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Evaluation of Cactus *(Opuntia Sp.)* as Forage Source for Growing Rabbits in the Gaza Strip

تقييم استخدام التين الشوكي"الصبر" في تغذية الأرانب النامية في قطاع غزة

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Department of Biology, Faculty of Science.

November, 2007

وقل رب زدني علماً

طه "114"

DEDICATION

In the memory of my mother

(1948-1988)

DECALARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains neither materials previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree of the university or other institutes, except where due acknowledgment has been made in the text

Signature
Khalil Naeif Abu Shammalah
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ABSTRACT

Objective: To evaluate Cactus *Opuntia cladodes (COC)* as partial food *on* the growth performance, organs and carcass weights of growing rabbits under small scale growth conditions.

Material and Methods: The study design was a case control. The experiment was carried out on the local weaned rabbits (n=48), aged 35-40 days and average initial live weights was about 550 g . The period of study was 8 weeks. The rabbits was classified randomly to four different groups. One was a control group and the others were case groups. The control group (C) was fed ad libitum on only high protein rabbit pellets which is commercially called Anber (RPA). Case groups were labeled trial 1(T1), trail (T2), and trial (T3) that fed ad-libitum COC and 80 %, 60 % and 40 % RPA, respectively. The actual nutrient contents in the two feeds were examined in AL-Azhar University food analysis labs. SPSS system was used to analyze the obtained data.

Results: COC feed was found to be poor in crude proteins compared to RPA. Dry matter values for RPA and COC were 86.4 % and 16.0 %, respectively. COC have lower crude fibers, fats, nitrogen free extract than RPA.

The growth rates of the growing rabbits were 26.31, 21.20, 18.56, and 10.64 g/day for C, T1, T2, and T3 trials, respectively. Feed conversion ratios based on RPA consumption were 3.33, 3.01, 2.85, and 3.25, for C,

T1, T2, and T3 trials, respectively. Mortality rate were 8.3%, 25%, 25% and 16.7%, for C, T1, T2, and T3 trials, respectively.

Partial COC feed decreased average weights of internal body fat tissues and some organs of the domestic rabbits. In contrast, 40 % RPA diet and ad libitum COC feed increased average liver weights of the rabbits.

Conclusion: COC as available and very low cost feed can be used as a partial feed of the RPA diet to maintain domestic rabbits growth under unavoidable economical and/or political conditions.

Key words : Cactus ***Opuntia*** cladodes, rabbit pellets, small scale growth condition.

تقييم استخدام التين الشوكي"الصبر"جزئيا في تغذية الأرانب النامية في قطاع غزة

خليل نايف أبو شمالة
الجامعة الإسلامية-غزة
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ملخص البحث

الهدف: تهدف الدراسة الحالية لتقييم استخدام التين الشوكي جزئيا على نمو وأوزان الأعضاء الداخلية واللحم الصافي للأرانب المنزلية في قطاع غزة.

المواد والطرق: منهج الدراسة عملي مقارن، تم استخدام فيها ثمان وأربعون أرنبا أعمارها ما بين 35-40 يوما أعمارها ومتوسط أوزانها حوالي 550 جراما، استمرت فترة الدراسة ثمان أسابيع، قسمت الأرانب فيها بالتساوي إلي مجموعة ضابطة وثلاث مجموعات تجريبية، وتم تغذية المجموعة الضابطة بعلف غني بالبروتين يسمى عنبر، وتغذية المجموعات التجريبية بالتين الشوكي ونسبة من علف العنبر تقدر ب 80 % للمجموعة الأولى، و60 % للمجموعة الثانية، و 40 % للمجموعة الثالثة، تم تحليل مكونات الأعلاف المستخدمة في التجربة في مختبرات تحليل الأغذية بجامعة الأزهر بغزة، و تم تحليل البيانات الناتجة باستخدام برنامج SPSS.

النتائج:

التين الشوكي مقارنة بعلف العنبر فقير بالبروتين، و المادة الجافة، و الألياف الخام، والدهون، و المستخلصات الخالية من النيتروجين.

كانت نتائج المجموعة الضابطة والمجموعات التجريبية الثلاث المذكورة أعلاه تسلسليا على النحو التالي: سرعة نمو الأرانب 26.31، و 21.21، و 18.56، و 10.64، جراما يوميا ، و نسبة التحول الغذائي 3.33، و3.01، و2.85، و 3.25 ، ونسبة الوفيات 8.3%، و25%، و 25 %، و16.7% على التوالي

كما أظهرت النتائج أن تغذية الأرانب النامية جزئيا من التين الشوكي قلل من نموها، ومن وزن اللحم الصافي وأوزان بعض الأعضاء الداخلية والدهون، ووجد أن الصبر زاد من متوسط أوزان الكبد للأرانب التي تناولت 40 % من علف العنبر.

الاستنتاجات:

يمكن استعمال التين الشوكي كمادة غذائية وفيرة وذات تكلفة بسيطة جزئيا في تغذية الأرانب المنزلية في حالة الظروف الاقتصادية والسياسية الصعبة.

كلمات المفتاح: تين شوكي، علف أرانب، تربية منزلية.

Dedication

To my Dearly Loved Parents

To my Brothers

To my wife, who continuously encourages me.

ACKNOWLEDGMENT

I would like to express my deepest gratitude and appreciation to my supervisors for their initiation and planning this study, keen supervision, patience, useful assistance and great valuable scientific helps that lead to the emergence of this work in its current form.

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Khalil Abu-Shamalah.

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List of Abbreviations

COC: Cactus *Opuntia* Cladodes

RPA: Rabbit pelleted Anber

DM: Dry matter.

CP: Crude protein

CF: Crude fiber

EE: Ether extract

NDF: Neutral detergent fiber

ADF: Acid detergent fiber

NFE: Nitrogen free extract

TDN: Total digestible nutrients

SEM: Standard error of mean

CHAPTER 1

INTRDUCTION

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INTRDUCTION

1.1 Overview

Rabbits production is beneficial mainly in the rural and sub urban areas under management system with pellet-based diets as the principle feed sources. The high cost of commercial concentrated diets limit the successful production of rabbits in the Gaza Strip [1].

Rabbits are mono-gastric (single stomach) herbivores and have a number of specific characteristics such as small body size, short generation interval (28-32 days), and rapid growth rate [2]. For optimum production, 2 months period is required to produce a 2 kg or more market rabbit under standard conditions. Does have been known to kindle up to 23 young at one time, the average is eight. A doe can produce up to 10 times its own weight, or more, in offspring per year.

Rabbit meat is one of the most nutritious meats available. It is highest in protein of high quality, lowest in fat and cholesterol, has the least number of calories per pound and has only 8 percent bone [3,4]. Rabbit meat can be prepared in over 300 different ways. Unlike wild rabbit, domestic rabbit meat is pearly white, tender, juicy and mild in flavor.

Rabbits require a large percentage of fibers in their diets to maintain normal gastrointestinal movement. Rabbit pellets consist mostly of ingredients from plants (primarily alfalfa meal and wheat middling). However, feeding has a strong influence on breeding, fertility, conception, kindling, nursing, growth, and resistance to disease.. A well balanced, palatable diet should be available to rabbits at all times in amounts which will adequately supply their nutritional needs. Weaned

growing rabbits require about 100 g RPA/ day and special "milk supplements" are not needed [1].

Opuntia used throughout this study for feeding of the domestic rabbits refers to the whole genus, of which the most widely known is opuntia ficus-indica. Previously, Opuntia was used almost interchangeably with cactus pear and prickly pear. Here, while these terms are occasionally used, the term opuntia is preferred because cactus pear can sometimes refer to the fruit, and also not all opuntia are prickly pears, there being many spineless clones.

COC are documented to be high in moisture content and in dry matter digestibility diet [5]. Cactus is a desertification plant and a highly palatable to wild and domesticated rabbits [6,7]. This plant resists diseases, tolerates a variety of climate conditions and excessive cutting.

1.2 Scope

The present study was a case control. The case groups were growing rabbits fed different partially RPD diet and ad libitum COC feed. The control group was growing rabbits fed RPD diet. Both groups matched each other in initial body weight, water supplementation, and all other environmental conditions.

The hypothesis under investigation was that whether rabbits partially fed RPA and ad-libitum COC are more likely to have similar body weight, body organs weights, and mortality rate to those rabbits fed only RPD diet.

1.3 Significance of the study

Feed is very important for raising rabbits because it accounts for most of production costs. In the Gaza strip, most people are very poor and domesticated rabbits eat a very expensive commercial high protein

pellets (e.g. RPA) that are irregularly imported from "Israel" due to the chronic political problems. These pellets are not made in the Gaza strip because of lack of lyophilized hay materials. Moreover, information is limited in the literature on the response of growing rabbits to COC as partial replacement of concentrated high protein feeds.

1.4 Objectives of the Study

The main objective of this study, therefore, is to evaluate the use of browse forage of thorn prickly pear cactus as a partial replacement of the commonly used very expensive and sometimes not available RPA on growth, carcass, organs weights, and mortality rate performances of growing local weaned rabbits.

Specific objectives

1- To recognize the response of growing rabbits on low protein containing diets under unavoidable conditions in the Gaza Strip.

2- To recognize the optimum percentage of COC/RPA ratio for the optimal growth.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

2.1 Rabbit species

There are about 54 species of rabbits. The genus *Lepus* contains 30 hares and jackrabbits. The genus *Sylvilagus* contains 13 cottontails. The other rabbit species are separated into many different groups. Anew rabbit species was recently discovered in the Annamite Mountains of southeast Asia. It is a member of the genous *Nesolagus* and closely related to the nearly extinct Sumatran rabbit.

In an adult (4-4.5 kg) or semi-adult (2.5-3 kg) rabbit the total length of the alimentary canal is 4.5 to 5 m. After a short oesophagus there is a simple stomach which stores about 60-80 g of a rather pasty mixture of feedstuffs.

The adjoining small intestine is about 3 m long and nearly I cm in diameter. The contents are liquid, especially in the upper part. Normally there are small tracts, about 12 cm long, which are empty. The small intestine ends at the base of the caecum. This second storage area is about 40-45 cm long with an average diameter of 3-4 cm. It contains 100-120 g of a uniform pasty mix with a dry matter content of about 20 percent.

Very near the end of the small intestine, at the entrance to the caecum, begins the exit to the colon. The caecum thus appears to be a blind pouch branching off from the small intestine-colon axis (Figure 2). Physiological studies show that this blind pouch-reservoir forms part of the digestive tract: the contents circulate from the base to the tip passing through the centre of the caecum, then return towards the base, along the wall. The caecum is followed by a 1.5 m colon: this is creased and dented

for about 50 cm (proximal colon) and smooth in the terminal section (distal colon).

The alimentary canal, which develops rapidly in the young rabbit, is nearly full size in an animal of 2.5 kg, when it has reached only 60-70 percent of adult weight.

Two major glands secrete into the small intestine: the liver and the pancreas. Bile from the liver contains bile salts and many organic substances but no enzymes. Bile aids digestion catalytically. The reverse is true of pancreatic juice which contains a sizable quantity of digestive enzymes allowing the breakdown of proteins (trypsin, chymotrypsin), starch (amylase) and fats (lipase).

2.2 Raising and managing rabbits: General principles.

Rabbit production increases food availability. It contributes to an increase in the availability of a healthy digestible meat supply at a lower environmental cost. The environmental cost being reduced by the higher feed conversion and the ability to use low grade forage supplies as well as by the different nature of the rabbit droppings compared to normal animal manure.

In many parts of the world, domestic rabbits are raised in a spare room of the dwelling unit, or in hutches in the kitchen garden, where they recycle waste parts of vegetables into excellent fertilizer, while providing the family with a supply of healthy, fresh meat. For indoor rabbit raising, a sheet of poly laid over a sloping wood shelf can drain the waste water into a bucket. A shallow slope lets the liquids run off while the manure pellets remain to be swept off into another bucket.

2.2.1 Hard feces Versus. soft feces

In these days of greater environmental awareness, the first consideration in setting up a rabbit raising project is to have or find a use for the manure. Rabbit droppings are an excellent fertilizer for gardens and pasture. An output per 20 does being adequate to provide fertilizer for one acre of pasture for the year. Rabbit droppings are about 3-1.5-0.3 on N-P-K value, so are a good nutrient for growing pasture [8]. Some supplementation of phosphorus and potassium is necessary for most garden plants and flowers. Rabbit droppings can be applied as supplied by the rabbit, "composting" is not needed, there are no weed seeds and rabbit manure does not burn plants. It is important to keep the floor as dry as possible so that manure stays dry; catch waste water in buckets to be emptied daily [9]. If you collect rabbit urine, use it sparingly, it will burn plants [8].

Rabbits are unique in that they produce two types of fecal material, a hard, dry fecal pellet and a soft of "night" feces. The soft feces are produced in the cecum (a pouch located between the small and large intestines) and are consumed by the rabbit directly from it anus as they are excreted. This practice is called coprophagy or cecotrophy and usually takes place when the animal is alone. Some feces contain a mucus

coating and are excreted in a cluster rather than as single pellets as with hard feces. Coprophagy is a natural process which provides the rabbit with B-vitamins which are synthesized (produced) by bacteria in the cecum and excreted in the soft feces. Night or soft feces are much higher in protein, water and lower in fiber than hard feces [10] .

2.2.2 Housing

Rabbits are environmentally controlled raised in a building with good fresh ventilation, heating during winter, and cooling during summer [8]. If you are going to build a rabbitry in a cold (and/or hot) inland area, you should restrict the size of the operation to supplying your own needs and may be a few selected customers; you will not be able to compete commercially with coastal breeders who don't have the high costs of creating a suitable environment. Actual heating of the rabbits is not needed, and high capital costs have to be avoided to have a successful rabbit operation in all months of the year [8].

2.2.3 lighting of the farm

Rabbits raising require natural lighting all year and solar heating in the winter. The natural photoperiod can be extended by single-tube fluorescent lighting which works by photocells to extend the lighting up to the limit of the timer at 16 hours photoperiod. This system turns off the artificial lighting during the day when there is sufficient natural lighting [11]. The does will generally have the litters about an hour after the lights come on to coincide with feeding time. Bucks can be kept in an area without extended hours of lighting. If the building has to be set in open sun, cover it with greenhouse shade (63% or higher) cloth and plant some poplar trees immediately.

2.2.4 Ideal temperature

The ideal growing temperature for rabbits is 15.6°C and 60% relative humidity. Humidity is almost never that low in the outdoors so you have to write off humidity and ignore it or spend large amounts on equipment and energy to remedy it, all for little gain. Rabbits do better when the temperature variation is minimal, but they will breed and grow adequately in the coastal climate. The major concern in construction and siting of the building, is minimizing heat gain in the summer, while most people would assume that the major concern would be providing warmth in the winter. This difference shows the difference in temperature tolerance between rabbits and humans, rabbits are fur-bearing animals while humans are not. Avoiding high temperatures is of highest importance, bucks can become temporarily sterile above 29°C [8]. During hot weather, do only the minimum amount of work in the rabbitry, and do all of it during the coolest night hours. During the heat of the day, do only the things necessary to keep the rabbits as cool as possible with the least disturbance.

2.2.5 Caging of the rabbits

Besides number of cages hung in the barn, you should have about 10% extra to allow for cleaning several cages at a time. Fryer cages are better if larger, such as double this width or if a smaller size is preferred, 91 cm wide by 76 cm deep is preferable. Best cages are 45 cm high rather than shorter sizes. The feeder is on the door for easy inspection. All cages should be singly hung for ease of cleaning. Between each cage is 2.5 cm space for a semi-rigid translucent plastic divider which hangs between the cages. Feeders are bin type feeders with no projection into the cage area. Caging is always in a single layer, two or three-tier caging should never

be put in a rabbitry, unless there is some way to take it all out a section at a time for cleaning.

Cages are hung at about 120 cm above natural soil base. On natural soil base, the manure can be shovelled out in a dry, loose pellet condition as required for fertilization of pastures or stored in bags for later use or sale. Use of rabbit manure on pastures for calves can sometimes be a problem because of rotavirus being transmitted to the calves [**12**]. but this does not bother sheep or any other use of the manure.

Cage capacity varies with time of year. Young rabbits (under 10 weeks) prefer to be crowded in cold weather. When it is cold, the small nest box of six week old bunnies will be just a box of ears. They prefer cramming into the box to share warmth instead of sitting out on cold wire. In cold weather a large fryer cage can be filled so that when the rabbits are sitting in normal awake position, all the floor is covered. A large cage with just a few cold rabbits in it is asking for digestive problems caused by low caecal temperature. However, on a hot day in summer, when the rabbits all spread out on their sides on the floor, 25% of the floor must remain uncovered or the rabbits will overheat [8].

2.2.6 Water supply

Rabbits require easy access to fresh water at all times. The easiest water "system" is supplied by using 4-litre (gallon) water bottles on metal stands at the front of each cage, with a brass nipple inserted through a rubber grommet. Open cans, jars or crocks of water must not be used - use some kind of water nipple or you will have continuous coccidiosis problems. A normal winter, in the Gaza strip, has only about three months that are somehow cold. The benefit of the water valves that go directly into the main line is that water can be heated and circulated in the winter. Most water additives should be avoided, they can cause undesirable life forms to grow inside the water system; water acidifiers

cause extensive damage to zinc-coated rabbit equipment so should not be used.

2.2.7 Dieting of rabbits

The fryer feed provides high energy and high fibre It should be between 12-18 % protein and having at least 8 % crude fiber [10]. for normal gastro-intestinal movement. All the rabbits should be on full feed, they eat and drink water in many small meals all day and night, with highest feed consumption just before night-fall. It is important to drop a few feed pellets into the nest box beginning about day 15 of lactation so that the young can start to nibble on the does' feed, this provides the function of creep feeding without the use of special equipment. The pups need to be feeding several days before they are leaving the nest on their own.

However, feed is very important when raising rabbits, because it accounts for most of production costs. Most domestic rabbits eat a commercial pelleted feed made to meet their nutritional needs. Rabbit pellets consist mostly of ingredients from plants (primarily alfalfa meal and wheat middling) [1].

Feeding has a strong influence on breeding, fertility, conception, kindling, nursing, growth, and resistance to disease. Young rabbits begin consuming feed when they are approximately three weeks of age. A well balanced, palatable diet should be available to rabbits at all times in amounts which will adequately supply their nutritional needs. Special "milk supplements" are not needed.

The following table shows the amounts of feed which should be fed daily for young rabbits and other rabbits in various stages of the life cycle [1].

Condition	Amount to feed daily (g)
Growing rabbits (After weaning)	90-120
Resting Does	60-150
Does in Gestation	120-240
Nursing Does (until litter is 3 weeks of age)	180-240
Does with litter of 7 or 8 (3 to 8 weeks)	450-900

2.3 Opuntia ficus-indica

Cactus is useful not only because it can withstand drought, but also because its conversion efficiency is greater than C3 grasses and C4 broadleaves. Biomass generation per unit of water is on average about three times higher than for C4 plants and five times higher than for C3 plants [13].Under optimal conditions, the various types of plants can produce similar amounts of dry matter per surface are, but under arid and semi-arid conditions, Cacti plants are superior to C3 and C4 plants [14]. However, Spring cultivars of *opuntia sp* are considered cheaper supplier elements than either alfalfa or corn [15]. Another significant advantage of cactus for animal feed is that it is often the only source of green forage in the dry season capable of providing vitamin A precursors. reported 29 µg of carotenoids and 13 mg of ascorbic acid per 100 g of immature cladodes to be used as vegetables for humans [16].

2.3.1 Opuntia species

* Botanical family: Cactaceae

The *Cactaceae* are mostly spiny succulents with photosynthetic stems comprising 30-200 genera and 1,000 to 2,000 species further characterized by the presence of betalains, and p-plastids. The leaves are alternate, generally extremely reduced and ephemeral or absent, or rarely

they are well developed and fleshy. The leaves are associated with highly modified axillary buds or shoots called areoles that bear spines. The flowers are mostly bisexual and actinomorphic and commonly have many weakly differentiated perianth segments arising from an epigynous zone. The androecium typically consists of a very large number of stamens arising from the inner face of the epigynous zone. The gynoecium consists of a compound pistil of 3-many carpels, an equal number of stigmas, and an equal number of parietal placentae with numerous ovules in the single locule of the inferior ovary. The fruit is a berry, often with spines or bristles. Most cactus cannot remove water from cold soils; therefore winter is the dormant season and summer is a time of active growth. The structure of cactuses enables them to survive in hot, dry climates. Most have thick, fleshy stems with a waxy skin surface. The stem acts as a reservoir to store water. The tough skin keeps the water from evaporating. In addition, surfaces of most cactuses can expand and contract to accommodate changes in the amount of water. There are two main types of spines: (1) centrals that are heavier, more deeply pigmented, and often hooked and (2) radials that are usually straight and scattered around the centrals. Cactuses have extremely long roots to reach out through the sandy, rocky soil. These roots grow close to the surface, collecting as much water as possible. A large saguaro may have root systems that are 50 feet (15 meters) long. After a heavy rain, these roots soak up and transport large amounts of water back to the plant stem.

Cactuses are important to animals and people. Small animals, insects, and birds feed on their stems and flowers. Birds build nests in cactus stems. Some woodpeckers make their homes in the larger species. And both birds and animals hide and seek refuge from predators in the stems of cactus plants. Cactuses are also a food source for people. Once

the spines have been scraped off, prickly pear stems can be fried and eaten. Many people eat cactus fruits or grind the seeds into a meal for cakes. Some cactuses are important in the production of a red food dye. And other cactuses, once cut and dried have been used as building material, a type of desert lumber.

Prickly pear cactus is native to new world , where it grows well in dry region , such as southwestern United states and Northern Mexico [17].There are almost 300 species of the genus Opuntia [18]. According to Scheinvar , 1995 the name *"Opuntia"* comes from an ancient Greek village in the region of Leocrid, Beocia:Opus or Opuntia, where Tournefort found a spiny plant which reminded him of the American [18]. *opuntias. Opuntia* includes 11subgenera*: Opuntia, Consolea, Austrocylindropuntia, Barsiliopuntia, Corynopuntia, Cylindropuntia, Grusonia, Marenopuntia, Nopalea, Stenopuntia and Tephrocactus.* [18]. mentioned nine wild species of the *Opuntia (O. hyptiacantha Web; O. joconostle Web; O. lindheimeri (Griff. And Haare) Bens.; O. matudae Scheinv.; O. robusta Wendl. Var. robusta; O. sacra Griff. ex Scheinv.; O. streptacantha Lem.; O. tomentosa SD. Var. tomentosa and var. herrerae Scheinv.)* and three cultivated species *(O. albicarpa sp. Nov.; O. ficus-indica (L.) Mill.; O. robusta Wendl. Var larreyi (Web.) Brava),* as well as one cultivated species of the *subgenous Nopalalea (O. cochenillifera (L.) Mill.).*

2.3.2 Use of Opuntia

This plant has been employed both as a medicine, since prehistoric times. The raw plant contains abundant mucilage, which is a complex fibers that may delay absorption of glucose [19].

In many studies undertaken in Mexico, the daily intake of 30 Opuntia capsules by patients with diabetes mellitus had a discrete beneficial effect on glucose and cholesterol [20-22]. However this dose was considered impractical and therefore was not recommended in the management of diabetes mellitus. The results of these and other studies concluded that prickly pear cacti did possess mild hypoglycemic effect, but not in statistically significant manner . The authors did mention that ingestion of prickly pear cactus might help lower serum cholesterol levels and perhaps augment the patients, sensitivity to insulin, as well as improve glucose tolerance curves [23-28]. In Mexico, cactus pears (Opuntia spp.) are regarded as very important plants, especially in semi-arid and arid regions where few crops can be cultivated. Historically, Mexicans have used cactus pears for food, as fodder for cattle, for medicinal purposes, in cosmetics, to produce dyes, and as natural fences. Cactus pears are also an important component of native ecosystems.

The prickly pear is extremely valuable as feed for cattle in Mexico and Texas, where most cacti are not suitable for human consumption. Farmers burn off the thorns with a propane torch, and the cactus is mixed with cottonseed cakes and mineral salts. Wild animals, such as deer, javelinas, birds and rodents, can also benefit from this plant, especially during a drought, since this plant is one of the most drought-tolerant plants in South Texas.

For centuries, the prickly pear has been a dietary staple for Native Americans and Mexican people. In Mexico, the tender flat-padded Opuntias are called nopalitos. The word “nopalito” means “little nopal,” and nopalli was one of the nahuatl generic names for Opuntia. . The tender stems, still considered a delicacy, are consumed in large quantities during Lent season. They were cooked by the Aztecs with meats, eggs or

other vegetables, and condiments such as wild onions, chili peppers, chocolate, and pumpkin seeds.

Before the spines emerge, the young pads are tender and green, with a taste similar to green beans or a bell pepper. They are low in fat and high in fiber and can be cooked in many different ways. They are suitable for use in salads, casseroles and soups. Nopalitos can be cooked like eggplant, boiled like greens, scrambled with eggs, or pickled. The nutritional content of prickly pear is similar to other green vegetables that have little protein and moderate carbohydrates. They are rich in fiber, calcium, phosphorus, iron and vitamins A, B, and C (which they lose when they are boiled or cooked).

Recently, cactus pads have become a popular food in the U.S. and are served at some upscale restaurants. Thanks to organizations such as the Texas Cactus Council, there is now more awareness about the culinary and healing possibilities of this plant.

The fruit, known as tunas (a word introduced by the Spaniards), are low in calories, high in vitamins A & C, calcium and phosphorus. Delicious raw, tunas make excellent fruit drinks.

Some of the flowers of Opuntia are also used as vegetables mixed with stews. The buds of O. versicolor are consumed by the Papago Indians.

Among the many uses of Opuntia in prehispanic times, one that especially attracted attention of the conquistadores was the use of the cochineal dye. Insects that attack plants are usually considered pests, but sometimes these insects are actually beneficial and profitable. Cochineal, a carminic acid red dye, comes from the pulverized bodies of Dactylopus coccus, an insect that parasitizes prickly pears. The Aztecs use them to dye textiles. In modern times, cochineal dyes are used as food coloring in

drinks, cake decorations, and in the production of cosmetics.

Healing properties. In folk medicine, the tunas, boiled and mixed with honey, are considered good for respiratory tract infections. O. leucotricha fruit can be eaten for sore throat, diarrhea, and arteriosclerosis. Opuntia pads, sliced in half and heated, are used in Mexico to mitigate pain and reduce swelling. The Aztecs used a paste made from Nopales for toothaches. Research has demonstrated that pectin - a high fiber, gelatinous substance in species such as O. streptacantha and Nopal Xonocostle, can reduce significantly the levels of blood sugar and low density lipoprotein (LDL) cholesterol. Dr. Eulogio Pimienta from the University of Guadalajara has published about the anti-diabetic properties of Xonocostle, and Dr. Alberto Frati, Chief of Internal Medicine at the Instituto Mexicano del Seguro Social in Mexico City presented, at a recent scientific meeting, very promising results from his clinical trials with prickly pear cactus in diabetic patients.

Flavonoids present in the plant and its fruit can have neuroprotective effects on cells cultured in vitro [29].as well as antioxidant and free radical scavenging properties [30].Research in experimental animals has found a diuretic in rats fed prickly pear cactus, as well as gastro protective effects that could potentially be useful in treatment of gastric ulcer [31].

Prickly pear cactus is usually consumed as a fresh or cooked green vegetable [32].The cactus pads , or stems , are sliced , diced and cooked (boiled or broiled) mush like string beans, and consumed as a salad or as part of a meal [33].

2.3.3 Chemical composition and nutritive quality of COC feed

Opuntia is particularly attractive as a feed because of its efficiency in converting water to dry matter, and thus to digestible energy . [14].Cactus in not a balanced feed and should rather be considered as a cheap source of energy.

COC have a chemical composition that is similar to most vegetables where COC contain vitamin C (12.7 mg /l00 g fresh weight), and ß – carotene (12.9 mg /l00 g fresh weight) [34].

Table 2.1 summarizes some other relevant nutrient contents of COC measured in different countries [35].It appears that globally the water content is high (80-95 %), the ash content is also high about 20 % of the DM. CP content is low and often below the level of 5 % of the DM. CF content is also relatively low, the average value is about 10 % of the DM. However, nutritive quality of Opuntia depends on plant type (species, varieties), cladode's age, season, agronomic conditions (soil type, climate, growing conditions, etc.) [35].

Contents of Table 2.2 shows the very low levels of P and Na and the high levels of Ca [36].Recent investigations have shown that COC have high contents in oxalates. The total oxalate amount is about 13 % of the DM from which 40 % are in a soluble form. These oxalates are probably bound to Ca making this anion less available to animals. This high amount of oxalates may also explain the laxative effect of COC when fed to animals [35].

Table 2.1. Average chemical composition of cactus cladodes calculated on the basis of the results published by several authors . [35,37].

	DM, %	% of DM			
		Ash	CP	CF	NFE
Average	11.01	17.19	4.76	10.91	65.30
Minimum	4.74	8.18	2.5	7.82	56.7
Maximum	17.00	23.53	7.87	14.50	72.67
Standard deviation	3.87	4.61	1.90	2.24	5.25

DM: dry matter, CP: Crude protein, CF: Crude fiber, NFE: Nitrogen free extract.

Table 2.2. Some mineral composition of *COC* (% dry matter) [35,38].

	DM, %				
		P	Ca	K	Na
Average	13.48	0.04	8.66	1.09	0.05
Minimum	8.95	0.02	7.56	0.43	0.001
Maximum	21.48	0.07	10.62	1.92	0.17
Standard deviation	4.50	0.02	1.09	0.45	0.05

DM: dry matter

2.3.3.1 Crude fiber content

Compared to alfalfa, cacti have a relatively low CF where the average value is about 10 % of the DM (Table 2.1). It consists especially from lignocellulose fraction [16].It is well known that high levels of lignocellulose or lignin are responsible for low digestibility of foodstuffs.

According to these data it is easy to guess that cactus pads organic matter digestibility is expected to be high [35].

2.3.3.2 Crude Mineral contents

Ash content of cactus pads is high, about 20 % (Table 2.1), mainly because of the high calcium content. Most of the Opuntias have phosphorus levels below animal requirement (Table 2.2). High Ca compounds levels in arid and semi-arid soils and the water deficiency pushes cactus to accumulate in its pads high quantities of Ca solutes especially. calcium oxalate. This process allows the plant to extract, through osmosis, as much water as possible from the soil. In any case, the Ca content of cactus pads is largely higher than animal requirements. An excess of calcium is not problematic in itself, but an unbalanced Ca/P ratio requires to be corrected. Most of authors report a Ca/P ratio of about 36 [35,39].

working on *O. polyacantha*, indicated that the phosphorus content was below livestock dietary requirements. Calcium levels seemed to be adequate but the calcium/phosphorus ratio, of about 36/1 is too high for optimal livestock performance. According to the same source, the other minerals (manganese, copper, zinc, magnesium, and iron) had concentrations within the range generally suggested to be acceptable in ruminant's diets. An exception was Na, K , and P contents which their averages were relatively low as shown in the Table 2.2 (about 0.05 %, 1.1 %, and 0.04 %, respectively).

2.3.3.3 Protein content

Crude protein content of cactus cladodes is low and tends to increase after fertilizer application. Nevertheless, Gegory and Felker, 1992 found that some clones from Brazil had over 11 % crude protein [5]. Gonzalez, 1989 demonstrated that N and P fertilizers increase CP contents of COC which jump from 4.5 % to 10.5 % of DM [40]. The second route to increase protein content of cactus forage is through the use of genetic selections containing higher protein. Lastly, it is also possible that inoculation of cactus roots with the free living, nitrogen-fixing bacteria *Azospirillum* sp. could increase the protein content of the cladodes, since Roa and Venkateswarlu, 1982 found this bacterium could associate with opuntia roots [41]..

Little attention was paid to the quality of COC proteins. Investigations showed that the amino acids composition of COC is quite satisfactory and is quite comparable to that of barley grain. While the amino acid profile of the opuntia stems is only useful for non-ruminant nutrition, Teles et al, 1984 found the amino acids profile of immature opuntia stems to have a biological value of 72, compared to hen egg protein of 100 [42].

2.3.3.4 Nitrogen-free extract content

The NFE content, which represents the highly digestible carbohydrate of COC was relatively high [16]. The high NFE values of the older cladodes indicated that they had the highest soluble cell contents which agrees with the observation that total carbohydrates increased during cladode development [43].

2.3.3.5 Effects of season of the year and age on nutrient contents

The trend of nutrient content variation is quite similar for cladodes of 1 and 2 years. The general trend is that DM content is highest during summer months, while CP content is at its lowest level for the same period. The tendency for ash content is less clear, but seems to be high for spring months. Crude fiber is less variable and seems to be higher during winter [35]. Retamal et al., 1987 reported that the highest values of moisture content, free reducing sugars, starch and CP were determined in spring in young cladodes [44].

The effect of cladode's age on nutrient contents is quite interesting. It is obvious that DM increases when cladodes was getting old. Analyzing data showed that CP contents decrease (5 to 3 % DM) and CF increase (9 to 20 % DM) when cladode's age move from 1 to 5 years [44]. High concentrations of N, P, and K occurring in winter, with Ca showing opposite pattern [45]. This trend is similar to other fodder sources, where valuable nutrients decrease with the plant age resulting from the relative increase in fiber content. Thus, cacti behave like any other conventional fodder where crude protein content decreases and crude fiber increases when the plant get old [35].

2.3.4 Digestibility

Cactus opuntia cladode are highly digestible and the main difference between cactus and other forage crops is the degradability of nutrient in the rumen. While with forage crop, potential degradability in the rumen is often reached after 48 hours, with cactus nutrients are degraded very rapidly (between 6 and 12 hours) and it can be assumed

that no significant nutrient extraction could be operated after 24 hours [46] .

According to Shoop et al, 1977 80% of the total digestion of Great Plains prickly pear (O. polyacantha) occurred during the first 16 hours of 48-hour incubation period whereas only 73% and 71% of total digestion for hay pellets and alfalfa hay, respectively, occurred during the initial 16 hours [39]. A rapid rate of digestion means a faster passage of the material through the digestive tract. This means also that cactus dry matter remains in the gastrointestinal tract only for a short time leaving more available volume for further intake. In other words the gut fill of cactus is low and explains why the increase of cactus amount in the diet will not reduce the intake of the other components of the ration [38].

2.3.5 Intake

Generally cacti are highly palatable for cows, sheep, and camels. It is expected that higher intakes are observed when water content of pads is higher. Sheep fed straw were able to consume up to about 560 g DM of spineless cactus. Animals receiving diets containing up to 500 g of spineless cactus did not show any digestive disturbance [35].

2.3.6 Cactus may help resolving the problem of animal watering in drought periods

Watering animals during summer time and drought periods is a real problem in tropical countries in which animals spend a lot of energy to reach water points. Therefore, the high water content of cactus pads is a positive criteria and feeding this species helps solving watering animals in dry areas. The data obtained showed clearly that water intake by an animal is nil when cactus intake is about 300 g of DM [35]. In other findings, volume of water consumed daily by animals decreased from 2.4

litter for the control diet to 0.1 litter when the level of spineless cactus is above 300 g DM [47].

2.3.7 Energy content

Gross energy content of most cacti species ranges from 3500 to 4000 Kcal/kg DM. Digestible energy is about 2000 Kcal, which is comparable to a medium quality grass [46]. Thus energy levels of cacti make them a valuable component to include in livestock diets. This energy comes mainly from the high carbohydrates concentration of the COC. However, The feeding value of spineless cactus is equivalent to 65 % total digestible nutrients (TDN) [35].

2.4 Cactus opuntia cladode as forage source for rabbits

The utilization by man of the cactus *Opuntia* was recorded from very long times, where it plays a major role in as forage for the cattle, sheep, camel etc. In recent years, plantations for fruit or forage production, have been developed in many countries of Africa, America, Asia and Europe. There is increasing interest in *Opuntias*, and *O. ficus-idica* in particular, and the important role they play and are likely to play in the success of sustainable agricultural systems in arid and semi-arid zones, where farmers must look to those few species that can profitably survive and produce. Thus *Opuntia* have become an endless source of products and functions, initially as a wild plant and ,later, as a crop for both subsistence and market-oriented agriculture, contributing to the food security of populations in agriculturally marginalized areas.

In the Gaza Strip cacti have been planted as a forage source for ruminants and as a fruit source for human since very long of time (Figures 2.1, and 2.2)

Figure 2.1: Different ages of COC and new generation of the fruit.

Figure 2.2: New generation of COC and ripening stages of the fruit.

The information about the usage of COC as forage source for growing rabbits are very rare in the literature. De Kock, 1980 emphasized the desirability of supplementary opuntia with a protein-rich supplement of alfalfa or hay (200 g in winter and 100 g in summer) with cactus fed ad libitum [48]. A lick of equal parts by mass of bone meal, salt and fodder lime is also recommended [48] to supplement the phosphate and sodium.

Russell and Felker, 1987 reported that Cacti provide a good complement when fed to livestock in combination of high protein plants such as leucaena and mesquite [32].

Gregory and Felker, 1992 reported that cactus is highly palatable to wild and domesticated rabbits [5]. Felker, 1995 has provided and mentioned an excellent review to Opuntia as forage and a synthesis of

common recommendations for cactus use and management for livestock feed [49].

Ruiz-Feria et al, 1996 evaluated Altex and new Zealand white rabbits using cactus (opuntia stricta) and Mesquite (Prosopis Glandosavar. Glandulasa) as forage resources based on growth and found rabbit fed 50 % cactus were 293 g heavier ($p<0.01$) than rabbits fed 50% mesquite because mesquite had low observed palatability compared to cactus [7].

Ruiz-Feria et al, 1998 also evaluated rabbit growth performance using leucaena and cactus forages , and found leucaena fed rabbits had the poorest performance, but when fed with 10 % level cactus, growth and carcass traits were improved [50].

Chapter 3

MATERIALS AND METHODS

Chapter 3

MATERIALS AND METHODS

3.1 Study design

The present study was a case control. The case groups were rabbits that fed ad libitum COC and partial amounts of RPA diet. The control group was only fed RPA diet. Both groups matched each other in initial body weight, water supplementation, and all other environmental conditions.

3.2. Study hypothesis

The hypothesis under investigation was that whether rabbits partially fed RPA and ad libitum COC were more likely to have growth rate, body organs weights and mortality rate comparable to those rabbits fed only RPA.

3.3 Setting of the study

The experiment carried out at rabbitary unit of Khalil Abu-Shamalah's Farm, El-Zwadia Town, Mid-Zone governorate, Gaza.

3.4 Date of the study

The present study started at April 1, 2006 and ended at June 1, 2006.

3.5. Experimental Animals and managements

Forty eight local weaned rabbits of mixed breed and sexes used for this study were purchased at 35-40 days of age from the General Economic Consumer Establishment, El-Sakhra, Gaza. To commence the trial, the rabbits were weight individually and distributed into 4 groups of

similar average initial live weights of about 550± g. The period of study was 8 weeks. The rabbits housed in metallic cages provided with feeder and drinking cups. The area of each cage was 0.35 m^2.The experimental animals were housed under environmental conditions of temperature and humidity with a lighting regime of 12 hours of light and 12 hours of darkness ,the experiment was carried out in 1-4-2006 to 1-6-2006. Housing and other management practices maintained similar for all treatment groups

Figure 3. 1: The experimental domestic rabbit

It had soft fur which was white as shown in figure , brown, and/ or black. It had also big ears, big eyes, short tail, and long whiskers.

3.6. Experimental design

The rabbits assigned into 3 case groups and one control group with 12 replications of one rabbit each. Animals on each treatment diet

randomly allocated to cages in a manner to ensure equitable treatment distribution within the farm. The farm was well aerated and sun lighted.

3.7 Experimental diets

The C group was fed ad libitum RPA diet. T1, T2, and T3 case groups were fed diets consisted of ad-libitum COC and 80 %, 60 %, 40 % RPA, respectively.

Throughout the study, the restricted feeding levels of cases were determined based on consumption of the control rabbits in the previous day. In addition, middle aged COC were harvest daily from the same research plot and were placed randomly as small squared spineless cactus pads in the rabbit forage feeders on the same day of collection. Water provided continuously with tetracycline (1gm/l) for 1st two weeks to protect the rabbits from bacterial infection. All feeds will be offered in the morning after collection of the left over. Data Collection: Live weight change recorded weekly until the end of the trail. Feeds offered and the left–over recorded daily for each treatment to determine average daily feed intake. Feed conversion ratio was determined by dividing the value of average daily feed intake (based on RPA consumption) by that of average daily live weight gain for each study group.

3.8 Carcass and internal organs evaluation

At the end of the feeding trial, while rabbits age was 60 days, four rabbits were selected from each treatment based on the group average weight for slaughtering in order to evaluate internal organs and carcass weights. Before slaughtering, the animals were starved overnight to clear the guts and the live weights were recorded. The skin with fur were removed carefully. Evisceration of the carcasses was carried out and the internal organs were weighted separately and expressed as an average and

a standard Error of mean (SEM). Head, feet and tail were removed to obtain the dressed carcass weight that expressed as percentage of live weight beyond slaughtering. The measuring scale used throughout the study was computing price scale (ACS-30C).

3.9 Chemical analysis

The actual nutrient contents of the two diets were examined in Al-Azhar university food analysis labs [51-53].

3.10 Data analysis

All obtained ordinal and nominal data were analyzed by ANOVA using SPSS system (Version 13). Difference between variables was considered statistically significant if p value < 0.05.

Chapter 4

RESULTS AND DISCUSSION

Chapter 4

RESULTS AND DISCUSSION

4.1. Diet composition

Table 4.1 shows the chemical composition of the RPA diet. The analysis of RPA diet was compared with ingredients percentage shown on the commercial label. There was a clear decrease in the actual concentrations of the total crude protein(CP), crude fibers (CF) and Ash. In contrast, there was a clear increase in the actual concentration of salt and Mg.

Table 4.1: Percentage of chemical composition of RPA.

Ingredients	*labeled	**tested
CP	17.0	12.7
H2O	13.0	13.6
EE	3.5	3.41
CF	10.5	6.81
Ash	7.5	5.0
Ca	0.80	0.67
P	0.60	0.51
Salt	0.65	1.31
Mg	0.04 (mg/kg)	0.06 (mg/kg)

Along with it contain Nitrogen free extracts, vitamins, and some minerals.*according to the commercial label.

** According to results of Al-Azhar University Food Analysis Labs. The values given are average of duplicate samples.

Table 4.2 shows the chemical compositions of the COC that was used for partial feeding of the growing rabbits. It is clear that COC feed was poor in CP and rich in DM and water compared to RPA. According to tables 4.1 and 4.2, DM values for RPA and COC were 86.4 % and 16.0 %, respectively. These findings about COC composition are very consistent with those reported by [5,36]. They

found that CP content of the COC is lower than 5 % of DM. In this study, COC had also lower CF, fats, NFE and ash than RPA. In contrast to thes findings, [35].Ruiza-Feria et al,1998 reported that COC (% DM basis) contains 9.3 % CP and 10.5 % CF [50].Nefzaoui and Ben salim,2005 reported that the average value of CF and ash are about 10 % and 20 of the DM, respectively [35]. These contradictions of results about CP, CF and ash contents of COC indicate that chemical composition of COC are very heterogeneous depending on COC surrounding environmental conditions, and age. However Gonzalez, 1989 reported that N and P fertilizers increased CP content of COC from 4.5 % to 10.5 % of DM [40]. Moreover Retamal et al, reported that the CP contents decrease (5 to 3 % DM) and CF increase (9 to 20 % DM) when COC' ages move from 1 to 5 years [44].

According to the results, COC also contain calcium more than iron . In agreement with this finding, recent investigations have shown that COC are rich in calcium solutes and poor in other minerals such as K, P, and Na [35,36].

Table 4.2 : Chemical composition of COC (% wet basis) [a].

Ingredients	***COC (%)***
Moisture	84.0
CP	8.7
CF	2.9
EE	0.02
Ash	1.2
Carbohydrates	7.0
NFE	10.9
ADF	3.9
NDF	7.3
Ca (mg/kg)	11.0
Fe (mg/kg)	1.3

[a]The values given are average of duplicate samples.

4.2. Live weight gain

Table 4.3 shows that average final body weights of the growing rabbits aged 56 days decreased significantly with decreasing percentage of RPA diet ($p< 0.05$) compared to control. The highest average final growth weight was observed on pure RPA diet that appeared to be logical consequence of the superior amino acids balance of this complete protein diet, compared with COC feed. Average final body weights for T1 and T2 were 1740 g and 1600 g, respectively. These values were relatively lower than the average final body weights of C (2024 g) and considered acceptable for marketing and slaughtering. The Average final body weights of C can be obtained by increasing age of the growing rabbits of T1 and T2 a few days. However, the average growth rate of the rabbits were 26.31, 21.20, 18.57, and 10.64 g/day for the C, T1, T2, and T3, respectively. Thus, growth rate was in the range of 10 to 26 g/day (Figures 4.1, and 4.2). The RPA diet as a sole source of supplementary protein gave the highest growth rate compared to other rabbit high protein concentrate feeds reported in the literature [53-55].These differences in growth rates of growing rabbits might be due to variations in age, genotypes, and different environmental conditions.

Table 4.3: Effect of partially COC intakes on average and standard error of mean (SEM) growth performances of the grower rabbits

Average Body wt. (g)	Dietary group				
	C	T1	T2	T3	P
Initial	551±0.18	548±0.15	555±0.20	550±0.17	NS
Final	$2{,}024^{a}$±0.21	$1{,}740^{b}$±0.10	$1{,}600^{c}$±0.14	$1{,}150^{d}$±0.20	S
Total gaining	1473^{a}±0.01	1188^{b}±0.01	1040^{c}±0.36	596^{d}±0.38	S
Growth rate (g/day)	26.31^{a}±0.02	21.20^{b}±0.03	18.57^{c}±0.27	10.64^{d}±0.31	S

-Means with difference superscripts in the same row differ significantly ($p < 0.05$)

-C: control , T1: trial one , T2: trial two , T3: trial three.

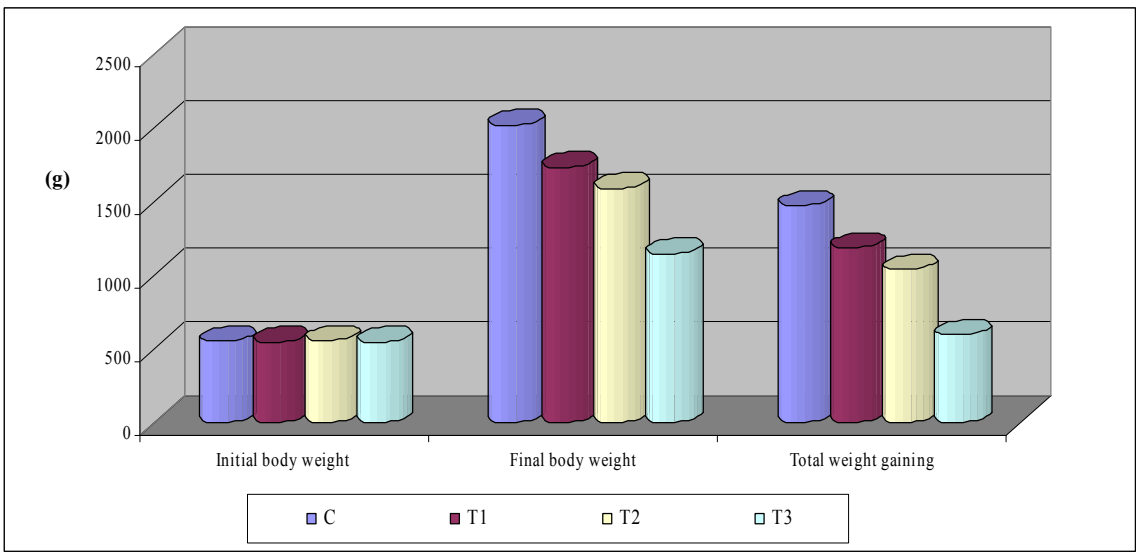

Figure 4.1: Multiple bar chart showing effect of partially COC intake on growth performance of the rabbits

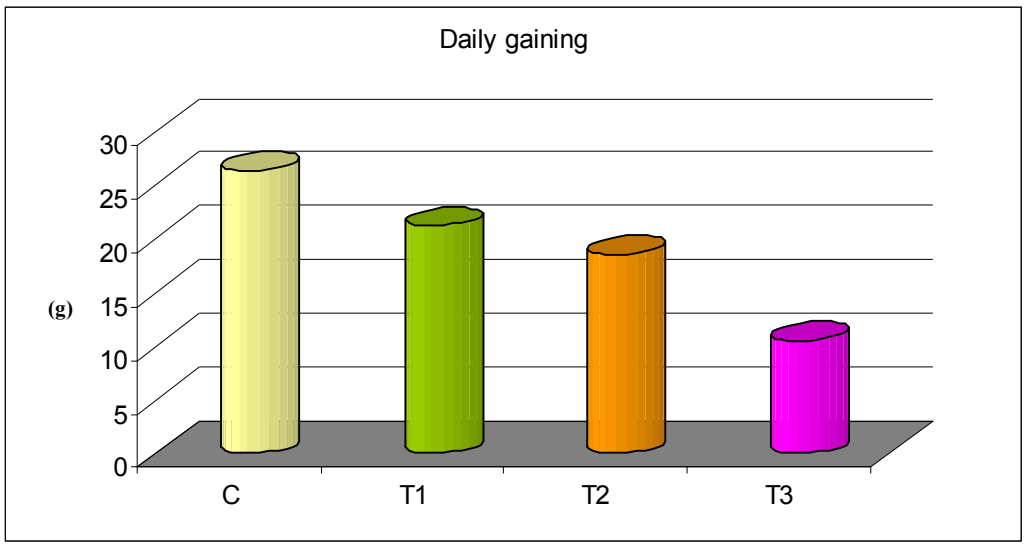

Figure 4.2: Bar chart showing effect of partially COC intake on daily weight gaining of the rabbits

4.3 Feed intake and conversion

Table 4.4 and Figure 4.3 show that average daily RPA diet intakes of the C , T1, T2, and T3 trials were 87.6, 63.8, 53.0, and 34.6, respectively. Thus, It appears that, the differences in the growth rates were due to the differences in the daily RPA diet intakes of the growing rabbits. However, feed conversion ratios based on RPA diet consumption for C, T1, T2, and T3 were 3.33, 3.01, 2.85, and 3.25 (Figure 4.4 and Figure 4.4.). There was a significant difference in feed between C and T1 or T2 trials ($p < 0.05$). However, no significant difference of feed conversion between C and T3 was observed. This probably because the daily intake of RPA diet in T3 trial was 40 % of C. Thus, feed conversion ratios based on RPA diet intake did not reflect true growth efficiency of the growing rabbits, and COC feed played a minor role in the growth rate. In T1 trial, rabbits consumed about 70 % of their diet from RPA and about 10 % of it was left over. Thus, COC is highly palatable for growing rabbits. These findings are very consistent with those reported by [5].

4.4. Mortality rate

Throughout running of the experiment only 1, 3, 3, and 2 rabbits died in C, T1, T2, and T3 trials, respectively. However, the mortality rates between the C group and other experimental groups were somehow significantly different ($p<0.05$). Surprisingly, mortality rate in T3 trial was less than T2 or T1 trials (Table 4.4). Thus, domestic rabbits can tolerate COC feed up to 60 % of the RPA diet. It should be emphasized that COC can be added partially to the growing rabbits in case of emergency. De Kock, 1980 emphasized the desirability of supplementary opuntia with a protein-rich supplement of alfalfa or hay (200 g in winter and 100 g in summer) with cactus fed ad libitum [48]. A lick of equal parts by mass of bone meal, salt and fodder lime is recommended by [48] to supplement the phosphate and sodium.

Table 4.4: Average (SEM) COC intake and feed conversion ratio of growing rabbits partially fed ad-libitum Cactus.

Parameters	**Dietary groups**				
	C	T1	T2	T3	P
Initial RPA (g/day)	$56^{a}\pm0.23$	$40^{b}\pm0.22$	$31^{c}\pm0.20$	$23^{d}\pm0.12$	S
Final RPA (g/day)	$115^{a}\pm0.13$	$79^{b}\pm0.29$	$70^{c}\pm0.11$	$45^{d}\pm0.02$	S
Daily Intake	87.60^{a}	63.80^{b}	53.00^{c}	34.60^{d}	S
Feed conversion	$3.33^{a}\pm0.25$	$3.01^{b}\pm0.01$	$2.85^{c}\pm0.15$	$3.25^{a}\pm0.01$	S
Mortality rate*(%)	8.3	25	25	16.7	S

-Means with difference superscripts in the same row differ significantly ($p<0.05$)

*Chi-square test (p-value <0.05).

-C: control , T1: trial one , T2: trial two , T3: trial three.

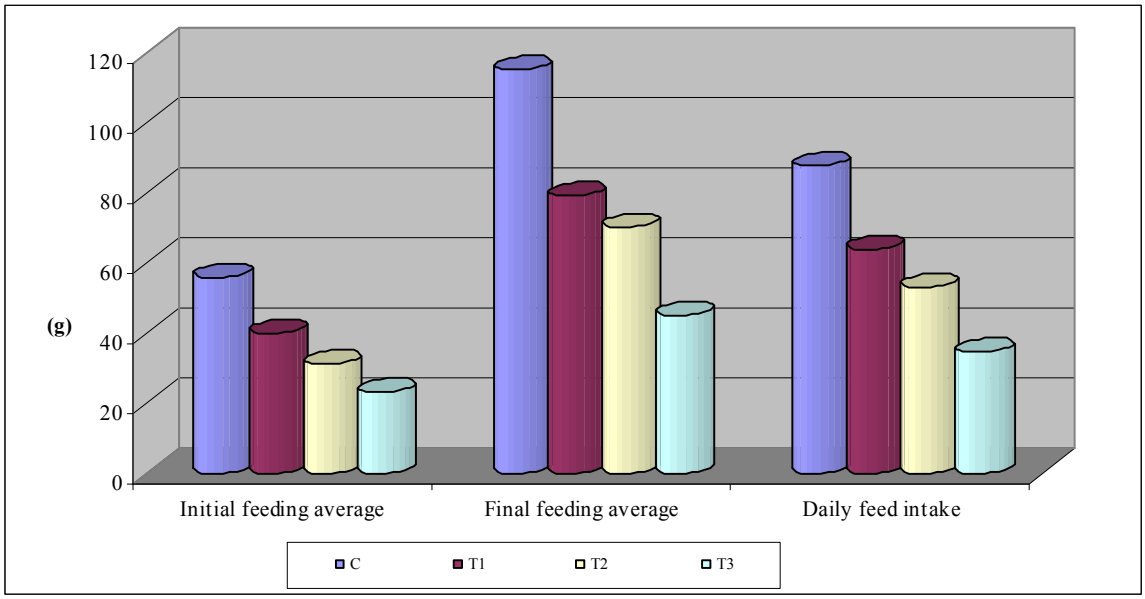

Figure 4.3: Multiple bar chart showing initial, final and daily RPA intakes of rabbits partially fed ad-libtum COC.

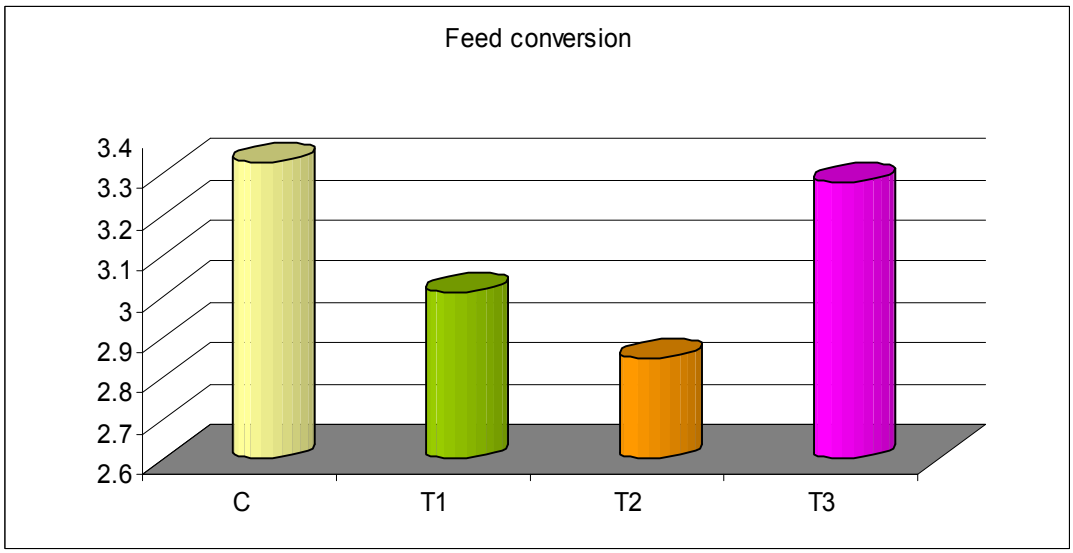

Figure 4.4: Bar chart showing effect of RPA intake on feed conversion of growing rabbits fed ad-libtum COC.

4.5 Organs and carcass weights

Results of body organs and carcass characteristics (Table 4.5 and Figure 4.5) showed that average weights of skin, head and kidneys/spleen/lungs of C , and T1 or T2 and T3 were significantly different. T1 and T2 trials did not differ in average of these organs weights. This significant difference also observed in average liver weights among the trials. But liver of T3 had the highest average weights among the trials that might be due to its involvement in COC metabolism. Other organs (legs and Vesira), carcass, internal body fat tissues showed significant differences across the dietary treatments (Figure 4.6). Average percentage of carcass weights of case groups were more than 40 % and those of T1 and T2 trials were identical and approximately similar to C trial.. These findings ensures that body weights of rabbits of T1 and T2 trials are acceptable for marketing. However, in general, partial COC feed succeeded in decreasing average organs weights and average weights of internal body fat tissues. In contrast, 40 % RPA diet and ad-libitum COC succeeded to increase average liver organ weights. Histological studies should be carried out on the liver of this study group before final conclusion.

Table 4.5: Effect of partially COC intake on some average (SEM) organs weight, body fat and % carcass weight of the growing rabbits

Average organs and carcass wt.	**Dietary groups**				
	C	T1	T2	T3	P
Skin	$206^{a}\pm 0.12$	$137^{b}\pm 0.18$	$134^{b}\pm 0.12$	$108^{c}\pm 0.21$	S
Head	$200^{a}\pm 0.14$	$152^{b}\pm 0.08$	$149^{b}\pm 0.13$	$129^{c}\pm 0.03$	S
Legs	$85^{a}\pm 0.09$	$58^{c}\pm 0.08$	$64^{b}\pm 0.14$	$46.50^{d}\pm 0.12$	S
Vesira	$187^{a}\pm 0.08$	$150^{b}\pm 0.19$	$133^{c}\pm 0.02$	$111^{d}\pm 0.11$	S
Liver	$61^{b}\pm 0.02$	$52^{c}\pm 0.21$	$52^{c}\pm 0.21$	$70^{a}\pm 0.18$	S
Kidney, Spleen and lungs	$49^{a}\pm 0.13$	$38^{b}\pm 0.11$	$39^{b}\pm 0.22$	$29^{c}\pm 0.21$	S
Carcass	$1070^{a}\pm 0.14$	$798^{b}\pm 0.20$	$726^{c}\pm 0.03$	$568^{d}\pm 0.23$	S
Internal body fat tissue	$8^{a}\pm 0.19$	$4^{b}\pm 0.38$	$3^{c}\pm 0.38$	$2.00^{d}\pm 0.53$	S
Caracas/ Weight of slaughtering*	48.70 %	45.40 %	44.50 %	40.45 %	S

- Means with difference superscripts in the same row differ significantly ($p < 0.05$).

*Chi-square test (p-value <0.05)

-C: control , T1: trial one , T2: trial two , T3: trial three

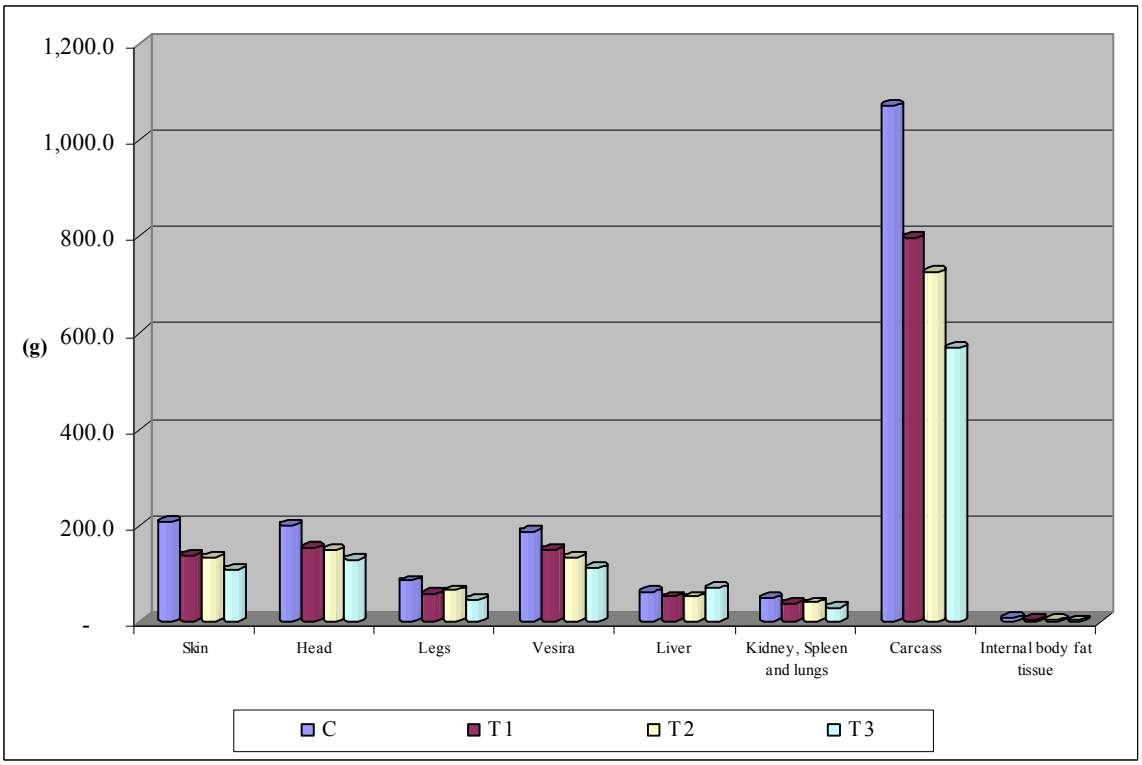

Figure 4.5: Bar chart showing the effect of partially COC intake on average organs and carcass weight of the growing rabbits.

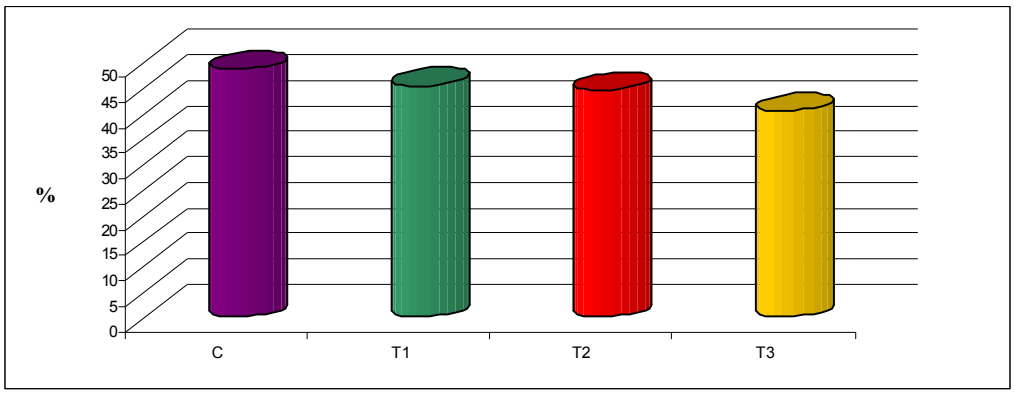

Figure 4.6: Bar chart showing weight of carcass/ weight before slaughtering * 100

Conclusion and Recommendation

Conclusions:

Rabbits in the Gaza strip are currently fed a very expensive commercial rabbit feeds that irregularly available due to the surrounding political conditions. Therefore, the available low cost cactus feed (COC) was tested to partially replace the exported expensive rabbit pelleted Anber (RPA). The experimental rabbits were grown on COC as a partial feed of RPA. The control group were fed only RPA.

After carrying out of the experiments, the results were obtained about the response of the growing rabbits to the lower protein feeds and conclusions are as the following:

-COC is poor in CP.

-COC has lower DM, CF, EE, NFE than RPA.

-Average final body weight for T1 and T2 were 1740 g and 1600 g, respectively, which are acceptable for marketing and slaughtering.

-Growth rate of the rabbits was in the range of 10 to 26 g/day.

-The COC was very palatable to the domestic rabbits.

- Feed conversion of T1 and T2 are similar to feed conversion of the control which reflects slower growth rate and higher sparing of costly RPA diet.

-Percentages of carcass/ body weight at the slaughtering age were 48.7, 45.4, 44.5 and 40.4 for C, T1, T2, and T3 trials, respectively which also indicated that T1 and T2 rabbits were very acceptable for marketing and slaughtering.

-Partial COC feed succeeded in decreasing average of organs weights and average of internal body fat tissues weights of the rabbits.

- In general, Rabbits tolerate COC feeding up to 40 % level of inclusion in RPA diet.

- COC can be used as strategic reservoir for feeding growing rabbits upon restricted political and economical conditions in the Gaza strip.

Recommendations

* The study recommends studying the effect of partial COC feed on reproductive performances of domesticated rabbits.
* It also recommends carrying out histological studies of some organs particularly liver of the growing rabbits partially fed COC.
* Further studies should be carried out about using forages other than COC and richer in protein contents.
* Further studies should be also carried in order to explain why the mortality rate in T3 was lower than T1 or T2.

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Appendices

Annex 1

Annex 2

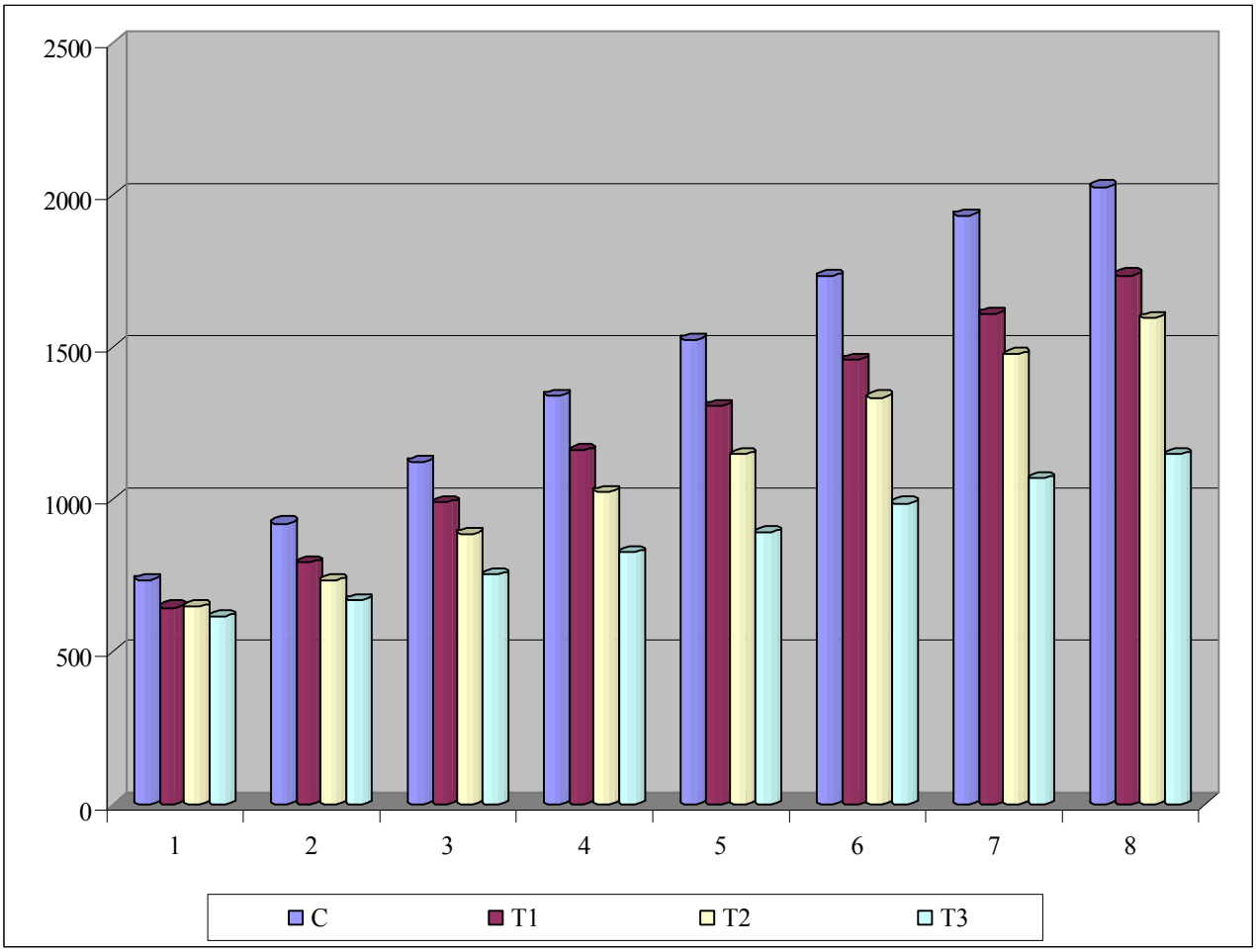
Annex 3

Annex 4

Effect of partially COC intake on growth performance of the rabbits from 1st week up to 8th week.

Wt. Gaining per week (g)

	C	T1	T2	T3	P
First	737±0.20	646±0.18	649±0.15	615±0.12	S
Second	922±0.21	793±0.14	733±0.14	670±0.11	S
Third	1,1238±0.20	989±0.12	888±0.15	752±0.10	S
Fourth	1,340±0.16	1,159±0.11	1,025±0.10	826±0.11	S
Fifth	1,524±0.18	1,307±0.14	1,147±0.09	890±0.13	S
Sixth	1,732±0.17	1,457±0.14	1,335±0.09	987±0.13	S
Seventh	1,931±0.17	1,608±0.13	1,475±0.13	1,068±0.16	S
Eighth	2,024±0.19	1,736±0.14	1,595±0.12	1,146±0.19	S

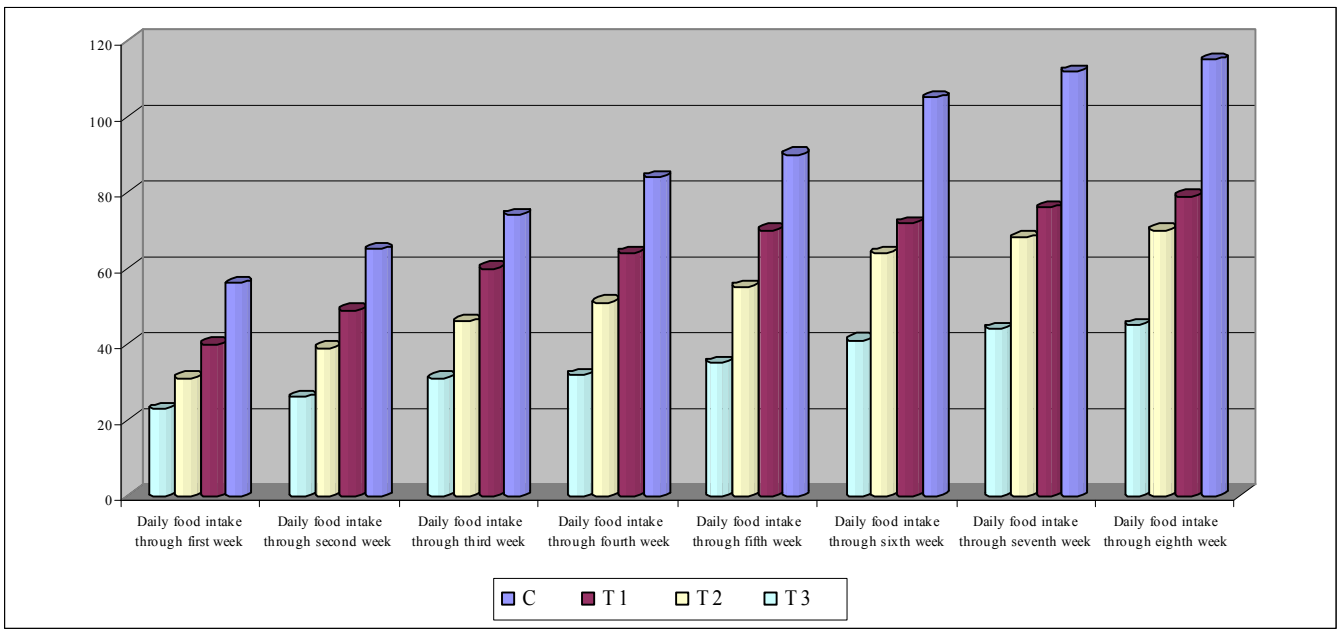


Multiple bar chart showing the effect of partially COC intake on growth performance of the rabbits from 1st week up to 8th week.

Annex 5

Daily commercial RPA diet intakes of rabbits partially fed ad-libtum COC from 1st week up to 8th week of growth

Food intake weekly(g)	C	T1	T2		T3	P. value
First	56±0.23	40±0.22	31±0.20	44.6	23±0.12	S
Second	65±0.24	49±0.10	39±0.07	40.0	26±0.05	S
Third	74±0.29	60±0.09	46±0.002	37.8	31±0.00	S
Fourth	84±0.18	64±0.15	51±0.04	39.3	32±0.01	S
Fifth	90±0.18	70±0.19	55±0.08	38.9	35±0.04	S
Sixth	105±0.14	72±0.35	64±0.07	39.0	41±0.05	S
Seventhss	112±0.15	76±0.25	68±0.07	39.3	44±0.03	S
Eighth	115±0.11	79±0.13	70±0.11	39.1	45±0.02	



Multiple bar chart showing the daily commercial RPA diet intake of rabbits partially fed ad-libtum COC from 1st week up to 8th week of growth

Annex 6: Some experimental parts in Photos.