Tanzania, Puerto Rico, Venezuela, Myanmar, the Caribbean islands and Philippines. In India is mostly used after dehulling in the form of dhal (decorticated split cotyledons), which is consumed after cooking in water to a desirable softness, but in some African countries, whole pigeon pea seed are consumed after boiling (ICRISAT, 1986).

The crop is most commonly grown to be used as dry seed, but seeds are also eaten as a green vegetable. In the Caribbean island (particularly Puerto Rico), the crop is grown primarily for export, and canned green seeds are exported to North America, dry seeds and the by products of (dhal) manufactured together with leaf and pod residues after harvest can provide suitable food for ruminants (Whiteman and Norton, 1981).

Grains, whole pods and milling trash suitably processed and mixed with additives, have been proposed as substitutes for soy bean and maize in poultry and pig feed, dry stems of pigeon pea are an important source of fuel in rural India (Wallis *et al*., 1986).

In Sudan, *C. cajan* is grown in about 70.000 feddan yielding about 700 kg/fed, (ICRISAT, 1994). Traditionally it is grown in Northern and Central Sudan as a minor crop, it is grown along irrigation channels in Gezira, or in small farm holdings in northern Sudan along the Nile, also it is grown in the west of Sudan as rain fed crop mainly in the semi-arid area of western Sudan. The crop is locally known as Lubia Addassy and is consumed as boiled dry grain particularly during the month of fasting “Ramadan”. The foliage is also used as feed for livestock and the dry stems are used as firewood, they are sometimes used as fence on dairy farms (ICRISAT, 1994).

2.1 Chemical composition of *Cajanus cajan*:

Pursegloves (1968) studied the chemical composition of *C. cajan* which contain about 10.1% moisture, 19.2% protein, 1.5% fat, 57.3% carbohydrate, 8.1% fibre and 3.8% ash.

Singh and Jambunathan (1982) reported that *C. cajan* cotyledons constitute about 85% of total seed mass, the embryo contributes only 1% to the total seed mass and the seed coat, 14%.

Otero (1952) demonstrated that *C. cajan* contains 11.46% crude protein and 22.6% crude fibre in leaves and 18.36% crude protein and 5.43% crude fibre in the seed.

Fialho, *et al*., (1985) found that *C. cajan* contain about 28.8% crude protein, 4.3% ash, 10.6% crude fibre, 1.4% fat, 71.5% nitrogen, energy 77.4%. However, Fialho, *et al*., (1985) reported that *C. cajan* cooked contains about 23% cp, 3.4% ash, 10.3% crude fibre, 1.1% ether extract, 81.6% nitrogen, energy 83.4%, also Fialho, et al., (1985) found that *C. cajan* toasted contain about 22.4% cp, 3.9I% ash, 10.6% crude fibre, 0.9% ether extract, 76.3% nitrogen, energy 83.4%.

Krause (1932) studied the chemical analysis of *C. cajan* seed content as percentage, moisture 12.26, ash 3.55, crude protein 22.34, crude fibre 6.44, fat 1.46.

Barton (1952) worked on the chemical composition of *C. cajan* was (8.5, g/100 g moisture), (17.9, g/l00 g protein), (1.11, g/100 g fat), (3.24, g/100 g ash), 10.2, mg/100 g calcium), (12.5, mg.100 g phosphorus), (102, mg/100 g iron).

Sibarani (1982) reported that *C. cajan* contain as percentage, protein (21.8), fat (1.6), carbohydrate (55.7), ash (3.6), crude fibre (5.3), moisture (11.8).

Schod and Maywold (1968) demonstrated that *C. cajan* starch contain about 40.4%, moisture 8.7%, amylase, 35.6%, nitrogen 0.28%, fat 0.09%, ash0.17%, phosphorus 0.019%.

Tangtaweewipat and Elliot (1989) detected that chemical composition of *C. cajan* is 21.3% crude protein, 1.2% ether extract, 4.4% ash and 1% tannin.

In Sudan Elhardalou (1980) stated that the chemical composition of *C. cajan* is 6.1% moisture, 19.3% protein, 2% fat, 6.4% crude fibre, 3.6% ash.

Recently, Magboul (1998) worked on the chemical composition of *C. cajan* was 6.43% moisture, 21.87% crude protein, 10.76% ether extract, 10.67% crude fibre and 4.31% ash.

Hamad (2000) reported that *C. cajan* contain about 31.5% cp, 11.85% cf, 55.8% NFE, 5% ash, 2.18% fat, 0.32% tannin, 0.31% calcium, 0.032% phosphorus, 0.05 iron.

2.1.1 Amino acids, fatty acids and mineral composition of *C. cajan*:

Singh and Eggum (1984) studied the amino acid composition of some legumes including *C. cajan,* then showed that the sulphur amino acids, methionine and cystine are the most limiting amino acids of legumes and had a lowest value for *C. cajan*, where was found that *C. Cajan* contain high level of lysine.

Singh and Jambunathan (1982) worked on *C. cajan* amino acid and protein and mentioned that globulins are deficient in sulphur amino acid, methionine and cystine constituting nearly 65% of the total seed proteins of pigeon pea, albumin fractions are very rich source of methionine and cystine, Glutein fraction is also a better source of sulfur amino acids than globulin.

Milner (1972), Kapoor and Gupta (1979) indicated that the amino acid composition of isolated protein of *C. cajan* are given in Table (1) they found that glutamic and aspartic acid had highest values.

Oshodia (1993) studied the amino acids and fatty acid content of *C. cajan*, they found that the seed contained nutritionally useful quantities of the most essential amino acids but it was low in sulphur-containing amino acids, total essential amino acid equal (43.61%). Morton (1976) reported that the oil of seeds of *C. cajan* is contains 5.7% linolenic acid, 51.4% linoleic and 21.4% palmetic acids. However caprylic, lauric, oleic and eicosonic acids were present only in small quantities.

Meiners *et al*., (1976) found that the amount of minerals content of *C. cajan* in (Appendix 1), the author found that iron, calcium, potassium and magnesium were the most abundant minerals.

2.1.2 Vitamins in *C. cajan*:

AVC (1951) reported that the seed is a good source of vitamin A, also contains a considerable quantity of thiamine, riboflavin and niacin. These vitamins being water soluble and heat unstable and likely to be reduce due to cooking, more than 70 to 80% of thiamine and riboflavin were lost due to processing.

2.2 Antinutritional factors of *C. cajan*:

Of the various antinutritional factors that are found in grain legumes, trypsin, chymotrypsin inhibitors, amylase inhibitor, polyphenolic compounds (commonly referred to as tannins) and oligosaccharides. These factors are important in *C. cajan*. Seed coat contained the highest proportion of tannin which as nutritional inhibitors in coarse grains (Singh, 1988).

Table 1: Amino acid composition of isolated protein of *C. cajan* (g/16g).

Amio acid	Albumin	Globulin
Lysine	10.6	7.9
Histidine	2.9	2.3
Arginine	5.7	8.8
Threonine	5.2	3.2
Valine	5.5	5.5
Methoionine	1.1	0.5
Isoleucine	6.1	5.9
Leucine	5.9	8.7
Phenylalanine	5.7	3.1
Aspartic cid	11.2	9.9
Serine	3.8	3.6
Glutamic acid	15.9	23.9
Proline	4.8	4.3
Glyaine	5.0	3.6
Alanine	5.2	3.7
Tyrosine	5.2	3.1

In legumes in addition, inhibitor of enzymes such as trypsin, chymotrypsin, amylase, and of flatulence causing oligosacharides such as stachyose, raffinose, and verbascose play important roles in *C. cajan*. The levels of these antinutritional factors have been determined in pigeon pea and chickpea whole seed (Sing *et al*. 1981) and Singh *et al.* (1982) as shown in Table (2).

Pigeon pea contains considerably higher levels of protease inhibitors than the other commonly consumed Indian grain legumes, but much lower levels than those of soybean, also contains considerable amount of polyphenolic compounds that inhibit the activity of digestive enzymes, trypsin, chymotrypsin and amylase (Sumathi and Patabhiraman, 1976).

Phytolectins are toxic factors that interact with glycoprotein on the surface of red blood cells, causing them to agglutinate. Pigeon pea contains phytolectins which are highly sensitive to heat treatment and hence may be of little nutritional significance, pigeon pea contains traces of glycosides but not at toxic levels (Singh, 1988).

Antinutritional factors both in pigeon pea and chick pea, which can be reduced or destroyed by cooking, the levels of these factors and the role of polyphenolic compounds (tannins) is importance in pigeon pea in areas where it is consumed without cooking when whole and mature or as a developing green seed (Jambunathan and Singh, 1980). Also, Singh (1988) showed that food legumes are well known for causing flatulence when consumed in large quantities, this property is mostly attributed to high levels of oligosaccharides: Stachyose, raffinose and verbascose, these three sugars together constitute about 53% of the total soluble sugar in pigeon pea.

2.3 *C.* cajan in poultry nutrition:

Amaefule and Obioha (2001) studied the performance and nutrient utilization of broiler starters fed diets containing raw, boiled or dehulled pigeon pea seeds, were used to compare three types of pigeon pea seed meal such as raw, boiled and dehulled at two levels, 20 and 30% of the diet, measurements recorded included weight gain,

feed intake, feed conversion ratio (FCR) and protein efficiency ratio (PER), better results were obtained when pigeon pea seed meal (ppsm) was included at 30% level than at 20% in all performance criteria, the interaction between processing method and level of inclusion was significant (P< 0.001) with dehulled (ppsm) included at 30% producing best results, while at 20% dehulled ppsm was not superior to boiled ppsm, in all measurements broilers fed boiled and dehulled ppsm performed significantly better (P< 0.01) than those fed raw seed meal. Also, Amaefule and Obioha (2001) fed broiler finisher

Table 2: The levels of antinutritional factors and in vitro protein digestibility in seed samples of pigeon pea and chickpea.

Component	**Pigeon pea**		**Chick pea**	
	Range	Mean	Range	Mean

Trypsin inhibitor mg/g	5.5-12.1	9.6	8.1–15.7	11.6
Chymotrypsin inhibitors mg/g	2.1–3.6	3.0	6.1–8.8	7.7
Amylase inhibitor mg/g	23.6–31.0	26.4	5.0 – 9.7	6.8
Stachyose (%)	0.5–1.0	0.8	0.8–1.9	1.2
Raffinose (%)	0.5–0.9	0.7	0.4–0.6	0.5
Verbascose (%)	0.6–1.1	0.8	N.P	N.P
Polyphenols (mg/g)	4.3-11.4	6.6	1.9–6.1	3.5
In vitro digestibility of Protein (%)	52.5–62.0	59.2	57.4–74.8	67.9

N.P. = Not performed

fed diets containing 30 and 40% raw, boiled or dehulled pigeon pea seed meals, results showed that dehulled seed meal diet produced broilers with the highest daily weight gain, final live weight and protein efficiency ratio, lowest feed intake, FCR and daily protein intake, broilers fed boiled seed meal diet performed significantly better than those fed raw seed meal diet in all measurements, broilers fed on 30% inclusion level of ppsm gave better results than those on 40% which significantly depressed growth rate, it is concluded that a better option is to dehull boiled pigeon pea seeds and include the meal at not more than 30% of the whole ration for broiler finishers.

Amaefule and Obioha (1998) stated the substitution of groundnut cake and maize by pigeon pea in broiler experiments, they fed broilers diets containing levels of 0, 30, 40 or 50% pigeon pea seed meal (ppsm), live weight an increased as the proportion of ppsm in the diet increased, final live weight were 1.47, 1.46, 1.71 and 1.73 kg for birds on the 0, 30, 40 and 50% ppsm diets respectively, feed and protein intake increased ($P < 0.05$) as a result of replacing groundnut cake and maize with ppsm up to 40%, but did not show a significant difference between 40 and 50%. Tangtaweewipat and Elliott (1989) fed broiler chickens different levels of ground pigeon pea (0, 100, 200, 300, 400 and 500 g/kg diet, replacing maize and soy bean meal, live weight gains were not significantly different between treatments, FCR of chicken fed on diets containing pigeon pea (0, 100, 200, 300 g/kg were 1.97, 2.10, 2.04 and 2.08 respectively not significantly different, FCR was significantly greater with pigeon pea 400 and 500 g/kg (2.25 and 2.35, respectively). In a second experiment ground pigeon pea was incorporated into layer diets at (0, 100, 200, 300, 350 or 400 g/kg, replacing maize and soy bean meal, to study the effect of egg production and egg quality over a three month period, pigeon pea meal at 200 g/kg or greater decreased egg production, feed intake (kg) per kg of eggs produced from layers given diets containing pigeon pea 0, 100 or 200 g/kg were 2.10, 2.15 and 2.14 respectively not significantly different, the diets containing pigeon pea 300, 350, and 400 g/kg resulted in poorer FCR (2.33, 2.38 and 2.73 respectively, no significant differences in feed intake and egg quality.

Ologhobo (1992), fed broilers some tropical legumes. He replaced 12.5% to25% of soy bean by *C. cajan* seed, and found that inclusion of legumes even at 12.5% result in significant decrease in weight gain and feed intake, feed intake (kg) per kg weight gain for broiler given diets containing 12.5% lima beans or pigeon pea and 12.5 or 25% groundnuts, did not differ from control. However, inclusion of *C. cajan* and kidney bean at 25% adversely affected (FCR). The weight of liver and brain were altered by higher levels of legumes. Grimaud (1988) conducted an experiment of feeding broiler chickens without or with 15, 20, 30, 40% *C. cajan* meal partly replacing wheat and soy bean meal, mean daily gain was 39.8, 41.7, 38.8, 39.5 and 41.7 and feed conversion indices 2.63, 2.81, 2.95, 2.72 and 2.89. However, the group fed 30% *C. cajan* meal mortality was 37%, results indicated that up to 25% *C. cajan* can be included in diets for chicks without affecting performance. In chickens given diets with 40% *C. cajan* meal for 6 weeks performance, were different from control group from about 3 weeks indicating the presence of antinutritional factors. Pancreas weight was greater in chicks fed with *C. cajan* meal.

Hamad (2000) fed broiler chickens different levels of decorticated *C. cajan* at (0, 7.5, 15%) and (0, 7.5, 15%) corticated the result showed that high level of feed intake was obtained by animals fed 7.5% and 15% decorticated, the higher weight gain was obtained by animals fed 7.5% decorticated *C. cajan*, the lower weight gained by birds fed 7.5% and 15% corticated *C. cajan*. The best significant feed conversion ratio obtained by birds fed 7.5% decorticated *C. cajan* compared to other groups. The effect of feeding broiler dietary *C. cajan* on serum composition. The results showed that treatments had no significant effect on serum albumin, lipid and protein but there were significant ($P < 0.05$) increase in calcium and uric acid level, the birds fed 7.5% corticated *C. cajan* showed higher level of uric acid. However, birds fed decorticated *C. cajan* at 15% level showed significantly ($P < 0.05$) lower level of serum uric acid than other level of decorticated *C. cajan* at 7.5, 15% levels showed significantly ($P < 0.05$) higher level of serum calcium than other treatment.

2.4 *C. cajan* for goat, sheep, pig, rats and cow:

Soto *et al*. (1990) fed sheep a native grass from a tropical region without or with15 or 30% pigeon pea (*C. cajan*), DM digestibility for native grass alone and with 15 and 30% pigeon pea was 47.65, 53.13 and 55.57% respectively with no significant differences. Feed intake of grass alone or with15 or 30% pigeon pea was 58.0, 58.1 and 59.00% and as a percentage of live weight 2.47, 2.48 and 2.53, there was no significant difference among treatments.

El Hag and Elwakeel (1998) a study on utilization of forage legume hays as a dry season supplement for goats in North Kordofan.

Hay samples from the three legumes including (*C. Cajan, clitoria ternatear* and *vigna unguiculata*), were evaluated for chemical composition and nutritive value and were found to have higher nutrient content than natural grass stands during the dry season.

Forage legume hay supplementation resulted in improved performance of lactating Sudan desert goats, supplemented goats had higher weight gains and higher milk yields in comparison to the controls, kids of supplemented goats also had higher weights and weight gains.

Karachi and Zengo (1997) forage of pigeon pea *(C. cajan*) was fed to growing goats as supplements to natural grazing, the supplemented goats gain live weight faster than the control animals, daily intake of pigeon pea (63.1 – 91.4 g/head). Daily live weight gains ranged from 25.5 to 43.2, 6.7 to 21.6 g/head for goats supplemented with pigeon pea and control non supplemented animals.

Grimaud (1988) working with pigs gave a ground feed without or with 45% pigeon pea meal partly replacing wheat and soy bean meal, mean daily gain was 700 and 675, and feed conversion indices 3.0 and 3.14 respectively. There were no significant differences in slaughter indices and no difference between group were observed.

Trompiz *et al*. (2001) studied the effect of partial substitution of feed concentrate (0, 8, 16 and 24%) for pigeon pea meal on productive performance of fattening pigs, there was an effect of substitution level (SL) on total live weight gain, daily live weight gain and feed conversion, the 0% substitution level resulted in higher total live weight gain (43.5 kg) and daily live weight gain (0.778 kg) than the other SL (37.72 and 0.673 kg), (39.85 and 0.711 kg), (30.30 and 0.546 kg) respectively for 8, 16 and 24). Feed conversion was better at 0%

SL (4.02) and at 8% SL (4.1) and at 16% SL (4.77) and 24% SL (5.55), even though there was a better performance at 0% substitution level. Narayanswamy *et al*. (1990) fed young rams were on a complete diet containing fallen banyan tree leaves and pigeon pea straw, average daily body weight gain was 72 and 97 g respectively. Feed conversion was 13.63 and 9.59 kg feed/kg gain. Apparent digestibilities of DM, organic matter, crude protein and crude fibre were lower with fallen banyan tree leaves than with pigeon pea straw, all the rams were in positive nitrogen, calcium and phosphorus balance. Joshi and Singhal (1982) observed that rats fed basal diet alone or with 50% legume, after 2 weeks blood sugar remained normal for rats given no legume or given pulse of *phaseolus radiatus*, and had increased significantly for rats given pulse of *P. aconitifolius, P. mungo* or *cajanus cajan*, or leaves of *P. radiates* or *C. cajan*, protein in pulse stimulated the secretion of insulin and so decreased blood sugar. Serum cholesterol decreased significantly for all those except the groups given no legume or given leaves of *P. radiates*, when rats were given aqueous extract or residue of the pulse results indicated that the substance that decreased serum cholesterol was soluble in water for *C. cajan* but not for the other 3 pulses.

Devendra *et al.* (1981) studied the comparative intake and utilization by adult goats and sheep of cassava, pigeon pea, leucaena and groundnut, CP content on a DM basis was 21.0, 20, 20.8 and 17.4% and CF content was 22.2, 25.3, 32.9 and 24% respectively. Daily goat DM intake ranged from 33.0 to 64 g for goats and 27.8 to 53.7, for sheep. Significant differences between SPP were only found for leucaena, goats had a higher digestibility of DM, OM and CF, higher N retention and higher forage nutritive values than sheep.

Krause (1932) fed cattle wholly on pigeon pea pasture have gained in weight from 0.7 to 1.25 kg per head per day at a carrying capacity of 1 to 3.75 beasts/hectare and live weight gains of 200 to 500 kg per ha per annum.

Vonschaaffhausen (1966) found that zebu bulls grazing apangola grass/pigeon pea pasture gained an averages of 30 kg in 90 days during a severe drought, while animals on control pasture lost 6 kg on rotation pasture of lablab purpureus and grass, also 47 bull gained 40 kg in 63 day

CHAPTER THREE
MATERIALS AND METHODS

This study was carried in Shambat at the Faculty of Animal Production, University of Khartoum during the period from July (2002) to August (2002) for 6 weeks.

3.1 Experimental procedure:

Twenty four males desert goat kids, were purchased from Ombader livestock market ranging in age between 3.5 – 4 months, and average live weight10.27 $\pm$ 0.69 kg, they were then transported to livestock unit. Faculty of Animal Production, University of Khartoum.

On arrival animals were rested, eartagged and allowed to adapt for 7 days. During this period the animals were fed the assigned diets adlibtum. Before the adaptation period pens were disinfected with Gamatox powder against ticks and mites prior to animal arrival, then dipping in Gamatox to remove external parasites, drenched with antihelmntic (Albendazole) against internal parasites and injected with antibiotic as prophylactic measure.

The animals were divided randomly into four groups with 4 pens of 6 animals each. Group A as control with average mean weight 10.08 kg, group B for treatment with 3% *C. cajan* with average mean weight 10.08 kg , group C for treatment with 6% *C. cajan* with average mean weight 10.25 kg and group D for treatment with 9% *C. cajan* with average mean weight 10.66 kg. Four groups were separately penned, each pen was provided with watering and feeding facilities.

3.2 Experimental rations:

The experimental diets were prepared to cover the nutrient requirement of growing kids according to NRC (1981), the basal rations were contained primarily contains sorghum, groundnut cake and wheat bran. The ration for control group with no added *C. cajan* (ration A). Other rations were supplements with *C. cajan* at rate 3%, 6%, 9% respectively. The ingredient proportion calculated, chemical composition and proximate analysis of the experimental diets are given in Tables (3, 4, 5,) respectively. During the feeding period, the animals were fed daily the assigned experimental diet adlibitum at 7:30 am throughout the study period, which extended for 42 days. Abu sabeen was also offered daily at rate of 0.04 kg/head/day.

Table 3: Composition of experimental rations as fed.

Ingredients %	A	B	C	D

Sorghum	55	56	57	65
Wheat brane	30.75	26.75	24.75	16
Groundnut cake	6	5	3	2
Cajanus cajan	0	3	6	9
Molasses	5	5	5	3.75
Bone meal	0.75	0.75	0.75	1.25
Salt	1	1	1	1
Lime stone	1.5	1.5	1.5	1
Tallow	0	1	1	1

Table 4: Calculated chemical composition of the experimental ration.

Ingredients %	Ration

	A	B	C	D
CP	16	16.1	16.1	16.1
CF	6.4	6.05	6.1	6.1
*ME	12	12	12	11.9
Ca	0.98	0.96	0.96	0.9
P	0.55	0.50	0.50	0.50

* ME (Mj/kg) calculated according to Ellis, (1981).

ME (Mj/kg)= 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE

Table 5: Determined chemical composition of experimental ration on dry matter basis.

Nutrients	Ration			
	A	B	C	D
Dry matter (%)	92	92.2	92	92.5
Crude protein (%)	19.8	17	16.6	17
Ether extract (%)	3.2	4	3	4.2
Crude fibre (%)	11.25	9.75	11.5	12
Ash (%)	6	7	6	5.5
NFE (%)	51.75	54.45	54.9	53.8
*ME (Mj/kg)	11.17	11.38	11.18	11.47

*ME: Calculated according to Ellis, (1981).

3.3 Data records:

Total feed offered and residual for each pen was recorded daily to calculate feed intake by different group. The animals were weighed weekly, they were fasted overnight except for water before weighting, the average weekly weight gain of each animal and its feed conversion efficiency was calculated.

3.4 Blood sampling:

Blood samples were collected from all animals at the end of the experiment by vein puncture in vacutainer tubes, the serum was separated by centrifugation of blood sample at 3000 rpm for 10 minutes, serum sample were stored frozen in $-20^{0}C$ until analyzed.

3.5 Haemoglobin (Hb):

Blood hemoglobin was determined by Sahali method (Appendix 2).

3.6 Chemical analysis:

3.6.1 Feed:

Proximate analysis of the rations was done according to procedure of (AOAC, 1982).

3.6.2 Serum total protein:

Total protein was analyzed by the method described by Kind and King (1954) (Appendix 3).

3.6.3 Serum glucose:

Serum blood glucose was measured by method described by Grod Wohl (1956) (Appendix 4).

3.6.4 Serum cholesterol:

Serum cholesterol was determined by the spectrophotometer using enzymatic calorimetric test (CHOD-PAP) (Trinder, 1969; Flegg, 1972; Richomond, 1972; Fasce, 1982; Deeg and Ziegenohrm, 1982) (Appendix 5).

3.6.5 Serum Ca, i.p. and Fe:

Were analyzed using spectrometer model (uican 8625). Serum Ca was analyzed according to the method described by Trinder, 1960) (Appendix 6).

Serum inorganic phosphorous was determined by method described by Varley, 1967) (Appendix 7). Serum Fe was determined by Earl (Appendx 8).

3.7 Statistical analysis:

The data collected was analyzed according to the analysis of variance (ANOVA) appropriates for CRD was used according to Gomaez and Gomez (1984). Means separation was carried out using the least significance difference (LSD).

CHAPTER FOUR
RESULTS

4.1 Chemical composition of *C. cajan*:

The results of chemical composition of *C. cajan* was shown in Table (6). The result indicated that *C. cajan* contain 21.7 CP, 12.0 CF, 64.3 NFE, 2.0 EE, 4.0 ash and DM 93.5.

4.2 Feed lot performance:

Feed intake results (g/head/week) are presented in Figure (1) and Appendix (9). The addition of *C. cajan* to the ration at level 3, 6 and 9% in group B, C and D respectively resulted in consistent increase in feed intake at week 4, 5 and 6. The highest feed intake was observed in animal fed 9% *C. cajan* followed by animals fed 6% *C. cajan* and then animals fed 3% *C. cajan*, also the highest daily feed intake was reported on animal fed 9% *C. cajan* showed in Table (7).

The growth performance of desert goat are presented in Figure (2) and Appendix (10), treatments had significant ($P< 0.05$) effect on average live body weight, there was no significant ($P< 0.05$) effect on live body weight in first four weeks, but there was significant ($P< 0.05$) effect on live bodyweight at week 5 and 6 on the animal fed *C. cajan*.

Table 6: Chemical analysis of *C. cajan* (on dry basis).

(%)	*C. cajan*
DM	93.5
CP	21.7
CF	12.0
NFE	53.8
Ash	4.0
EE	2.0
ME (Mj/kg)	11.36

ME calculated according to the equation of Ellis, (1981).

ME (Mj/kg) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE

Table 7: Effect of dietary *C. cajan* on overall performance of desert kids

Item	A	B	C	D	± S.E	L.S
Number of animals	6	6	6	6	-	-
Initial live body weight (kg)	10.08	10.08	10.25	10.66	±0.69	N.S
Final live body weight (kg)	12.31^{c}	13.47^{bc}	14.27^{ab}	15.4^{a}	±0.36	*
Average daily feed intake (g/head/day)	391.44	418.61	439.51	459.8	-	N.P
Average daily gain (g/head/day)	53^{d}	81^{c}	96^{b}	113^{a}	±3.70	*
Feed/gain	74	5.16	4.57	4.06	-	N.P

N.S = Non significant

L.S = Level of significance

±S.E = Standard error of means

* = Significant ($P < 0.05$)

N.P = Not performed

a, b, c, d: Value with different superscript in the same row are significantly different

The average body weight gain (g/head/week) is shown in Figure (3) and Appendix (11). Treatments had significant ($P < 0.05$) effect on kids weight gain, the highest value of weight gain noticed on the animals fed 9% *C. cajan* at week 4, 5 and 6, also the treatment had highly significant ($P<0.05$) effect on average daily gain in animals fed 9% *C. cajan* as shown in Table (7) compared to the control groups.

The overall feed conversion ratio (g feed/g gain) of dietary treatment of *C. cajan* are presented in Table (7). The best feed conversion ratio was observed on animals fed 9% *C. cajan* (4.06), followed by animals fed 6% *C. cajan* (4.57) and then animal fed 3% *C. cajan* (5.16), however, the control groups showed the worst (FCR) (7.4).

4.3 Blood composition:

Serum total protein, glucose, cholesterol, calcium, inorganic phosphorus (ip), iron and haemoglobin are presented in Table (8). The treatments had a significant ($P < 0.05$) effect on blood haemoglobin. There was consistent increase associate by increasing the level of *C. cajan* in the ration, the higher level of haemoglobin reported on animals fed 9% *C. cajan* followed by animals fed 6% *C. cajan* and then animal fed 3% *C. cajan*. On the other hand, treatments had a significant ($P < 0.05$) effect on blood cholesterol, the

Table 8: Effect of dietary *C. cajan* on blood composition of desert kids.

Parameters	A	B	C	D	± SE	Level of significant
Hemoglobin (gm/dl)	6.14^{c}	8.78^{b}	9.34^{b}	11.83^{a}	±0.34	*
Cholesterol (mg/dl)	65.45^{b}	66.93^{b}	89.53^{a}	74.33^{b}	±4.94	*
Ca (mg/ 100 ml)	8.13	8.33	8.18	8.52	±0.12	N.S
(IP) (mg/100 ml)	4.70	4.77	4.70	4.70	±0.08	N.S
Glucose (mg/100 ml)	74.01	62.4	72.9	69.6	±4.93	N.S
Total protein (g/100 ml)	7.60	7.77	7.85	7.97	±0.09	N.S
Fe (mg/100 ml)	56.17	58.83	60.33	64.50	±2.9	N.S

a, b, c: Values with different superscripts in the same row are significantly different at ($P < 0.05$).

± SE: Standard error of means.

(iP) inorganic phosphorus.

higher level of cholesterol showed in kids fed 6% *C. cajan*. As far as serum total protein, glucose, calcium, inorganic phosphorous and iron were not significantly affected by dietary *C. cajan*, however, the level of the serum iron showed a numerical increase by increasing the level of *C. cajan*.

CHAPTER FIVE
DISCUSSION

The chemical composition of *C. cajan* showed that it contains about 21.7% crude protein, these results were in line of that reported by Sibarani (1982); Tangtaweewipat and Elliot (1989); Magboul (1998); Fialho, *et al*., (1985), but disagreed with the finding of

Purseglove (1968) and Elhardalou (1980) who reported that CP was 19%, also the results showed that seeds contained 12.0 crude fibre. These results were in agreement with that of Hamad (2000), but disagree with the finding of Purseglove (1968); Fialho, *et al*., (1985); Sibarani (1982); Elhardalou (1980); Magboul (1998) who showed lower value of crude fibre in range 5 – 10%. In the present study calculated metabolizable energy was approximately (11.36 Mj/kg).

In the first three week low feed intake was observed on the animals fed different level of *C. cajan* and this may be that kids were not adopted to the taste of tannin (Singh, 1988). However high feed intake was reported on animals fed 3, 6 and 9% *C. cajan* during the period from week 4 – 6, and this may be that animals were adapted to the ration and tolerate the taste of tannin.

Although some antinutritional factors of *C. cajan* which cause flatulence has been reported by (Singh, 1988), in this study there was no sign of toxicity or bloat, diarrhea or other side effect were observed during experimental period. Also the highest daily feed intake were noticed at level 9% similar results are reported by Karachi and Zengo (1997).

The animals fed ration supplemented with *C. cajan* showed an increase in weight gain. The growth increased consistently to initial live body weight as percentage (33.6, 39, 44.5%) in group fed 3, 6, 9 *C. cajan* respectively. This positive response on growth coincided with high feed intake to the ration supplemented with *C. cajan*. This may be attributed to high level of lysine (Singh and Eggum, 1984), and may lead to increase the biological value of the protein in these ration. Similar results were reported by Karachi and Zengo (1997). Amaefule and Obioha (1998) and Elhag and Elwakeel (1998) but disagreed with that of Grimaud (1988) who fed pigs ration supplemented with 45% *C. cajan,* the results showed that treatment had no effect. This variations in response of *C. cajan* may be related to the level used and the kind of digestive system of animal. The presence of microflora in ruminant that play an important role in digestion and detoxification of some toxin substances (Madonald, *et al.* 1987).

The best feed conversion ratio has been noticed on animal fed 9% *C. cajan* and this may be related to its content of lysine and quality of protein (Singh and Jambunathan, 1982), (Singh and Eggum, 1984).

The high level of blood haemoglobin observed on animals fed 9% *C. cajan* and this may be attribute to the level of methionine and cystine (Singh and Jambunathan, 1982) that are essential for protein synthesis. The seed contain high level of iron (Meiners *et al.,* 1976) which coincided with haemoglobin synthesis and may enhance the level of Hb on animal fed *C. cajan*. In the present study the increase in serum cholesterol was not consistent with increasing the level of *C. cajan*, however high level of serum cholesterol observed on animals fed 6% *C. cajan.* This response may be due to associative effect of saturated and unsaturated fatty acids in *C. cajan* at this level, which may enhance the absorption and synthesis of cholesterol (Mcdonald, *et al*., (1987). The treatment of *C. cajan* had no effects on serum total protein, calcium, inorganic phosphorous and glucose, and these were in line with finding of (Hamad, 2000).

The treatment of *C. cajan* had no effect on serum iron, but there is a numerical increase in the level of serum iron and this may be related to iron content of *C. cajan* (Meiners *et al*., 1976) and it may be in corporate into Hb synthesis which increase Hb level.

CONCLUSION AND RECOMMENDATION

* The chemical composition of *C. cajan* revealed that *C. cajan* contained 21.7% crude protein, 12.0% crude fibre, 64.3% nitrogen free extract, 2.0% ether extract, 4.0% ash and 93.5% DM, it can be used as a good source of protein and carbohydrate for goat.
* Increasing level of *C. cajan* in kids ration resulted in consistent increase in weight gain, however animals fed

9% *C. cajan* obtained highest feed intake, weight gain and best feed conversion.

* Animals fed *C. cajan* observed consistent increase in the Hb level.
* Feeding 9% *C. cajan* had no adverse effect on animal health, however further studies are suggested using higher level of seeds for longer period.

REFERENCES

A.O.A.C., (1982). Methods of analysis. Association of official analytical chemistry. Washington, D.C.

A.V.C., (1951). Association of vitamin chemist. Methods of vitamin assay (2nded). P. 111-166.

Amaefule, K.U. and Obioha, F.C. (1998). The substitution of pigeon pea seed for groundnut cake and maize in broiler finisher nation. Nigerian, J. Anim. Prod. College of Animal Science, Federal University of Agriculture, Umudike, Abiastate, Nigeria, 25 (1-2), 9-12.

Amaefule, K.U. and Obioha, F.C. (2001). Performance and nutrient utilization of broiler starters fed diets containing raw, boiled or dehulled pigeonpea seeds. Nigerian, J. Anim. Prod. College of Animal Science and animal Health, Federal University of Agriculture, Umudike, Abia State, Nigeria, 28: 1, 31-39.

Barton, W. (1952). The microbiological assay of the vitamin B complex and amin acid. Pitaman. P. 46.

Deeg, R. and Ziegenohrm, (1982). J. Clin. Chem. 28, 1574.

Devendra, C. and Bums, M. (1983). Goat production in the tropics. Common-wealth Agricultural Bureau. Printed by Unwin brothers Ltd. Old working, Surruy.

Devendra, C.; Morand, P.; Bourbouze, A. and Simiane, M. (1981). The utilization of forages from cassave, pigeon pea, leucaena and groundnut by goats and sheep in Malaysia. Nutrition and systems of goat feeding. Agric. Res. And Development Inst, Selangor, Malaysia. 1: 338-345.

El Hag, F.M. and El Wakeel, A.S. (1998). Forage legume hay as a dry season supplement for goats in North Kordofan. Sudan, J. Agric. Res., Elobeid Research Station, Elobeid, Sudan, 1:1, 41-44.

Elhardalou, S.B. (1980). Chemical characteristics of some legumes grown in Sudan. The Sudan J. of Food Sec. 12: 35-42.

Ellis, N. (1981). Nutrient composition of Sudanese animal feed. Bulletin 1. Central Animal Nutrition Research Laboratory, Kuku, Khartoum North, Sudan.

Fasc C.F. (1982). Clin chem. 18, 901.

Fialho, E.T.; Albino, L.F. and Blume, E. (1985). Composicao quimica evalores energeticos de algunos alimentos para suines. Pesq. Agropec. Brasilia, 20: 1419-1431.

Flegge, H.M. (1972). Ann Clin. Bichem 10, 79.

Gomoez, K.A. and Gomez, A.A. (1984). CRD design In: Statistical procedure for agricultural research. Johnwilly and Sons, New York.

Gradwohl, (1956). Biochemistry and Nutrition Section.

Grimaud, P. (1988). Pigeon pea a possible alternative for traditional pig and poultry farming in new Caeonia. Review of Medicine Veterinary Tropics. 11: 29-36.

Hamad, B.A. (2000). Effect of feeding corticated and decorticated (*C. Cajan*) seeds on broiler chicks performance. Animal Production Thesis. University of Khartoum, 2000.

International Crops Research Institute for Semi Arid Tropics Patancheru, A.P., India (1994).

International Crops Research Institute for the Semi Arid Tropics, (1986). Patanchera. A.P., India. Annual report (1985).

Joshi, L.D. and Singhal, P.C. (1982). Feeding of some pulses on blood sugar and serum cholesterol. Indian, J. Nutr. Dep. Biochemistry, Medical College, India, 19 (11): 337-341.

Kapoor, A.C. and Gupta, Y.P. (1979). Amino acid pattern of soy protein isolate and its supplementary effect on biological parameters of cereal protein Curr. Agric. 3: 173-179.

Karachi, M. and Zengo, M. (1997). Legume forages from pigmeon pea, leucaena and sesbania as supplements to natural pastures for goat production in Western Tanzania. Agro-forestry Systems, Tobora, Tanzania, 39 (1): 13-21.

Kind and King (1954). J. of Chemistry and Pathology.

Krause, F.G. (1932). The pigeon pea (*C. cajon*) its improvement culture and utilization, Agric. Exp. Stat., Bll, 64.

M.A.R. (2001). Ministry of Animal Resources. Statistic of Animals Resource in Sudan.

Magboul, Y. (1998). Performance of broiler fed corticated (*C. Cajan*). Animal Production Thesis, University of Khartom, 1998. Pp. 28.

Mcdonald, P.; Edwards, R.A. and Greenhalgh, J.F.D. (1987). Animal Nutrition, Fourth ed., English Language book Society (ELBS), Longman.

Meiners, C.R. Derise, N.L.; Lau, H.C.; Crew, M.G.; Ritchey S.J. and Murphy, E.W. (1976). The content of nine mineral elements in raw and cooked mature dry legumes. J. Agric. Fd. Chem. 24: 1126-1130.

Milner, M. (1972). Nutritional improvement of food legumes by breed. Proceeding of asymposiuo sponsored by protein Advisory group of United Nations Systems, New York.

Morton, J.F. (1976). The pigeon pea (*C. cajan*) a high protein tropical bush legume, Hort Science. 11 (1): 11-19.

Narayanswamy, P.; Parthasarthy, M. and Krishna, N. (1990). Evaluation of complete rations containing groundnut haulms, banyan (Ficus beng) and pigeon pear straw in growing sheep. Indian, J. Anim. Nutri. Department of Animal Nutrition, College of Veterinary Science, India. 7 (2): 127-139,

NRC, (1981). Nutrient requirements of goats Angora, dairy and meat goats in temperate and tropical countries. Nat. Academy Sci. Washington, D.C. pp. 91.

Ologhobo, A.D. (1992). Nutritive value of some tropical legumes for poultry. J. of Applied Animal Research. 2(2): 93-104.

Oshodia, I. (1993). Amino acids and fatty acid of C. cajan. International. J. of Food Science and Nutr. (4): 187-191.

Otero, J.D. (1952). Informacoes Sobre algunes plants Forrageires. Directora de Estatistica. Da produccao, Riode Janetro

Purseglove, J.W. (1968). Tropical crops dicotyledons. Longmans Green and Co. Ltd., And Hard. Lon. Sudan, J. Fd. Sci. Tech. 1980, 12: 35-40.

Richomand, W. (1972). Scand, J. Clin. Lab. Suppl. 26 Abstract 3, 25.

Schod, T.J. and Maywold, E.C. (1968). Preparation and properties of various legum starches. Cereal chemistry. 45: 564.

Sheldrake, A.R.; Narayanan, A. and Venkatarat, N. (1979). The effect of flower removal on the seed yield of pigeon pea. Annual of applied biology, India, 91: 383-390.

Sibarani, S.A. (1982). Study on tempch preparation using pigeon pea (*Cajanus. Cajan*) by traditional inculum and analyses of its nutritive value. Master of Science Thesis, University of Indonesia, Jakarta, Indonesia.

Singh, U. (1988). Antinutritional factors of chickpea and pigeon pea and their removed by processing. Plant Foods for Human Nutrition. Qualitas plantarum. 38: 251-261.

Singh, U. and Eggum, B.O. (1984). Amino acids composition of *C. cajan*. Plant Food for Human Nutrition. 34: 273-283.

Singh, U. and Jambunathan, R. (1980). A survey of the methods of milling and the consumer acceptance of pigeon pea in India. International workshop on pigeon peas. Patancheru, Andhyra Pradesh. Vol. (2): 15-19.

Singh, U. and Jambunathan, R. (1982). Distribution of seed protein fractions and amino acid in different anatomical parts of chick pea and pigeon pea (*C. Cajan*) plant food for human nutrition. Qualitas plantarum. 31: 374-354.

Singh, U.M.; Kherdekar, S. and Jambunathan, R. (1982). Studies on desi and kabuli chick pea cultivars. The levels of amylase inhibitors, levels of oligo saccharides and vitro starch digestibility. J. Fd. Science, 17: 80-85.

Singh, U.R.; Jambunathan; and Gurtu, S. (1981). Seed protein fractions and amino acid composition of some wild species of pigeon pea. J. Fd. Science and Tech. 18: 83-85.

Soto, A.M.; Calderon, R.F.; Murrieta, A. and Rivas, F. (1990). Free intake and digestibility of native grass supplemented with two amounts of pigeon pea in pelibuey sheep. Veterinaria - Mexico, 21 (2): 105-108.

Sumathi, S. and Patabhiraman, T.N. (1976). Protease inhibitors of seed. Indian, J. of Biochemistry and Bio physics. 13: 52-56.

Tangta Weewipat, S. and Elliot, R. (1989). Utilization of *C. cajan* as poultry feed in evaluation of *C. cajan* as protein energies sources in layers rations. J. Agric., 5 (1): 37-45.

Trinder, P. (1960). Ann-Clin. Biochem. 6, 24.

Trinder, P. (1969). Ann-Clin. Biochem. 6, 24.

Trompiz, J.; Ventura, M.; Esparza, D.; Higuera, A.; Padron, S. and Aguirre, J. (2001). Effect of partial substitution of feed concentrate for pigeon pea meal (*C. cajan*) on productive performance of fattening pigs. Faculty of Veterinary Science, University of Venezuela, Venezuela. 11 (5): 391-396.

Vander Maesen, L.J. (1986). Cajanus DC and Atylosia W. and A (leguminosae). Agricultural University, Wageningen paper Netherlands, Wageningen, 4, 85.

Varley, H. (1967). Practical clinical biochemistry, 4the ed., William Heinemann Medical Books Ltd., and inter science books. Inc., New York.

Vonschaaffhausen, R. (1966). Weight increase of zebu cattle grazing on the legume dolichos lab-lab and cajanus indicus. Grass lds Congr., 965-968.

Wallis, E.S.; Faris, D.G.; Elliot, R. and Byth, D.E. (1986). Varietal improvement of pigeon pea for small holder livestock production systems. Presented at the workshop on crop live stock systems research, Philippine. T.L.

Whiteman, P.C. and Norton, B.W. (1981). Alternative uses for pigeon pea. In proceeding of the international workshop on pigeon pea, ICRISAT Centre, 1980. Patanchera. A.P., India Vol. 1.

APPENDIXES

Appendix (1):

Mineral composition of (*C. cajan*) as percentage.

Mineral	Macro-elements	Micro-elements
Phosphorous	0.348	-
Potassium	11.075	-
Calcium	0.635	-
Magnesium	0.887	-
Sulphur	0.001	-
Iron	-	0.522
Zinc	-	0.020
Manganese	-	0.011
Copper	-	0.006

Source: Meiners *et al*. (1976).

Appendix (2)

Chemical analysis of blood haemaglobin

Haemoglobin was measured by Sahali method (acid haematin methods with apipette graduated tube of Sahali apparatus was filled to 20 with HCl 10%, 0.02 ml of blood sample was sucked by apipette, then the blood was expelled into the acid in the tube with a glass steerer, the contained of the tube was kindly mixed until the colour of the mixture was fixed, distilled water was then added gradually to the mixture in the tube and the colour of the mixture was matched with the standard colour of the apparatus, readings were reported when the colour of the mixture was just darker than, and just lighter than the brown standard colour.

The Hb% was calculated at a mean of the two readings, then the Hb concentration (gm/dl) was then calculated as follows:

$$\text{Hb concentration} = \frac{\text{Hb\% x 14}}{100}$$

Appendix (3)

Chemical analysis of serum total protein

Serum total protein was measured by the method described by Kind and King (1954).

Prepared of Reagent:

Biurat reagent:

Dissolve 9 g sodium. Potassium tartrate in 500 ml.0.2 N.NaoH, add 3.0 g Cupprinic sulphate add 5.0 g. potassium iodide and make up .IL. with 0.2 N.NaoH.

Standard protein:

Add 0.5 g of crystalline bovine albumin in 100 L. D.W and 0.2 N. sodium hydroxide 8 g.100 ml.

Test:

In test tube put 2.8 ml. D.W. and 0.2 ml serum, put 3 ml of the blank and 3 ml of the standard, to all tubes add 5 ml biurate reagent and shake, place tubes in water bath 37^{o}-10 minutes and read at 540.

Calculate:

Concentration of total protein (g/100 ml)

$$\frac{\text{A sample x standard conc.}}{\text{A standard}}$$

Standard Conc. = 7.5 g/100 ml.

Appendix (4)

Chemical analysis of serum glucose

Serum glucose was measured by method described by Grad Whol (1956). In a centrifuge tube measure, take 1.85 ml copper sulphate or sodium sulphate, 0.05 ml blood, 0.1 ml sodium tungestate (10%), mix after each addition, stand for 5 minutes and centrifuge, take 1 ml of supernant in a test tube, and in another test tube 1 ml of standard solution and take 1 ml D.W for blank, to each tube add 1 ml colour (sol. A and B), mix and cover tube to boiling water for 10 min., only remove from bath and place cool water, add 3 ml phosphomolybdic acid, mix and add 5 ml D.W read at 607.

Calculation: $\frac{\text{A sample x 200}}{\text{A standard}}$ mg/100 ml

Appendix (5)

Chemical analysis of serum cholesterol

Serum cholesterol was determined according to enzymatic – calorimetric test (CHOD – PAP).

Principle:

Reagent 1 (piepes pH 6.9 – 90 mmol/L, phenol – 26 mmol/L) and Reagent 2 (peroxidase 1250 U/L, cholesterol esterase 300 U/L, cholesterol oxidase 300 U/L and 4-amino phenazone 0.4 mmol/L), were mixed to form the working reagent was added to 10 M/serum, the mix was incubated for 5 minutes in water bath 37^{o}C. The sepectrometer was adjusted at 505 nm, then the extintion (E) of standard was measured using 10 ML standard and one ml of working reagent, 10 ML of serum was added to one ml of working reagent to obtain the E. sample, the cholesterol concentration was calculated according to the following formula:

$$\text{Cholesterol conc} = \frac{\text{E. Sample}}{\text{E. standard}} \quad \text{X Conc. standard}$$

Where: Standard conc. = 200 mg/dL.

Appendix (6)

Chemical analysis of serum calcium

Serum calcium was measured by the method described by Trinder, (1960).

Test:

In a centrifuge tube put 0.5 ml serum and 1.0 ml of chloranilic acid.

Standard:

0.5 ml working standard and 1.0 ml of chloranilic acid. Stand 15 minutes and centrifuge 10 minutes. Decart supernant and drain tubes on clean filter paper, wash precipitate with 0.5 ml D.W, centrifuge for 5 minutes and drain, dissolve the precipitate in 4 ml of 4% ferric nitrate, stand for 5 minutes read at 500 blank ferric nitrate.

$$\text{Calculation} \quad \frac{\text{A sample x 10}}{\text{A standard}} \quad \text{mg/100 ml}$$

Appendix (7)

Chemical analysis of serum inorganic phosphorous

Serum inorganic phosphorous was determined by method described by Varley, (1967).

Prepare of reagent:

10% trichloro acetic acid, take 10 g TCA in 100 ml D.W, and 15 g of ammonium molybdate in about 400 ml D.W, add 10 ml of N sulphric acid make up to 800 ml with D.W.

Metol:

1 g of methyamino phenol in 100 ml of 3% of sodium bisulphate.

Standard:

Dissolve 0.21979 of potassium dihydrogen phosphate make up to 1L, with D.W. add few drops of chlor. form.

Test:

1 ml of serum to 9.0 ml of 10% (TCA) and filter, take 5 ml of supernant.

Standard:

0.5 ml of working standard, plus 4.5 ml of 10% (TCA).

Blank:

5.0 ml of TCA to all tubes add 1.0 ml ammonium molybdate (solution) mix and add 1 ml of metol solution mix and allow to stand for 30 minutes at room temperature, read at 680 Mn.

Calculation:

$$\frac{\text{A sample x 5}}{\text{A standard}} \quad \text{mg/100 ml}$$

Appendix (8)

Chemical analysis of serum iron

The serum iron was determined by Earl.

Prepared of reagent.

Saturated potassium per sulphate 8 g – 100 ml D.W. sodithicoyanate 25 g. dissolved in 5 ml, acetone and complete to 100 ml. D.W.

Stock standard iron:

50 mg of iron in digestion flask and 10 ml.60% per chlonic acid and boil until dissolved, cool and dilute to 100 ml D.W.

Working stand iron:

2 ml of stock in 100 ml D.W.

Blood iron digestion:

2 ml blood in digestion flask and 2 ml conc. H_2SP_4 and 2 ml.60% perchloric acid, heat gently for 45-60 min., after cooling add 2 ml conc. nitric acid. Reheat the flask until the contents in the flask is colourless, cool and transfer the content in a 50 ml volumetric flask and make up to make D.W.

Test:

Take 0.2 ml of solution and add 9.8 ml D.W. in centrifuge tube. Add 0.2 ml saturated potassium persulphate and 1 ml 25% sodium thiocyant, add 5 ml N amylalcohol and shake gently and centrifuge 5 minutes. Take the supernet and read at 480.

Standard:

0.2 ml working as same as test reagent.

Calculation:

$$\frac{\text{A sample x 50}}{\text{A standard}} \quad \text{Mg/100 ml}$$

Appendix (9)

The effect of dietary *C. cajan* on desert kids weekly feed intake (g/head/week)

Weeks	A	B	C	D
1	2167.8	2274.14	2407.8	2457
2	2680.6	2811.9	2876.9	2911.5
3	3082.8	3151.6	3149.2	3254
4	2870.5	3183.8	3231.5	3327.8

5	2915.6	3215.5	3298.13	3621.18
6	2723.06	2944.8	3495.9	3740.93
Mean	2740.06	2930.29	3076.6	3218.73

Appendix (10)

Effect of dietary *C. cajan* on live body weight (kg)

of desert goats kids (kg/head/week)

Weeks	A	B	C	D	$\pm$ SE	Level of significant
Initial weight	10.08	10.08	10.25	10.67	$\pm$0.69	N.S

1	10.58	10.75	11.0	11.67	±0.72	N.S
2	11.08	11.49	11.82	11.68	±0.79	N.S
3	11.48	11.91	12.24	12.30	±0.42	N.S
4	11.72	12.23	12.69	13.16	±0.39	N.S
5	11.97^{b}	12.81^{ab}	13.44^{a}	14.24^{a}	±0.49	*
6	12.30^{c}	13.47^{bc}	14.27^{ab}	15.4^{a}	±0.36	*

* = Significant ($P < 0.05$)

N.S = Non significant ($P < 0.05$)

±SE = Standard error of means

a, b, c, d: Value with different superscript in the same row are significantly different

Appendix (11)

The effect of dietary *C. cajan* on desert kids weekly weight gain (g/head/week)

Weeks	A	B	C	D	± SE	Level of significant
1	497.2^{b}	658.3^{ab}	733.3^{a}	500.0^{b}	±59.67	*
2	b	a	a	b	±78.55	*

	500.0	750.0	833.3	508.3		
3	b	b	b	a		
	400.0	416.7	425.0	625.0	±48.8	*
4	bc	b	b	a		
	233.3	316.7	450.0	858.3	±40.7	*
5	d	c	b	a		
	250.0	583.3	750.0	1083.3	±33.79	*
6	c	b	b	a		
	341.7	666.7	830.3	1166.7	±67.62	*
Mean	d	c	b	a		
	370.3	565.28	670.3	790.26	±26.05	*

* : Significant ($P < 0.05$).

±SE: Standard error of means.

a, b, c, d: Values with different superscript in the same row are significantly different.