Al-Azhar University-Gaza
Deanship of Postgraduate Studies
Faculty of Agriculture and Environment
Department of Animal and Poultry Production

Utilization of Fiberolytic Enzymes for Improving Digestibility in Assaf Lambs Feed

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Approval Sheet

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M. Sc. Thesis
In Agricultural Sciences
(Animal and Poultry Producation)

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جامعـــة الأزهـــر – غـــزة
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2017

بِسْمِ اللَّـهِ الرَّحْمَنِ الرَّحِيمِ

" يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ "

صدق الله العظيم (المجادلة: 11)

Declaration

I, the undersigned hereby, declare that the thesis titled:

Utilization of Fiberolytic Enzymes for Improving Digestibility in Assaf Lambs Feed

Is my own research work and the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has never been submitted elsewhere for any other degree qualifications nor for any academic titles, nor for any other academic or publishing institutions.

I here, to affirm that I will be completely responsible in academic and legal terms if this work proves the opposite.

Student's name: **ASAD MOHAMMAD ABD ELMALEK ABUTAIMA**

Signature: *Asad Abu-Taima*

Date: 19 - 03 – 2017

Dedication

I Dedicate thise

Thesis to my parnts for their limitless love and care

To my family members ,friends and grand mother

Whose presence brought warmth

to my live

to the Faculty of Agriculture and Environment.

to the ministry of agriculture.

Acknowledgement

*I thank **Allah**, the most gracious, most beneficent most merciful for the help and guidance to achieve goals and make them possible.*

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Iam eternally grateful for their love and encouragement wish no words can describe.

Abstract

The experiment was planned to investigate the effect of feeding Assaf lambs on diets supplemented with two levels of fibrolytic enzymes (low or high) on the growth performance, carcass characteristics, rumin liquor, blood components and economical efficiency. The three groups of 12 Assaf lambs (4 each) fed the following diets: Control, which consisted of 15% alfalfa hay and 85% concentrate feed mixture, (CFM) (on DM basis).; (T1): Control + 2 g fibrolytic enzymes/h/day; and (T2): Control + 4 g fibrolytic enzymes/h /day. The growth trial lasted for 28 weeks. Lambs were fed at levels of 3.5 % DM of body weight. Animals were weighed weekly before feeding at 8:00 a.m. to calculate the average daily gain (ADG). Animals were fasted for 12 hours before slaughter, weighed just before slaughter (SW) and after complete bleeding. Weights of carcass knife separable fat, internal and external offals and body fats were weighted and calculated as percentage of body weight at slaughtering (SW). Blood serum samples and rumin liquor were taken at the final day of treatment directly before slaughtering from jugular vein from all animals. **The main results summarized as follows:**

- **Feed intake and body weight**: There were no significant effect between lambs concerning feed intake, initial LBW and final LBW.
- **Carcass traits:**

Dressing percentages A or B were not significantly affected by fibrolytic enzymes treatment.

Carcass cuts: Lambs fed rations with low (T1) or high level of fibrolytic enzymes (T2) significantly increased ($P<0.05$) weights of shoulder, loin and neck than control in the diet, but did not significantly ($P>0.05$) affect weights of legs, rack, brisket and flank. Low and high level of fibrolytic enzymes decreased the percent of shoulder and rack than control, but increased the percent of loin, flank and neck than control.

- **Edible offals:** Lambs fed rations supplemented with fibrolytic enzymes (low level) (T1) significantly ($P<0.05$) increased the weights of liver, kidney, tests and heart than control. However, high level of fibrolytic enzymes significantly ($P<0.05$) decreased kidney testes and heart weight than control. Total edible offals weight was superior with T1 followed by control, then T2.
- **Non-edible parts:** Lambs fed diets with high fibrolytic enzyme (T2) had higher pelt and empty gastro-intestinal part (GIP) than control group with significantly ($P<0.05$) differences. However, there were no significant differences ($P>0.05$) between the different groups concerning head, feets and GIP full.
- **Rumen liquor: pH** showed insignificant ($P>0.05$) values by Assaf lambs fed on control, T1 and T2 diets. All ruminal pH values were above 6.0**.** Time of sampling had a significant effect ($P<0.05$) on rumen pH values. **Total volatile fatty acids**: TVFA's concentration showed higher ($P<0.05$) values by Assaf lambs fed fibrolytic enzymes supplemented-diets compared with Assaf lambs fed control**.** **NH_3-N** showed significant ($P<0.05$) increase by Assaf lambs fed fibrolytic enzymes supplemented-diets compared with Assaf lambs fed control**.** Time of sampling had a significant effect ($P<0.05$) on rumen NH_3-N with an opposite trend of pH values.

- **Blood components: Total protein and its fractions:** Supplementing lambs diets with low level of fibrolytic enzymes (T1) significantly ($P<0.05$) increased total protein and globulin contents than control or high fibrolytic enzymes level (T2). Albumin content decreased with high (T2) enzymes (T2) than the control or (T1) diets. **Kidney functions (**urea or creatinine), **Liver functions (**AST or ALT) **or Lipids (**triglycerides and cholesterol**) and glucose metabolism:** Treated rations did not significantly ($P>0.05$) affect its levels.

- **Economical efficiency**: was increased to be the highest with high fibrolytic enzymes level and was the lowest with control

From the previous results, it could be concluded that supplementation of fibrolytic enzymes as 2 or 4 g /h/d enhanced productive performance of Assaf lambs, but it was the highest with high level of fibrolytic enzymes supplementation than low fibrolytic enzymes level.

Keywords: fibrolytic enzymes**,** growing Assaf lambs, rumin, blood serum, economical efficiency.

Abstract in Arabic Language

ملخص الدراسة

صممت هذه التجربة لدراسة تأثير : إستخدام الإنزيمات المحللة للألياف (بمستويين: منخفض أو عالى) لتحسين الهضم فى غذاء الأغنام العساف على مواصفات النمو و صفات الذبيحة و سائل الكرش و بعض مكونات الدم و الكفاءة الإقتصادية للحملان. إستخدم فى هذه الدراسة 12 حمل من نوع العساف عمر حوالى 4 شهور، قسمت إلى ثلاث مجموعات متساوية (4 حمل / مجموعة). المجموعة الأولى (المجموعة الضابطة) غذيت على عليقة مركزة (بنسبة 85% من العليقة) بالإضافة الى دريس الالفالفا (بنسبة 15% من العليقة) أما المجموعة الثانية فقد تم إضافة 2 جرام من الانزيم المحلل للسليولوز الى العليقة لكل رأس يوميا، بينما تم إضافة 4 جرام من الانزيم المحلل للسليولوز الى العليقة لكل رأس يوميا فى المجموعة الثالثة. و قد استمرت التجربة لمدة 28أسبوعا، و تم تغذية الحملان بنسبة 3.5 % كمادة جافة من الوزن الحى، و تم وزن الحملان مرة كل أسبوعين لحساب معدل النمو اليومى كما تم سحب عينات سائل الكرش قبل الاكل و بعده بـ 3 و 6 ساعات من التغذية الصباحية و تم عمل تجارب الذبح و قياسات الذبيحة و تقديرات الدم. ويمكن تلخيص النتائج فيما يلى:

- **المأكول ووزن الجسم:** لم يتأثر معنويا بالمعاملات.

- **صفات الذبيحة: نسبة التصافي:**. لم تتأثر نسبة التصافي بشكل معنوى فى المجموعات المختلفة.

-**قطعيات الذبيحة:** أظهرت الحملان المغذاة على علائق محتوية على انزيمات محللة للسليولوز سواء المستوى العالى او المستوى المنخفض زيادة معنوية (على مستوى 5%) فى أوزان الكتف والخاصرة والرقبة عنها فى المغذاة على عليقة المقارنة.

-**الأجزاء الصالحة للأكل:** أظهرت الحملان المغذاة على علائق محتوية على الانزيمات المحللة للسليولوز (المستوى المنخفض) زيادات معنوية فى أوزان الكبد والكلى والخصية والقلب عنها فى عليقة المقارنة، بينما اظهر المستوى العالى من الانزيمات المحللة للسليولوز انخفاضا معنويا فى أوزان الخصيتين و الكلى و القلب عنها فى عليقة المقارنة. وكان مجموع وزن الأجزاء الصالحة للأكل أعلى فى المعاملة الأولى يليها المقارنة وأخيرا المعاملة الثانية.

-**الأجزاء غير الصالحة للأكل:** أظهرت الحملان المغذاة على علائق محتوية على الانزيمات المحللة للسليولوز (المستوى العالى) أعلى اوزان فى القناة الهضمية الخالية عنها مع عليقة المقارنة معنويا.

-**سائل الكرش:** لوحظ عدم وجود فروق معنوية بين المعاملات بالنسبة لدرجة الـ pH ، حيث كانت اعلى من 6.0، و مع ذلك كانت هناك فروق معنوية بالنسبة لوقت سحب العينة على مستوى 5%، واظهرت الاحماض الدهنية الطيارة فروق معنوية بين المعاملات، حيث كانت اعلى مع الحملان المغذاة على علائق مدعمة بالانزيمات المحللة للسليولوز، نيتروجين امونيا الكرش اخذ نفس اتجاه الاحماض الدهنية الطيارة و عكس اتجاه درجة الـ pH ، بمعنوية (على مستوى 5%)

-**مكونات الدم:** أظهرت الحملان المغذاة على علائق محتوية على الانزيمات المحللة للسليولوز (المستوى المنخفض) أعلى بروتين كلى و جلوبيولين بصورة معنوية ($P < 0.05$) عنها مع عليقة المقارنة و المستوى

العالى من الانزيمات المحللة للسليولوز، و لم تؤثر المعاملات على وظائف الكلى او الكبد او تمثيل الدهون و الجلوكوز

-**الكفاءة الاقتصادية:** كان صافي الإيرادات أعلى مع المستوى العالى من الانزيمات المحللة للسليولوز وكان أدنى مع المجموعة المقارنة، في نفس الوقت تم زيادة الكفاءة الاقتصادية أيضاً.

من النتائج السابقة، يمكن أن نخلص إلى أن تناول العلائق المحتوية على الإنزيمات المحللة للسليولوز في علائق الحملان بنسب 2 او 4 جرام/رأس /يوم أدى إلى تحسين الأداء الإنتاجي للحملان العساف، و كان أعلى مع زيادة مستوى الإنزيمات المحللة للسليولوز في علائق الحملان حتى مستوى 4 جرام/رأس/يوم.

الكلمات الدالة: انزيمات محللة للسليولوز، حملان عساف، نمو. مواصفات ذبيحة، سائل كرش، مكونات دم، جدوى اقتصادية

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List of Abbreviations

ALT Alanine aminotransferase
ADG Average daily gain
AST Aspartate aminotransferase
BWG Body weight gain
CF Crude fiber
CFM Concentrate feed mixture
CP Crude protein
DM Dry matter
DMI Dry matter intake
DP Dressing percentage
EBW Empty body weight
EE Ether extract
FC Feed conversion
GIT Gastro-intestinal tract
GIP Gastro-intestinal part
Kg/d Kilograms/day
LBW Live body weight
NFE Nitrogen-free extract
NRC National Research Council
OM Organic matter
PEM Polioencephalomalacia
TMR Total Mixed Ration
T1 Ration supplemented with 2 g fibrolytic enzymes/head/day
T2 Ration supplemented with 4 g fibrolytic enzymes/head/day

1 INTRODUCTION

In Palestine there is an acute shortage of conventional feed stuffs for livestock feeding. The big feed gap between the requirements and the available sources forced the planners and nutritionists to look for non–conventional resources where there is no competition with human, such as agricultural by–products which available around the year but are not efficiently used or others is one of this agro-industrial by products.

Increasing digestibility of the diet by using exogenous feed enzymes will lead to the beneficial effects on animal performance, so such treatments are likely to be of great benefit for ruminants in negative energy balance, such as animals in early lactation so, this work will study the effect of incorporation of fibrolytic enzymes in animal's diets on its productive performance.

The present work aims to study the effect of adding cellulytic and pectolytic enzymes to diets of Assaf lambs on its productive performance.

2 Literature Review

There is increasing evidence that exogenous fibrolytic enzymes improve nutrients digestibility *in vitro* and *in vivo*.

Colombatto *et al.* (2006) examined (*in vitro*) the impact of fiberolytic enzymes on the rate and extent of fermentation of alfalfa stems. They found that addition of enzyme linearly increased *in vitro* organic matter (OM), dry matter (DM), neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose degradation.

Giraldo *et al*. (2007) investigated the effects of exogenous pure cellulases on ruminal microbial growth and fermentation of 70:30 grass hay: concentrate (DM basis) substrate in Rusitec fermenters. The results indicated that adding cellulases enhanced *in vitro* fermentation by increasing substrate fiber degradation, Volatile Fatty Acids (VFA) production, and ruminal microbial growth. Furthermore.

Rode *et al*. (1999) investigated the effects of exogenous fibrolytic enzyme supplementation on digestibility by dairy cows (*in vivo*).They reported that total digestibility of nutrients, determined was dramatically increased by enzyme treatment.

Titi and Tabbaa (2004) investigate the efficacy of direct feeding a cellulase enzyme on lamb diets digestibility. Result indicated that cellulase enzyme increased dry matter and organic matter digestibilities of treated lambs compared to those of control. A similar trend was observed for the crude fiber, NDF and ADF digestibility coefficients. In addition.

Abdel-Gawad et al. (2007) evaluated the effects of fiberolytic enzymes on the *in vivo* nutrient digestibilities by sheep for corn stalks, wheat straw, rice straw and sugarcane bagasse. They found that fiberolytic enzymes supplementation significantly increased digestibilities

of DM, OM, CP, NFE, CF and hemicellulose of all roughage compared with control.

Titi and Lubbadeh (2004) studied the effects of feeding cellulase enzyme to ewes and Assaf lambs on milk production and composition. They stated that in both species, milk production was increased by10–12% affected by the feed enzyme treatment with no effect of sex, species or any of their interaction. Treated Awassi ewes had higher milk fat and protein when compared with the control ewes, while, no differences were found between treated and untreated goat groups. In both species, mean values for total solids were higher in the treated groups compared to untreated groups for sheep and Assaf lambs. They added improved milk production occurred without apparent changes in feed intake, which might suggest that improvement was through improved feed utilization.

Positive effects of fibrolytic enzymes on nutrients digestibility have been reported in different studies **(Feng *et al.*, 1996 and Dong *et al.*, 1999). Dong *et al.*, 1999** demonstrated that the effects of enzymes might start when the enzyme is in contact with the substrate, so enzyme-feed interaction appears as important. **Giraldo *et al.*, 2004** confirmed that a pre-ingestive enzyme-feed interaction is necessary for any significant beneficial effects on ruminal digestion. Other studies demonstraded that a pre-feeding enzyme-feed interaction period is necessary for fibrolytic enzyme-mediated increases in digestion **(Lewis et al., 1996; McAllister et al., 1999; Wang et al., 2001; Krueger and Adesogan, 2008)**.

The enzyme addition onto feeds may create a stable enzyme-feed complex that protects free enzymes from proteolysis in the rumen as reported by **Kung *et al.*, 2000.**

Several potential modes of action have been proposed. These include: a) increase in microbial colonization of feed particles. **(Yang *et al.* 1999),** b) enhancing attachment and /or improve access to the cell wall

matrix by ruminal microorganisms and by doing so, accelerate the rate of digestion (**Nsereko *et al.*, 2000)** and c) enhancing the hydrolytic capacity of the rumen due to added enzyme activities and /or synergy with rumen microbial enzymes **(Newbold, 1997; Morgavi *et al.*, 2000).**

2.1 Role of fiberolytic enzymes in saccharification of agricultural by-products.

Cellulose present in renewable lignocellulosic material is considered to be the most abundant organic substrate on the earth. Cellulose is a long-chain polymer polysaccharide, of beta-glucose. It forms the primary structural and principal constituent of the cell wall of plants.

Cellulase (a complex multienzyme system) acts collectively to hydrolyze cellulose from agriculture wastes to produce simple glucose units (**Smith, 1996**).

Cellulase refers to a family of fiberolytic enzymes which act in concert to hydrolyze fiber of plant cell wall to glucose, cellobiose or oligosaccharides (**Murad and Azzaz, 2010; Chinedu *et al*., 2010**).

Three types of cellulase enzymes are involved in the cellulase hydrolysis process including cellobiohydrolase, endoglucanase or carboxy methylcellulase (CMC) and β-glucosidases (**Bhat, 2000; Saber *et al.*, 2010**). The widely accepted mechanism for enzymatic cellulose hydrolysis involves synergistic actions by endoglucanase, exoglucanase or cellobiohydrolase and β-glucosidase (**Knowles *et al*., 1987; Wood and Garica-Campayo, 1990; Henrissat, 1994; Teeri, 1997; Lynd *et al*., 2002; Zhang and Lynd, 2004**).

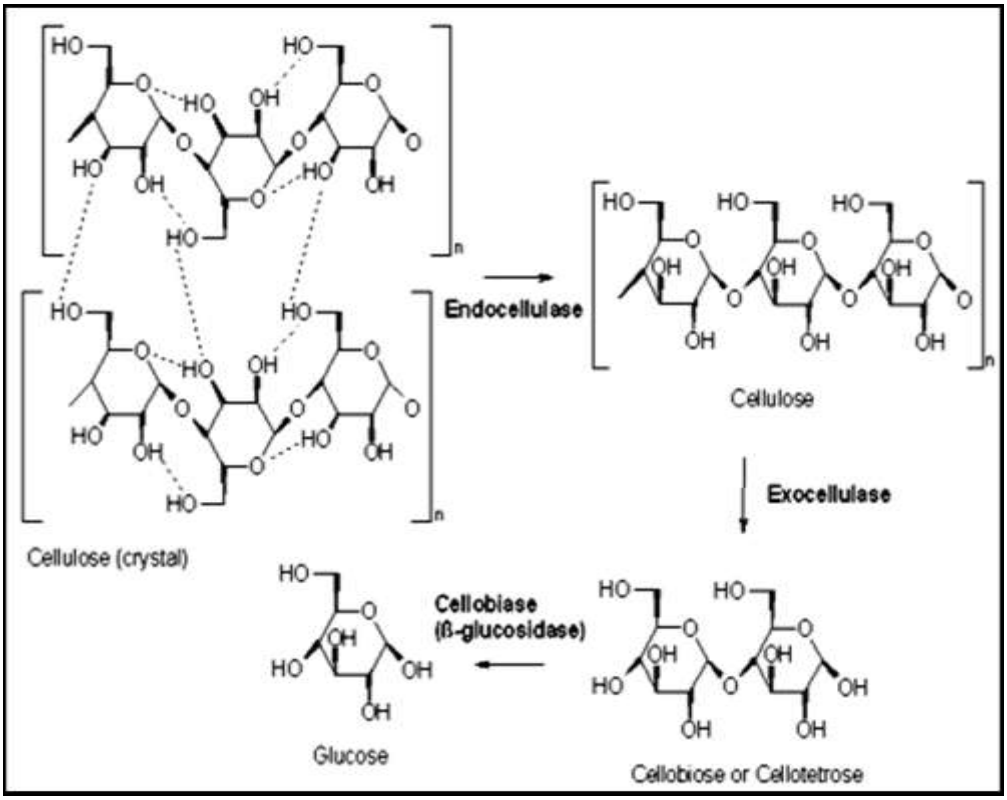

Figure (2.1): The three types of reaction catalyzed by cellulases (Zhang and Lynd, 2004).

Endoglucanases hydrolyze accessible intramolecular β-1, 4- glucosidic bonds of cellulose chains randomly to produce new chain ends; exoglucanases processively cleave cellulose chains at the ends to release soluble cellobiose or glucose; and β-glucosidases hydrolyze cellobiose to glucose in order to eliminate cellobiose inhibition. These three hydrolysis processes occur simultaneously as shown in Fig. (2.1) and Fig (2.2).

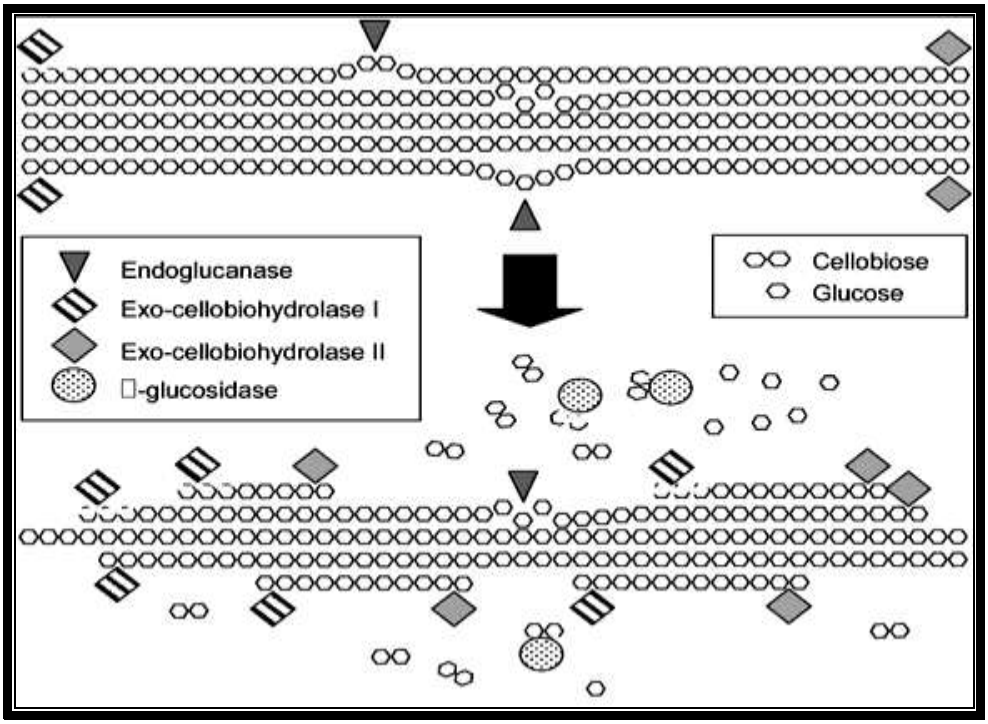

Figure (2.2): A simplified schematic representation of the process involved in complete enzymatic hydrolysis of a cellulose microfibril. (Malherb and Cloete, 2003)

Many researchs being achieved in cellulases production and their characterization during recent years (**Rajoka and Malik, 1997; Murad and Azzaz, 2010; Khan and Husaini, 2006; Milala *et al*., 2009; Ong *et al*., 2010 and Roslan *et al*., 2011**).

The level of cellulase activity and its application depends on the microbial producing strain, the media composition and process control (**Ghose, 1987; Kheng *et al*., 2006**).

Fungi are the main cellulase producing microorganisms. A few bacteria and actinomycetes have also been reported to produce cellulases (**Milala *et al*., 2009**).

Arunachalam *et al*., 2010 reported that the biotechnology application of cellulases began in the early 1980's in the animal feed, followed by food applications and account for approximately 20% of the world enzyme market.

There are huge amounts of agricultural wastes can be used for cellulases production including rice straw, wheat straw and banana wastes (**Roslan *et al*.,**

2009; Murad and Azzaz, 2010). Shahriarinour *et al.* (2011) mentioned the great interest in utilizing cellulose wastes as feedstock through fermentation processes thereby converting low cost starting materials into products of great value.

There are few studies on cellulase production from raw biomass such as rice straw (**Roslan *et al*., 2011**).

2.2 Using fibrolytic enzymes in ruminants feeding.

Slow or incomplete digestion of fibrous substrates often limits the overall digestive process in the rumen and can significantly influence animal performance in livestock production systems that use forages as major component of the diet. As a result, many strategies have been developed to stimulate the digestion of the fibrous components in ruminant feeds. These have included the use of specific nutrients which stimulate fiber digestion and processing feeds to increase the rate and extent of fiber digestion.

Recent advances in fermentation technology and biotechnology have allowed for the economic production of large quantities of biologically active enzymes that can also be used as livestock feed supplements. These technologies provide new possibilities for altering digestive processes in a wide variety of animals. Fibrolytic enzymes preparations can be used to drive specific metabolic and digestive processes in the gastrointestinal tract and may augment natural digestive processes to increase nutrient availability and feed intake (**McAllister *et al*., 2001).**

In the last decade, fiberolytic enzymes preparations have become valuable tools for economically improving digestive processes in the ruminant (**Yang *et al*., 2000; Bowman *et al*., 2002 ; Titi and Tabbaa, 2004; Abdel-Gawad *et al*. 2007; Gado *et al*., 2007; Knowlton *et al*., 2007; Murad *et al*., 2009; Azzaz, 2009)**.

To date, little is known about the way that exogenous fiberolytic enzyme improve feed by rumen microorganisms.

2.3 Effect of fibrolytic enzymes addition or activities in diet on:

2.3.1 *In-vitro* digestibility

Mohamed *et al.* (2005) studied the effect of an enzymatic mixture containing cellulase, xylanase and protease activities on the fermentation of substrate composed of 65% forage (berseem hay and rice straw) and 35% concentrates by using batch culture of mixed ruminal microorganisms. They found that after 24 hr of incubation, all enzymatic treatments decreased final pH and increased dry matter (DM), neutral detergent fiber (NDF) and acid detergent fiber (ADF) digestibility of substrate. Also, acetate and propionate production were increased by all enzymatic treatments.

Colombatto *et al.* (2006) examined (*in vitro*) the impact of fiberolytic enzymes on the rate and extent of fermentation of alfalfa stems. A commercial enzyme product was added to alfalfa stems at six levels: 0, 0.51, 1.02, 2.55, 5.1 and 25.5 g/kg DM. They found that addition of these enzymes linearly increased *in vitro* OM, DM, NDF, ADF, and hemicellulose degradation.

Eun *et al.* (2006) evaluated the use of exogenous enzymes to improve the cell wall degradation of rice straw. Two developmental cellulases, two developmental xylanases, and two commercial enzyme products (combination of endoglucanases and xylanases) were used. The results indicated that adding enzymes increased nutrients degradability of rice straw.

Abdel-Gawad et al. (2007) evaluated the effects of commercial fibrolytic enzymes (Fibrozyme) composed of xylanase and cellulase activities on IVDMD and IVOMD of corn stalks, wheat straw, rice straw and sugarcane bagasse. These low quality roughages were used at three levels roughage: concentrate ratios (100:0, 40:60 and 30:70%). Enzyme was supplemented at 4 levels (0, 2, 2.5 and 3 gm/kg DM). Results indicated that using 2gm/kg DM of Fibrozyme supplementation increased *in vitro* dry matter and organic matter disappearance of rations. Corn stalks followed by wheat straw showed better response for digestion pattern than rice straw and sugarcane bagasse.

Ranilla *et al.* (2007) reported that fibrolytic enzymes (xylanase and cellulose) could stimulate *in vitro* rumen fermentation of alfalfa hay, grass hay and barley straw. The enzymes were added at three levels 0, 50 mg and 100 mg/g substrate DM. Results indicated that this fibrolytic enzymes stimulated *in vitro* fermentation of substrates at short (5 and 10 h), but not at long (24 h) incubation times.

2.3.2 *In-vivo* digestibility.

Beauchemin *et al.* (1999) investigated the effects of grain source and fibrolytic enzyme supplementation on nutrients digestion. Two grains were combined with and without enzyme which contained primarily cellulase and xylanase. They observed that enzyme supplementation increased nutrients digestibility in the total tract.

Yang *et al.* (2000) investigated the effects of adding fibrolytic enzymes to the diets of dairy cows on digestibility. The treatments were control, enzymes applied to the total mixed ration and enzymes added to the barley-based concentrate. They found that total tract digestibility of dry matter was higher for enzyme supplemented ration than that for the control one.

Pinos-Rodríguez *et al.* (2002) studied the effect of a directly fed exogenous fibrolytic enzyme on intake and digestion by sheep. The diets were alfalfa hay, alfalfa hay plus exogenous fibrolytic enzymes, ryegrass hay and ryegrass hay plus enzymes. The enzymes increased apparent digestibility of CP, hemicellulose and NDF for alfalfa diet compared with the other diets.

Knowlton *et al.* (2002) found that digestibility of DM was similar for control and fibrolytic enzyme-supplemented diets in early lactation cows, but in late lactation cows, DM digestibility was numerically greater with the enzyme addition compared to control. Apparent NDF digestibility did not affect by enzyme treatment. Apparent protein digestibility, milk protein, and protein retained in body tissue were not significantly affected by enzyme treatment or by the interaction of stage of lactation and treatment.

Titi and Tabbaa (2004) investigated the efficacy of direct feeding of a cellulase enzyme on lamb diets digestibility. Results indicated that cellulase

enzyme increased ($P < 0.05$) dry matter and organic matter digestibilities of treated lambs compared to those of control. A similar trend was observed for the crude fiber, NDF and ADF digestibility coefficients. However, no differences were observed in crude protein digestibility between treated and control lambs.

Abdel-Gawad et al. (2007) evaluated the effects of fiberolytic enzymes composed of xylanase and cellulase on the *in vivo* nutrient digestibilities for corn stalks, wheat straw, rice straw and sugarcane bagasse. They found that fiberolytic enzymes supplementation increased ($P<0.05$) digestibilities of DM, OM, CP, NFE, CF and hemicellulose of wheat straw compared with control (berseem hay), while ADL was significantly ($P<0.05$) higher for wheat straw than the control and corn stalks.

Gado *et al.* (2007) studied the effect of biological treatments (cellulase; rumen liquor and *Cellumonas cellulasea*) of bagasse to improve the performance of Baladi Assaf lambs. They indicated that treated bagasse with different treatments had a significant positive effect on DM and CP digestibilities. However, cellulase enzyme increased ($P<0.05$) the percent of DM digestibility coefficient when compared with the other treatments. Digestibility of OM, EE, NFE positively affected by cellulase treatment

Knowlton *et al.* (2007) studied the effect of an exogenous phytase and cellulase-containing enzyme formulation on nutrient digestibility and excretion in Holstein cows. They found that cows fed the enzyme formulation had lower fecal dry matter, neutral detergent fiber, and acid detergent fiber excretion and lower fecal excretion of nitrogen and Phosphorus. Apparent digestibility of DM, ADF, NDF, and N tended to increase with the enzyme formulation.

Muwalla *et al.* (2007) studied the effect of fibrolytic enzyme inclusion on nutrient digestibility of Awassi lamb fed on a high concentrate diet. They mentioned that DM, OM, CP, and NDF digestibilities were unaffected by the enzyme inclusion.

2.3.3 Rumen parameters.

The effect of fungal enzyme preparation on ruminal fermentation was studied on Lambs. Ruminal pH, NH_3, TVFA concentrations and proportion of individual acids were not influenced by the addition of enzyme **(Judkins and Stobart, 1988).**

Feng *et al.* (1996) evaluated *In vivo* responses of enzyme addition to fresh forage, wilted forage and dry forage immediately before feeding compared to untreated forage. The authors mentioned that ruminal NH_3-N concentration, total VFA concentration, and pH were not altered by dietary treatments.

Lewis *et al.* (1996) compared the effect of a solution containing cellulases and xylanases on the digestion of a forage-based diet using beef steers. This study indicated that ruminal pH was lower and total VFA concentration at 6 h after-feeding was greater for steers fed enzyme treatments compared with the control.

Broderick *et al.* (1997) reported that ruminal pH and NH_3-N concentration for Holstein cows were not influenced by the solutions of xylanase and cellulase enzymes supplemented to cow's diets.

Krause *et al.* (1998) determined the effects of treating barley grain with a fibrolytic enzyme mixture (contained mainly cellulase and xylanase activities, with relatively low levels of amylase activity) on ruminal fermentation in cattle. They found no effect of enzyme on ruminal pH.

Beauchemin *et al.* (1999) studied the effect of cellulase and xylanase enzymes on rumen parameters of cows fed barley based diet. They found that ruminal pH and TVFA's concentrations were unaffected by cellulase and xylanase treatments, while ruminal NH_3-N concentration was significantly reduced for cows fed barley treated or not treated by enzymes.

Yang *et al.* (1999) found that ruminal fermentation characteristics were not affected by enzyme treatments. Ruminal VFA concentration was numerically higher for cows fed diets containing enzymes (cellulase and xylanase) than for cows fed the control diet.

Abdel-Gawad et al. (2007) evaluated the effects of fibrolytic enzymes composed of xylanase and cellulase on rumen fermentation for corn stalks, wheat straw, rice straw and sugarcane bagasse. They found that no significant differences ($P>0.05$) were detected among the experimental rations in ruminal pH, but significant ($P<0.05$) values of ruminal NH_3-N concentration was recorded for lambs fed treated corn stalks and wheat straw compared with control. Total VFA's concentration of rumen liquor increased ($P<0.05$) for lambs fed treated corn stalks compared with other treatments.

Gado *et al.* (2007) studied the effect of biological treatments (cellulase; rumen liquor and *Cellumonas cellulasea*) of bagasse to improve the performance of Baladi Assaf lambs. They indicated that rumen liquor pH values did not differ significantly among treatments. Total VFA's values for treated bagasse by cellulase enzyme, rumen liquor and *Cellumonas cellulasea* were higher than that for untreated bagasse.

2.3.4 Blood parameters

Gado *et al.* (2007) reported that biological treatment (cellulase; rumen liquor and *cellumonas cellulasea*) of bagasse increased plasma total protein and urea concentrations.

Kholif (2006) found that animals fed on fibrolytic enzymes or fungi treated silage had higher values of serum total protein ($P<0.05$), albumin ($P>0.05$), and glucose. Serum globulin, urea, total lipids, GOT and GPT concentrations were not affected by treatments.

2.4 Factors affecting fiberolytic enzyme activity.

2.4.1 Enzyme product composition

Cellulase and xylanase are generic terms for groups of specific enzyme activities, such that two products with identical labels for enzyme level may differ in the effects on ruminal fiber digestion. Several researches on animal responses to enzyme supplements are published without reference to enzyme activity, or with enzyme activities measured at temperatures and pH that differ from that in the rumen, such that the potential activity of such products is

overestimated. Ruminal conditions can cause a loss of fibrolytic enzyme activity, such that no responses in feed intake and milk production will be seen following enzyme application (**Vicini *et al*., 2003**).

2.4.2 Mode and time of enzyme delivery

Previous calls for more research on pre-feeding storage times of enzyme- treated dietary components (**Wallace *et al*., 2001**) led to *in vitro* and *in vivo* studies in which enzymes were added immediately or 24 h prior to feeding. However since such studies showed no differences due to time of enzyme treatment it has been suggested that there is little or no requirement for a reaction phase for enzymes added to diets **(Beauchemin *et al*., 2003).**

However, more research is required in this area since many studies now involve enzyme addition to concentrates at milling and entail enzyme-diet interaction periods of up to one month. Depending on storage conditions, enzyme activity may be reduced by such protracted periods. Intraruminal dosing of exogenous enzymes did not affect apparent digestibility of DM, crude protein (CP) or neutral detergent fiber (NDF) but reduced rumen pH and the activity of key endogenous fibrolytic enzymes and also increased the soluble DM fraction and effective DM degradability (**Hristov *et al*., 2000**).

Earlier work by these authors **Hristov *et al*., (1998)** showed that abomasal infusion or dietary supplementation with exogenous enzymes did not increase DM intake, *in situ* degradation or total tract digestion in cattle. No differences were also found between dietary concentrate or TMR supplementation or rumen infusion with enzymes on DM intake digestibility or milk yield in dairy cows (**Sutton *et al*., 2003**).

These studies suggest that post-ingestive supply of fibrolytic enzymes is no more effective than dietary supplementation for increasing feed intake, digestion and milk yield in cattle. It is not clear why dietary treatment was not effective in the studies above, since this mode of delivery is the key to harnessing the potential of exogenous enzymes in ruminant nutrition (**Wallace *et al*., 2001**).

2.4.3 Ruminal activity and stability of direct-fed enzymes

Enzyme activity is dictated by several factors including presence of inhibitors and co-factors, prevailing pH, moisture, temperature and concentration of enzyme and substrate. A common error is the determination of enzyme activity under conditions that optimize enzyme action but differ considerably from the ruminal environment, such that measured enzyme activity is overestimated. Clearly, if the enzyme is expected to exert most of it's' effect in the rumen, the enzyme activity should be measured under conditions that mimic the ruminal environment. Adoption of recently proposed methods for standardizing fibrolytic enzyme activity measurement (**Colombatto and Beauchemin, 2003**) should help in this regard.

Dawson and Tricarico (1999) suggested that the most active period for enzyme effects is in the first 6 – 12 h of the digestive process. They also speculated that such action occurs prior to bacterial colonization of feed substrates or action of endogenous enzymes. In support, **Newbold (1997)** noted that enzymes must function within a few hours of feeding before being degraded by the proteolytic activity of rumen microbes. The likelihood of ruminal proteolysis limited the use of enzymes in ruminant feeds for decades. However, **Morgavi *et al*. (2001)** found that four commercial enzymes were stable when incubated in rumen fluid, pepsin or pancreatin, and adduced this to carriers and stabilizers, manufacturing processes and enzyme-substrate interactions. Host proteases and the acid pH of the abomasum are more likely to degrade exogenous enzymes than ruminal proteases (**Hristov *et al*., 1998 and Morgavi *et al*., 2001**).

Sustained enzyme stability in the rumen can result from natural or artificially induced enzyme glycolysation, which involves covalent bonding of monosacharides to specific amino acid side chains in enzymes (**van de Vyver *et al*., 2004**). Glycolysation has been shown to confer resistance to proteolysis in monogastrics and ruminal fluid (**van de Vyver *et al*., 2004**), but non glycosylated enzymes may also resist ruminal proteolysis due to adaptation over time and their genetic composition (**Fontes *et al*., 1995**).

However, several different enzyme preparations are commercially available, and lack of response to enzyme treatment in some of the studies may be attributed to ruminal enzyme instability. For instance (**Vicini *et al*., 2003**) attributed the lack of response to enzyme treatment in their study to higher ruminal pH and lower ruminal temperature than the optima for the fibrolytic activities in their enzyme preparation. Therefore, there are notable variations in the stability of commercially available enzyme preparations and their rumen stability should be verified before they are used in practice.

2.4.4 Enzyme- feed specificity and the portion of the diet to which enzymes are applied

The following studies reveal the importance of matching enzymes to specific substrates: **Beauchemin *et al*. (1997)** reported greater responses when enzymes were applied to dry forages instead of wet forages. **Feng *et al*. (1996)** showed that direct-fed enzymes were more effective when applied to dried grass at feeding than to freshly cut, dried grass at harvest or wilted dried grass after harvest. When the same enzyme was applied to hay and corn silage, it increased the NDF digestion of corn silage but not hay (**Siciliano-Jones, 1999**).

Application of the same enzyme to alfalfa and ryegrass increased the digestibility of alfalfa but not ryegrass (**Pinos-Rodriguez *et al*., 2002**).

Further evidence for enzyme feed specificity is apparent from studies in which enzymes were added a specific dietary component.

Bowman *et al*. (2002). found that enzyme application to the concentrate (45% of total mixed ration, TMR) instead of a pelleted supplement (4 % of TMR) or a premix (0.4% of TMR) did not affect intake, salivation or rumen function but numerically increased fat-corrected milk yield compared to control cows. They concluded that the proportion of the diet to which the enzyme is applied must be maximized to ensure a beneficial response.

In contrast, (**Yang *et al*., 2000**) showed that applying enzymes to the concentrate was more effective than applying them to the TMR in terms of the response in milk yield and digestibility of DM, organic matter (OM) and CP.

However other studies found no differences in milk yield and intake when enzymes were applied to TMR or forage (**Vicini *et al*., 2003**) or to TMR or concentrate (**Phipps *et al*. 2000 and Sutton *et al*., 2003**) or to alfalfa cubes and the concentrate (**Yang *et al*., 1999**). Since concentrates are ruminally readily fermented and contain low fiber concentrations, the beneficial effects of enzyme addition to this dietary fraction may be due to synergistic effects on microbial populations and endogenous enzyme secretion, than to direct cell wall hydrolysis. Another study in which enzyme application to concentrate proved to be more effective (**Yang *et al*., 2000)** had a lower forage to concentrate ratio (38:62) than those (57:43, 55:45, and 60:40) (**Yang *et al*., 1999; Phipps *et al*., 2000; Sutton *et al*., 2003 and Vicini *et al*., 2003**). Therefore, the effect of the dietary component to which the enzyme is added may depend on the forage to concentrate ratio and the uniformity of enzyme application to that component.

2.4.5 Level of enzyme application

Several studies have shown that applications of high levels of enzymes to forages or diets produce less desirable responses than low levels.

For instance **Lewis *et al*. (1999)** noted that a medium level of enzyme supplementation produced more milk than a low or high level of application.

Beauchemin *et al*. (2000) found that a high level of enzyme application (3.67 L of enzyme product/tons of total mixed ration DM basis) was less effective than a low level (1.22 L of enzyme product/tons of total mixed ration DM basis) at increasing total tract digestibility. The enzyme product contained mainly beta-glucanase, xylanase, and endocellulase activities. The reason for the poor response to the low enzyme level is obvious, but that for the higher level is less apparent. It may be partly attributed to negative feedback inhibition which is one of the classical modes of regulation of enzyme action.

This feedback mechanism occurs when enzyme action is inhibited by production of a critical concentration of a product of the enzyme-substrate interaction. For instance fermentation of sugars produced by cell wall hydrolysis may reduce ruminal pH to levels that inhibit cell wall digestion. An

alternative hypothesis is that excessive enzyme application blocks binding sites for enzymes or may prevent substrate colonization.

(**Beauchemin *et al*. 2000 and Beauchemin *et al*., 2003**). The fact that enzymes can be overfed or underfed makes their application complex (**Dawson and Tricarico, 1999**) and underscores the need for determining the optimal level of application for each enzyme preparation.

in vitro evaluation of the activities of two fibrolytic enzymes revealed that when added at the rates recommended by their manufacturers, the enzymes would not increase significantly glycanase and polysaccharidase activities in rumen fluid unless much higher application rates are used (**Wallace *et al*., 2001**). This highlights the need for further *in vivo* studies to verify the application rates and activities of some commercially available enzymes.

3 Methodology

3.1 Study Design

The present experiment was conducted in a private sheep farm in Khan Younes, South governorate, Gaza sector, Palestine, during the period of 1st March 2013 to the end of October 2013. This work aimed to study the effect of adding cellulytic and pectolytic enzymes to diets of Assaf lambs on its productive performance.

3.2 Sample Size

Twelve male Assaf lambs (5/8 awassi x 3/8 east Frisian) aging about 4 months with average weight of 26.61 kg were used in this experiment. Lambs were randomly divided into three experimental groups (4 lambs of each). Average initial live body weights of animals were 24.34 ± 1.25 kg, 23.94 ± 1.23 kg, and 23.60 ± 1.23 kg for control, T1 and T2 groups, respectively.

The dietary treatments were control; (T1) control + 2.0 g fibrolytic enzyme/h/day; and (T2) control + 4.0 g fibrolytic enzyme /h/day. The control diet consisted of 15% alfalfa hay and 85% concentrate feed mixture, on DM basis. Fibrolytic enzyme which imported from Japan (Tomoko® is a commercial enzymes source of Biogenkoji Research Institute – Japan was used. The enzyme product was made from Aspergillus Awamori (3 × 106 cells/g) including 1000 unit/g of acidic protease, 30 unit/g of pectinase, 25 unit/g of xylanase, 20 unit/g of α-amylase, 10 unit/g of phytase, 5 unit/g of glucoamylase and 4 unit/g of cellulase as provided from the manufacture) was obtained from Egypt.

Fibrolytic enzyme was added to a portion of wheat bran then mixed thoroughly with the other concentrate ingredients.

The growth trial lasted for 28 weeks. Lambs were fed at levels of 3.5 % DM of body weight. Chemical compositions of the ingredients are

shown in Table (3.1). Animals were fed individually twice a day at 8:00 a.m. and 4:00 p.m.

Fresh water was available all the time round. Feed intake and body weight changes of the lambs were recorded every two weeks during the experimental period.

Table (3.1): Chemical composition of feed ingredients and control diet.

Item	DM**	DM basis %					
		OM	CF	CP	EE	NFE	Ash
CFM	90.3	93.5	11.1	16.0	4.3	62.1	6.5
Alfalfa hay	88.3	89.6	30.0	12.6	2.7	44.3	10.4
Control diet*	90.0	92.9	13.9	15.5	4.1	59.3	7.1

CFM: Concentrate feed mixture consisted of 49% maize, 24% wheat bran, 12% barly, 12% soyabean meal, 2% limestone and 1% sodium chloride. *Calculated.

** (DM) dry matter, (OM) organic matter, (CF) crude fiber, (CP) crude protein, (EE) ether extract, (NFE) nitrogen free extract.

3.3 Slaughter technique

Animals were fasted for 12 hours before slaughter, which was performed according to the Islamic rules. Animals were weighed just before slaughter (SW) and after complete bleeding. Head, skin and feet were separated and weighed. Internal organs and offals (heart, lungs, liver, testes, spleen, kidneys and digestive tract) were removed and individually weighed. Gastro-intestinal tract full and empty weights were recorded. Fat tail of sheep was removed, weighed along with omentum, intestinal and kidney fats. Weights of carcass knife separable fat, internal and external offals and body fats were calculated as percentage of body weight at slaughtering (SW).

3.4 Rumen liquor sampling

At the last day of each experimental period, rumen liquor samples were collected by stomach tube from each animal at zero, 3 and 6 hrs post- feeding of the ration. Samples were strained through two layers of cheese cloth and immediately used for determination of ruminal pH using digital pH-meter. Rumen liquor samples were stored in glass bottles with drops of toluene and thin layer of paraffin oil and stored in a deep freeze (-18^{o}C) for analysis of ammonia nitrogen (NH_3-N), and total volatile fatty acids (TVFA's).

3.5 Blood Sampling

Blood samples were taken at the final day of treatment directly before slaughtering from jugular vein from all animals. Collected blood samples were centrifuged at 4000 r.p.m. for 20 min. and the supernatant was stored in glass vials at -18^{o}C till analysis.

3.6 Methods of analysis

3.6.1 Feedstuffs

Dry matter (DM), crude protein (CP), ether extracts (EE), crude fiber (CF) and ash of feed ingredient and feces samples were analyzed according to **A.O.A.C. (1995).** Nitrogen free extract (NFE) was calculated by the difference.

3.6.2 Ruminal pH

Values of rumen pH were determined using Hanna digital pH meter.

3.6.3 Ruminal ammonia-nitrogen (NH_3-N)

The concentration of ammonia-nitrogen in the rumen liquor was determined by Kjeldahl distillation method **(A.O.A.C., 1995).**

3.6.4 Ruminal total volatile fatty acids

Rumen total volatile fatty acids were determined by steam distillation method as described by **Warner (1964).**

3.6.5 Blood serum constituents

3.6.5.1 Total protein

Serum total protein was measured calorimetrically by the biuret reaction according to **Gornal *et al.* (1949).**

3.6.5.2 Albumin

Serum albumin was determined by calorimetric method as described by **Doumas *et al*. (1971).**

3.6.5.3 Globulin

Serum globulin was calculated by subtracting the values of albumin from corresponding value of total protein for each sample.

3.6.5.4 Albumin: Globulin ratio (A/G ratio)

The A/G ratio was calculated by dividing the albumin value of each sample by its corresponding globulin value.

3.6.5.5 Glucose

Serum glucose was determined calorimetrically according to **Trinder (1969).**

3.6.5.6 Transaminases

Serum alanine transferase (ALT) and aspartate transfrase (AST) were determined calorimetrically according to the method of **Reitman and Frankel (1957).**

3.6.5.7 Urea

Serum urea was determined calorimetrically according to **Fawcett and Scott (1960).**

3.6.5.8 Cholesterol

Serum total cholesterol was determined calorimetrically according to **Allain *et al*. (1974).**

3.7 Economical evaluation

The relation between feed costs and live body gain was calculated for the different experimental animal groups.

The general equation by which the costs of each one kg of live body weight gain was calculated as follow:

The cost for one kg gain = Total costs of feed intake US$ / Total gain (kg).

Economical Efficiency = [Total gain price] / Total gain cost.

3.8 Statistical analysis

Data were statistically analyzed according to **SAS (2000).** The differences among groups were estimated using the general linear model (GLM) procedures.

One way ANOVA procedure used to analyze the data of the main effects on growth, carcass traits, meat quality and blood serum constituents according the following model:

$$Y_{ij} = \mu + Z_i + E_{ij}$$

where μ = general mean Z_i = effect of treatment

E_{ij}= experimental error.

Significance was tested at ($P<0.05$) for all means separation according to **Duncan (1955).**

4 RESULTS AND DISCUSSION

4.1 Growth performance

4.1.1 Live body weight, feed intake and daily gain:

The effect of dietary fibrolytic enzyme levels on live body weight (LBW) could be detected by comparing the results of control diet (zero fibrolytic enzyme added) with those of low fibrolytic enzyme (T1, 2.0 g/h/d) or high fibrolytic enzyme (T2, 4.0 g/h/d).

Results in Tables (4.1, 4.2 and 4.3) showed that there was no significant effect between lambs concerning feed intake. However, the high level of fibrolytic enzyme supplementation insignificantly (P>0.05) reduced feed intake. Also, Table (4.1) showed that there were no significant effect between lambs concerning initial LBW and final LBW, however, treatments with fibrolytic enzymes showed insignificantly increases (P>0.05) in total LBW gain. Daily LBW gain insignificantly increased (P>0.05) only with high level (T1) of fibrolytic enzymes supplementation (Fig. 4.1).

Chen et al., (1989) noted that fibrolytic enzymes insufficiency may cause pyruvate accumulation and increase circulating lactate during work, which may promote fatigue.

Table (4.1) : Effect of fibrolytic enzymes level on live body weight (LBW) gain of Assaf lambs.

Parameter	Treatments					
	Control		T1		T2	
	Mean	SD	Mean	SD	Mean	SD
Initial LBW (kg)	24.34[a]	1.33	23.94[a]	0.76	23.60[a]	1.26
Final LBW (kg)	70.00[a]	2.97	70.25[a]	3.25	72.70[a]	5.19
Total LBW gain (kg)	45.66[a]	3.12	46.31[a]	2.02	49.10[a]	1.88
Daily LBW gain (g)	233[a]	21.4	236[a]	17.0	251[a]	19.8

- Dissimilar superscripts at the same row mean significant differences (P<0.05).
- T1= 2 g fibolytic enzyme/h/day, T2=4 g fibolytic enzyme /h/day
- Data was calculated on 196 treatment-days basis.

impair training, and thus reduce performance. So, it could be explain that adding 4 g/h/d to Assaf lambs' diets is more useful than adding 2 g/h/d concerning daily LBW gain.

The results of **Abdel-Gawad et al. (2007)** on rams and **Azzaz (2009)** on goats agreed with these results.

Table (4.2) : Live body weight every 2 weeks for Assaf lambs

Week	Control	T1	T2
Initial LBW (kg)	24.34	23.94	23.60
2nd	26.78	26.68	26.38
4th	28.23	28.23	28.30
6th	30.00	31.73	30.93
8th	33.90	34.40	34.25
10th	35.90	37.05	38.47
12th	39.00	40.40	41.17
14th	42.35	43.90	44.50
16th	46.65	47.78	48.30
18th	51.73	51.75	52.13
20th	55.83	56.25	57.23
22th	59.55	60.25	62.17
24th	63.65	63.39	65.38
26th	67.98	67.63	68.97
28th	70.00	70.25	72.70

T1= 2 g fibrolytic enzyme/h/day, T2=4 g fibolytic enzyme/h/day,

Table (4.3) : Calculated feed intake (DM basis) every 2 weeks for Assaf lambs (for196 day).

Week	Control	T1	T2
2nd	0.94	0.93	0.92
4th	0.99	0.99	0.99
6th	1.05	1.08	1.08
8th	1.19	1.20	1.20
10th	1.26	1.30	1.35
12th	1.37	1.41	1.44
14th	1.48	1.54	1.56
16th	1.63	1.67	1.69
18th	1.81	1.81	1.82
20th	1.95	1.97	2.00
22th	2.08	2.11	2.18
24th	2.23	2.22	2.29
26th	2.38	2.37	2.41
28th	2.45	2.46	2.54
Total intake kg	342.45	345.90	352.05
Ave. Daily intake	1.747	1.765	1.796

T1= 2 g fibrolytic enzyme/h/day, T2=4 g fibolytic enzyme/h/day,

4.2 Carcass traits

Data concerning the carcass traits of the growing Assaf lambs fed the experimental rations containing different levels of fibrolytic enzymes are presented in Tables (4.4, 4.7).

4.2.1 Dressing percentage:

Fasting weight, empty body weight, dressing (A) and (B) percent (based on fasting weight and empty body weight, respectively) are illustrated in Table (4.4). Lambs fed rations with fibrolytic enzymes supplementation (T1 and T2) had higher fasting and empty body weight than those fed control ration, but the differences were not significant (P>0.05). These results indicated that fibrolytic enzymes supplementation to rations increased fasting weight by about 0.35 and 3.85%, and increased empty body weight by 0.04 and 3.73% for T1 and T2, respectively. Dressing percentages A or B were not significantly affected (P>0.05) by the dietary treatment

Researches on goats (**Atti, et al. 2004**) and lambs (**Rocha, et al. 2004**; and **Woolley et al. 2005)** using different levels of crude protein in diets showed the same trend.

Also, the results of **Malcolm-Callis, et al (2000)** and **Spears and Kegley (2002)** on steers; and **McBeth, et al. (2002)** and **Shaeffer (2006)** on cattle, using 20-30 mg Zn / kg DM in rations did not affect carcass weight or dressing percentage.

Also, results of **El-Shanti et al. (2012)** on Assaf lambs confirm these results.

Table (4.4) : Effect of dietary fibrolytic enzymes levels on fasting weight, empty body weight and dressing percentages of Assaf lambs.

Parameter	Treatments					
	Control		T1		T2	
	Mean	SD	Mean	SD	Mean	SD
Fasting weight (kg)	70.00	5.64	70.25	3.96	72.70	3.24
Digestive tract wt. (kg)	14.55	0.95	14.76	0.82	15.18	0.65
Empty body weight* (kg)	55.45	-	55.47	-	57.52	-
Hot carcass weight (kg)	35.44	3.08	35.68	1.88	36.10	1.87
Dressing A (%)**	50.63	-	50.08	-	49.66	-
Dressing B (%)***	63.91	-	64.68	-	62.76	-

-Dissimilar superscripts at the same row mean significant differences (P<0.05).
T1= 2 g fibrolytic enzymes/h/day, T2=4 g fibrolytic enzymes/h/day

***** Empty body weight = Fasting weight – Digestive tract weight
**Dressing % =Hot carcass weight relative to body weight
*** Dressing % =Hot carcass weight relative to empty body weight

4.2.2 Carcass cuts:

Shoulder, legs, loin, neck, rack, brisket and flank weights and percentages of carcass weight are presented in Table (4.5). Results in Table (4.5) showed that supplementing .

Table (4.5) : Effect of dietary fibrolytic enzymes levels on carcass cuts of Assaf lambs.

Parameter	Treatments					
	Control		T1		T2	
	Mean	SD	Mean	SD	Mean	SD
Hot carcass weight (kg)	35.44	3.08	35.68	1.88	36.10	1.87
Carcass cuts weight (kg)						
Shoulder	7.75[b]	.0.39	8.15[a]	0.36	7.95[ab]	0.44
Legs	1.22[a]	0.13	1.34[a]	0.06	1.38[a]	0.08
Loin	8.00[b]	0.55	8.74[ab]	.052	8.89[a]	0.68
Neck	2.66[b]	0.33	3.30[a]	0.26	3.11[a]	0.49
Rack	8.35[a]	0.52	8.15[a]	0.87	8.22[a]	0.97
Brisket	6.24[b]	0.42	6.33[b]	0.39	6.80[a]	0.88
Flank	2.05[a]	0.11	2.16[a]	0.23	2.31[a]	0.29
Carcass cuts percentage (%)*						
Shoulder	21.38	--	21.36		20.56	--
Legs	3.36	--	3.52		3.57	--
Loin	22.06	--	22.90		22.99	--
Neck	7.33	--	8.64		8.04	--
Rack	23.03	--	21.36		21.27	--
Brisket	17.20	--	16.55		17.59	--
Flank	5.64	--	5.66		5.98	--

*Relative to hot carcass weight.

- Dissimilar superscripts at the same row mean significant differences (P<0.05).

T1= 2 g fibrolytic enzymes/h/day, T2=4 g fibrolytic enzymes/h/day

rations with low (T1) or high level of fibrolytic enzymes (T2) significantly increased (P<0.05) weights of shoulder, loin and neck than control in the diet, but did not significantly (P>0.05) affect weights of legs, rack, brisket and flank. Concerning percentages (relative to hot carcass weight) of shoulder, legs, loin, neck, rack, brisket and flank (Table 4.5), it could be noted that low and high level of fibrolytic enzymes decreased the percent of shoulder and rack than control, but increased the percent of loin, flank and neck than control. The results of **El-Shanti et al. (2012)** on Assaf lambs waew simiar to these results.

4.2.3 Edible offals:

Liver, kidney, testes, spleen, heart, lungs and trachea weights and percentages of carcass weight are presented in Table (4.6). The results showed that low level of fibrolytic enzymes supplementation (T1) significantly ($P<0.05$) increased the weights of liver, kidney, tests and heart than control. However, high level of fibrolytic enzymes significantly ($P<0.05$) decreased kidney testes and heart weight than control.

Total edible offals weight was superior with T1 followed by control, then T2. The same trend was noted with edible offals percentage (relative to empty body weight)**,** except with testes, which showed higher percent with low level of fibrolytic enzymes supplementation followed by control then high level of fibrolytic enzymes supplementation.

It is of interest to note that the total edible offals percentage was highest with low level of fibrolytic enzymes supplementation (T1), followed by control, then high level of fibrolytic enzymes (T2). The reasons of this trend are not clear.

Table (4.6) : Effect of dietary fibrolytic enzymes levels on the edible offals weight and percentage of Assaf lambs.

Parameter	Treatments					
	Control		T1		T2	
	Mean	SD	Mean	SD	Mean	SD
Empty body weight* (kg)	55.45	--	55.47	--	57.52	--
Edible offals weights (kg)						
Liver	1.16^{b}	0.08	1.29^{a}	0.12	1.24^{ab}	0.11
Kidney	0.19^{a}	0.042	0.19^{a}	0.005	0.16^{b}	0.025
Testes	0.86^{b}	0.11	1.15^{a}	0.023	0.71^{c}	0.06
Spleen	0.08^{b}	0.014	0.08^{b}	0.002	0.10^{a}	0.02
Heart	0.40^{ab}	0.026	0.43^{a}	0.05	0.33^{b}	0.08
Lungs and Trachea	0.84^{a}	0.13	0.84^{a}	0.11	0.84^{a}	0.10
Total edible offal weights	3.53	--	3.98	--	3.38	--
Edible offal percentage (%)**						
Liver	2.09	--	2.33	--	2.16	--
Kidney	0.34	--	0.34	--	0.28	--
Testes	1.55	--	2.07	--	1.23	--
Spleen	0.14	--	0.14	--	0.17	--
Heart	0.72	--	0.78	--	0.57	--
Lungs and Trachea	1.51	--	1.51	--	1.46	--
Total edible offal percent	6.37	--	7.18	--	5.88	--

***** Empty body weight = Fasting weight – Digestive tract weight

** Relative to empty body weight..

- Dissimilar superscripts at the same row mean significant differences ($P<0.05$).

T1= 2 g fibrolytic enzymes/h/day, T2=4 g fibrolytic enzymes/h/day

4.2.4 Non-edible parts:

Non-edible parts (weight and percentage) of slaughter weight are showed in Table (4.7). Lambs fed diets with high fibrolytic enzyme (T2) had higher pelt and empty gastro-intestinal part (GIP) than control group with significantly ($P<0.05$) differences. However, there were no significant differences ($P>0.05$) between the different groups concerning head, feets and GIP full. The same trend was noted for non-edible parts as percentage (relative to empty body weights) except pelt and GIP full which were slightly decreased with low level of fibrolytic enzymes supplementation (T1).

These results agreed with those noted by **El-Shanti et al. (2012)** on Assaf lambs confirm these results. These results, also, agreed with those noted by **Atti, et al. (2004**) whish showd no significant differences between groups treated with different ratios of crude protein or zinc concentrations.

The weight of pelt and the other components, which are rich in bone and had a low metabolic activity (head and four feet) were varied slightly with ration. Because these organs are early maturing parts (**Wallace, 1948**) and so they are less affected by dietary in growing animals (**Kamalzadch, et al. 1998**).

Table (4.7) : Effect of dietary fibrolytic enzymes levels on non-edible parts (weight and percentage) of Assaf lambs.

Parameter	Treatments					
	Control		T1		T2	
	Mean	SD	Mean	SD	Mean	SD
Empty body weight* (kg)	55.45	--	55.47	--	57.52	--
Fasting weight (kg)	70.00	5.64	70.25	3.96	72.70	3.24
Non-edible cuts weights (kg)						
Pelt	6.09[b]	0.31	6.01[b]	0.38	6.82[a]	0.67
Head	3.11[a]	0.37	2.98[a]	0.23	3.38[a]	0.085
4 feet (legs)	1.22[a]	0.13	1.34[a]	0.06	1.38[a]	0.08
GIP full	14.55[a]	0.95	14.76[a]	0.82	15.18[a]	0.65
GIP empty	3.23[b]	0.13	3.56[a]	0.14	3.63[a]	0.42
GIP content	11.32	--	11.20	--	11.55	--
Non-edible cuts as percentage (%)**						
Pelt	10.98	--	10.83	--	11.86	--
Head	5.61	--	5.37	--	5.88	--
4 Feet	2.20	--	2.42	--	2.40	--
GIP full	26.24	--	26.61	--	26.39	--
GIP empty	5.83	--	6.42	--	6.31	--
GIP content	20.41	--	20.19	--	20.08	--
Total non-edible cuts%	71.27	--	71.27	--	72.92	--

***** Empty body weight = Fasting weight – Digestive tract weight
**Relative to empty body weight.
- Dissimilar superscripts at the same row mean significant differences ($P<0.05$).
T1= 2 g fibrolytic enzymes/h/day, T2=4 g fibrolytic enzymes/h/day

4.3 Rumen liquor

Rumen liquor parameters are important indicators of rumen environment, microbial activity and subsequently rumen metabolism. The most indicative parameters determined in this study were ruminal pH, ruminal total volatile fatty acids (TVFA's) and rumen ammonia nitrogen (NH_3-N).

4.3.1 Ruminal pH

Ruminal pH showed insignificant ($P>0.05$) values by Assaf lambs fed on control, T1 and T2 diets (Table, 9).

All ruminal pH values were above 6.0 which indicate a better digestion of cellulolytic materials (**Mertens, 1978**). These results may be due to the intensive fermentation process of both nonstructural and structural carbohydrates and the production of volatile fatty acids.

The findings of **Khattab *et al*. (1996) and Azzaz (2009)** observed that fibrolytic enzymes treatment significantly decreased ruminal pH.

Table (4.8) : Ruminal pH of Assaf lambs (Mean±SD).

Experimental diets	Sampling Time			Overall Mean	± SD
	Pre feeding	Post feeding			
	Zero	3 hrs	6 hrs		
Control	7.05	6.58	6.83	6.82[a]	0.06
T_1	7.15	6.55	6.88	6.86[a]	0.09
T_2	7.05	6.50	6.85	6.80[a]	0.08
Overall Mean	7.08[a]	6.54[c]	6.85[b]		
± SD	0.085	0.086	0.087		

[a,b.,c] **Means designated with the same letter within the same row (column) are not significantly different at (P<0.05).**

Mean values of ruminal pH in the different experimental diets through the different sampling times of lactating Assaf lambs are shown in Table (4.8). The average pH values at zero time (before feeding) were 7.05, 7.15 and 7.05 for control diet, T_1 and T_2, respectively. Then, the pH values were gradually decreased to reach minimum values at 3 hrs post feeding, being 6.58, 6.55 and 6.50 for the expected diets orderly. At 6 hrs post feeding, the pH values were increased to reach 6.83, 6.88 and 6.85 in the same respective order. These results indicated that time of sampling had a significant effect ($P<0.05$) on ruminal pH values.

4.3.2 Ruminal total volatile fatty acids

Ruminal total volatile fatty acids (TVFA's) concentration showed higher ($P<0.05$) values by Assaf lambs fed (T_2) and

Table (4.9) : Ruminal total volatile fatty acids concentration (meq/dl) of the experimental Assaf lambs.

Experimental diets	Sampling Time			Overall Mean	± SE
	Pre feeding	Post feeding			
	Zero	3 hrs	6 hrs		
Control	7.24	11.23	9.78	9.42[b]	0.46
T_1	8.45	13.18	10.81	11.02[a]	0.53
T_2	9.05	14.49	11.50	11.68[a]	0.51
Overall Mean	8.25[c]	13.18[a]	10.70[b]		
± SE	0.22	0.52	0.27		

[a,b.,c] Means designated with the same letter within the same row (column) are not significantly different at (P<0.05).

(T_1) diets being 11.68 and 11.02 meq/dl, respectively than those fed control diet (9.42 meq/dl) as shown in Table (4.9). The increase of TVFA's value was 23.99 and 16.98 % for T_2 and T_1, respectively compared with control. The pattern of TVFA's values reflects the pattern of fermentation activity in the rumen (**Shafie and Ashour, 1997**). **Lewis *et al.* (1996) and Azzaz (2009)** observed that fibrolytic enzymes treatment significantly decreased ruminal pH and increased TVFA's concentration in the rumen.

Mean values of ruminal total volatile fatty acids (TVFA's) in the Assaf lambs fed the different experimental diets through the different sampling times are shown in Table (4.9). The mean values of total volatile fatty acids at zero time were 7.24, 8.45 and 9.05 meq/dl for control, T_1 and T_2, respectively. Maximum values of TVFA's were recorded at 3 hrs post feeding, being 11.23, 13.18 and 14.49 meq/dl for control, T_1 and T_2, respectively. while, at 6 hours post feeding, it was decreased to reach 9.78, 10.81 and 11.50 in the same respective order.

In general, the data obtained from this study indicated that TVFA's concentration was conversely associated with pH value. Similar findings were reported by **Giacomini *et al.* (1985); Burrin and Britton (1986); Taie (1993) and Baraghit *et al.* (1995).** They indicated that the progress of increasing ruminal TVFA's concentration paralleled with a reduction in ruminal pH. The energetic of rumen microbial production is related to the fermentable materials

degraded to TVFA's by the rumen microorganisms during digestion **(Hume *et al.* 1970; Walker and Nader, 1970** and **Mathison and Milligan, 1971).**

4.3.3. Ruminal ammonia nitrogen (NH_3-N) concentration

Ruminal ammonia nitrogen (NH_3-N) showed significant ($P<0.05$) increase by Assaf lambs fed (T_2) and (T_1) diets compared with Assaf lambs fed control diet as shown in Table (4.10).

Table (4.10) : Ruminal ammonia nitrogen concentration (mg/dl) of the experimental Assaf lambs.

Experimental diets	Sampling Time			Overall Mean	± SE
	Pre feeding	Post feeding			
	Zero	3 hrs	6 hrs		
Control	13.01	22.38	18.72	18.04^{b}	1.07
T_1	16.64	25.02	20.93	20.86^{a}	0.92
T_2	16.99	25.71	21.06	21.25^{a}	1.38
Overall Mean	15.54^{c}	24.37^{a}	20.24^{b}		
± SE	0.79	1.06	0.93		

$^{a,b.,c}$ Means designated with the same letter within the same row (column) are not significantly different at ($P<0.05$).

The increase of rumen ammonia nitrogen concentration with the fibrolytic enzymes treatments may be due to higher CP digestibility and higher fermentation rate in fibrolytic enzymes treated diets. **Khorshed (2000)** observed that ruminal ammonia-N increased in rumen of sheep and Assaf lambs when fed on rations treated with biological treatments.

Mean values of ruminal NH_3-N in the different experimental diets through the different sampling times of lactating Assaf lambs are shown in Table (4.10). The means of NH_3-N concentration at zero time among the different treatment were 13.01, 16.64 and 16.99 mg/dl for control, T_1, and T_2, respectively. The NH_3-N concentrations were increased at 3 hrs post feeding to be 22.38, 25.02 and 25.71 mg/dl, then it was decreased after 6 hours to reach 18.72, 20.93 and 21.06 in the same respective order.

The differences in the mean values of NH_3-N among the different sampling times were significant ($P<0.05$). The lowest values ($P<0.05$) was

recorded at zero time (before feeding) (being 15.54 mg/dl) and then values increased (P<0.05) to reach the highest value at 3 h post feeding (being 24.37 mg/dl) and then decreased (P<0.05) to reach 20.24 mg/dl at 6 h post feeding.

4.4 Blood components

Biochemical parameters of blood serum have been used as indicators of the nutritional and physiological status of growing lambs. The results of blood serum constituents in Assaf lambs fed the tested diets are presented in Table (4.11).

4.4.1 Total protein and its fractions:

The overall means of serum total protein, albumin and globulin concentrations, and albumin/globulin ratio are shown in Table (4.11). Supplementing lambs diets with low level of fibrolytic enzymes (T1) significantly increased

Table (4.11): Blood serum parameters of Assaf lambs fed rations supplemented with low or high level of fibrolytic enzymes.

Parameter	Treatments					
	Control		T1		T2	
	Mean	SD	Mean	SD	Mean	SD
Total protein (g/dl)	6.30^{b}	±0.47	7.20^{a}	±0.56	6.30^{b}	±0.49
Albumin (g/dl)	3.80	±0.44	3.80	±0.38	3.30	±0.41
Globulin (g/dl)	2.50	±0.28	3.50	±0.32	3.00	±0.38
A / G ratio	1.52	±0.85	1.09	±0.60	1.10	±0.75
Glucose (mg/dl)	68.33	±4.48	63.33	±3.28	65.67	±4.37
Urea (mg/dl)	35.00	±1.07	37.00	±1.22	37.33	±1.28
Creatinine (mg/dl)	0.78	±0.26	0.87	±0.35	0.88	±0.21
AST (u/l)	111.0	±1.26	141.0	±1.45	116.0	±1.32
ALT (u/l)	15.33	±0.62	16.00	±0.73	19.67	±0.87
TG (mg/dl)	110.0	±2.53	117.0	±2.59	114.0	±2.50
Cholesterol (mg/dl)	87.67	±1.46	125.00	±1.54	90.00	±1.22

-Dissimilar superscripts at the same row mean significant differences (P<0.05).
T1= 2 g fibrolytic enzymes/h/day, T2=4 g fibrolytic enzymes/h/day

(P<0.05) total protein content than control or high fibrolytic enzymes level (T2). However, albumin, globulin and albumin/globulin ratio showed an insignificant trend (P>0.05). At the same time, albumin content decreased with high level of fibrolytic enzymes (T2) than the control or low level (T1) diets. This trend could be attributed to the change in blood serum globulin content.

Omole (1982) noted that the increase in serum total protein content might be related to the increase in blood albumin concentration. Also, **Habeeb, et al. (1989)** reported that the increase of total protein might be related to the increase of thyroxin production, which stimulates the protein synthesis. Also, **Freeman (1983)** noted that zinc may play a role in activation of some enzymes that are responsible of utilization of amino acids in protein synthesis and other physiological functions related to metabolic rate. Moreover, it is known that the change in albumin level reflects the change in liver function.

The reduction in albumin synthesis when rations supplemented with fibrolytic enzymes (T1 and T2) could be related to depression in anabolic hormonal secretion such as thyroxin (**El-Masry, 1987**) and insulin (**Habeeb, 1987**) or to the increasing in catabolic hormones such as glucocorticoids **(Alvarez and Johnson, 1970)**.

Although the changes in serum total protein and its fractions are significant between treatments, the data were within the normal range.

4.4.2 Kidney functions:

Data in Table (4.11) showed the effect of supplementing rations with different levels of fibrolytic enzymes on blood serum urea and creatinine as indicators of kidney functions of growing Assaf lambs. Treated rations did not significantly (P>0.05) affect urea level in the blood serum of lambs. However, serum creatinine gradually increased

(P>0.05) with increasing fibrolytic enzymes in lambs rations. Unaffected of serum urea due to fibrolytic enzymes supplementation to lambs' rations reflect the fact that the increase in blood urea nitrogen comes from increasing dietary crude protein level. An increase in rumen ammonia absorption resulting in greater amounts of ammonia being used in liver to synthesize urea. Therefore, urea concentration in blood reflects the ingestion of dietary protein (**Thomas, et al., 1988**). Liver is the major site for urea formation, which contains all enzymes involved in urea production.

Creatinine, the anhydride of creatine, is formed largely in muscles by irreversible non enzymatic dehydration of creatine phosphate, which is now known to be concerned with the energy mechanism of these tissues and serves primarily as a temporary store of energy **(Murray, et al., 1991).**

At the same time, blood serum creatinine concentration is a better indicator of glomerular filtration rate **(Enger and Blegen, 1964).** Although the changes in serum creatinine is significant between treatments, the data were within the normal range.

4.4.3 Liver functions:

Data in Table (4.11) show the effect of supplementing rations with different levels of fibrolytic enzymes on blood serum transaminases (aspartate aminotransferase, AST and alanine aminotransferase, ALT) as indicators of liver functions of growing Assaf lambs. Treated rations did not significantly (P>0.05) affect AST or ALT levels in the blood serum of lambs. However, it could be detected a slightly increase in AST and ALT (P>0.05) with increasing fibrolytic enzymes level in lambs rations. Increasing the metabolism process and growth performance of fibrolytic

enzymes supplemented groups may be a response to increased ALT activity of lambs fed diets supplemented with fibrolytic enzymes as noted by **Davidson (1994)**, who reported that the function of ALT enzymes is the transfer of amino group from amino acid to synthesis another one and play an important role in gluconeogenesis. Furthermore, an increase of ALT activity is a response to the increase needed for gluconeogenesis.

4.4.4 Lipids and glucose metabolism:

Data in Table (4.11) showed the effect of supplementing rations with different levels of fibrolytic enzymes on blood serum triglycerides and cholesterol as indicators of lipid metabolism of growing Assaf lambs. Treated rations did not significantly ($P>0.05$) affect triglycerides and cholesterol levels in the blood serum of lambs. However, glucose content gradually decreased ($P>0.05$) with increasing fibrolytic enzymes in lambs rations. It is known that lipids virtually have an important role in all aspects of biological life, serving as hormones or hormones precursor, aiding in digestion, providing energy storage and metabolic fuel and acting as functional and structural components in biomembranes **(Tietz, 1990)**.

Dietary lipids are contributed as a source of plasma lipids as they are absorbed as non-esterified fatty acids, rapidly estrefied to triglycerol then packaged into chylomicrons and very low density lipoproteins within the intestinal mucosa, from here lipids enter the lymph and finally the venous blood (**Noble, 1981**).

King *et al.* (1985) recorded that 17-29% of fatty acids synthesis attributed to acetate. Passage of dietary lipids through the rumen resulted in significant fatty acids biohydrogenation, which is reflected in a relatively high proportion of saturated fatty acids in the circulating triglycerol and non-estrefied fatty acids (**Pethick and Dunshia, 1993**).

From the information above it could be assumed that increase metabolism and growth performance of fibrolytic enzymes supplemented groups may be considered as a response to decreased cholesterol content in blood serum of lambs supplemented with fibrolytic enzymes.

4.5. Economical efficiency

Results of economical evaluation of Assaf lambs as affected by dietary fibrolytic enzymes supplementations are shown in Table (4.12). These data showed that the total feed intake coasted 193.60, 190.27 and 188.33 US$ (including the cost of supplements), while the price of total body weight gain (Total revenue) was 273.96, 277.86 and 294.80 US$ for control, T1 and T2, respectively (on the basis that the price of each kg gain equals 6.00 US$, the price of one kg mixed feed equals 0.50 US$ and the price of one kg fibrolytic enzymes equals 3.50 US$). It is of interest to note that feed cost per kg weight gain were 4.24, 4.13 and 3.88 US$ for control, T1 and T2, respectively. Obviously, feed cost/kg weight gain decreased with supplementing ration with fibrolytic enzymes from 4.24 to 4.13 with low fibrolytic enzymes level (about 97.41% of control) and to 3.88 with high fibrolytic enzymes level (about 91.51% of control). So the net revenue was the highest with T2 (high fibrolytic enzymes level) and was the lowest with control group. At the same time the economical efficiency was increased to be the highest with T2 (high fibrolytic enzymes level) and was the lowest with control group. The relative economical efficiency increased by 2.59% and 8.49% for groups T1 and T2 above control, respectively, (Table 4.12) as a result of feed supplements.

From the previous results, it could be concluded that supplementation of fibrolytic enzymes as 4 g/h/d could be improved the

economical efficiency than the low level of fibrolytic enzymes (2 g/h/d) or control diets.

Table (4.12) : Effect of dietary fibrolytic enzymes levels on economical efficiency of Assaf lambs fed tested rations.

Parameter	Treatments		
	Control	T1	T2
Total body weight gain, BWG, (kg)	45.66	46.31	49.10
Total revenue (US $) (A)	273.96	277.86	294.6
DMI kg/h/d	1.796	1.765	1.747
Total DMI kg/h	352.02	345.94	342.41
Total feed intake, as fed (kg/head)	387.2	380.53	376.65
Price/kg feed (US $)	193.60	190.27	188.33
Total of fibrolytic enzymes added (g)	0.00	336	672
Price of fibrolytic enzymes added US$	0.00	1.176	2.352
Total feed cost (US $) (B)	193.60	191.45	190.68
Feed cost / kg gain (US $)	4.24	4.13	3.88
Net revenue (US $) (A-B)	80.36	86.41	103.92
Economical efficiency (A/B)*	1.42	1.45	1.54

* Economical efficiency expressed as the ratio between the price of total live weight gain and the price of feed consumed.
- Price of one kg of mixed of concentrate feed mixture and hay (85:15) as fed was 0.50 US$, one kg fibrolytic enzymes was 3.50 US$ and one kg live body weight was 6.0 US$
-T1= 2 g fibrolytic enzymes/h/day, T2=4 g fibrolytic enzymes/h/day.

5 Conclusion and Reommendation

The present experiment was conducted in a private sheep farm in Khan Younes, South governorate, Gaza sector, Palestine, during the period of 1st March 2013 to the end of October 2013.

The experiment was planned to investigate the effect of feeding Assaf lambs on diets supplemented with two levels of fibrolytic enzymes (low or high) on the growth performance, carcass characteristics, blood components and economical efficiency. The three groups fed the following diets: Control, which consisted of 15% alfalfa hay and 85% concentrate feed mixture, (CFM) (on DM basis).; (T1): Control + 2 g fibrolytic enzymes/h/day; and (T2): Control + 4 g fibrolytic enzymes/h /day. The growth trial lasted for 28 weeks. Lambs were fed at levels of 3.5 % DM of body weight. Animals were weighed weekly before feeding at 8:00 a.m. to calculate the average daily gain (ADG). Animals were fasted for 12 hours before slaughter, weighed just before slaughter (SW) and after complete bleeding. Weights of carcass knife separable fat, internal and external offals and body fats were weighted and calculated as percentage of body weight at slaughtering (SW). Blood serum samples were taken at the final day of treatment directly before slaughtering from jugular vein from all animals.

The main results could be summarized as follows:

1. **Feed intake and body weight**: There were no significant effect between lambs concerning feed intake, initial LBW and final LBW. However, dietary treatments with fibrolytic enzymes showed insignificantly increases ($P>0.05$) in total LBW gain.

2. Carcass traits:

2.1. Dressing percentage: Lambs fed rations supplemented with fibrolytic enzymes (T1 and T2) had higher fasting and empty body weight than those of control but the differences were not significant ($P>0.05$). Also, hot carcass was lower in lambs fed control and high fibrolytic enzymes level (T2) than those fed low fibrolytic enzymes level (T1). Dressing percentages A or B were not significantly affected by fibrolytic enzymes treatment.

2.2. Carcass cuts: Lambs fed rations with low (T1) or high level of fibrolytic enzymes (T2) significantly increased ($P<0.05$) weights of shoulder, loin and neck than control in the diet, but did not significantly ($P>0.05$) affect weights of legs, rack, brisket and flank. Low and high level of fibrolytic enzymes decreased the percent of shoulder and rack than control, but increased the percent of loin, flank and neck than control.

2.3. Edible offals: Lambs fed rations supplemented with fibrolytic enzymes (low level) (T1) significantly ($P<0.05$) increased the weights of liver, kidney, tests and heart than control. However, high level of fibrolytic enzymes significantly ($P<0.05$) decreased kidney testes and heart weight than control. Total edible offals weight was superior with T1 followed by control, then T2. The same trend was noted with edible offals percentage (relative to empty body weight)**,** except with testes, which showed higher percent with low level of fibrolytic enzymes supplementation followed by control then high level of fibrolytic enzymes supplementation. It is of interest to note that the total edible offals percentage was highest with low level of fibrolytic enzymes supplementation (T1), followed by control, then high level of fibrolytic enzymes (T2).

2.4. Non-edible parts: Lambs fed diets with high fibrolytic enzyme (T2) had higher pelt and empty gastro-intestinal part (GIP) than control group with significantly ($P<0.05$) differences. However, there were no significant differences ($P>0.05$) between the different groups concerning head, feets and GIP full. The same trend was noted for non-edible parts as percentage (relative to empty body weights) except pelt and GIP full which were slightly decreased with low level of fibrolytic enzymes supplementation (T1).

3. Rumen liquor

3.1. pH: Ruminal pH showed insignificant ($P>0.05$) values by Assaf lambs fed on control, T1 and T2 diets. All ruminal pH values were above 6.0**.** Time of sampling had a significant effect ($P<0.05$) on rumen pH values.

3.2. Ruminal total volatile fatty acids: TVFA's concentration showed higher ($P<0.05$) values by Assaf lambs fed fibrolytic enzymes supplemented-diets compared with Assaf lambs fed control**.** The mean values of total volatile fatty acids at zero time were the lowest values. Maximum values of TVFA's were recorded at 3 hrs post feeding, decreased thenafter.

3.3. Ruminal ammonia nitrogen: NH_3-N showed significant ($P<0.05$) increase by Assaf lambs fed fibrolytic enzymes supplemented-diets compared with Assaf lambs fed control**.** Time of sampling had a significant effect ($P<0.05$) on rumen NH_3-N with an opposite trend of pH values.

4. Blood components:

4.1. Total protein and its fractions: Supplementing lambs diets with low level of fibrolytic enzymes (T1) significantly ($P<0.05$) increased total protein and globulin contents than control or high fibrolytic enzymes level (T2). Albumin content decreased with high level of fibrolytic enzymes (T2) than the control or low level (T1) diets.

4.2. Kidney functions: Treated rations did not significantly ($P>0.05$) affect urea level in the blood serum of lambs. However, serum creatinine gradually increased ($P>0.05$) with increasing fibrolytic enzymes in lambs rations.

4.3. Liver functions: Treated rations did not significantly ($P>0.05$) affect AST or ALT levels in the blood serum of lambs. However, it could be detect a slightly increase in AST and ALT ($P>0.05$) with increasing fibrolytic enzymes level in lambs rations.

4.4. Lipid and glucose metabolism: Treated rations did not significantly ($P>0.05$) affect triglycerides and cholesterol levels in the blood serum of lambs. However, glucose content gradually decreased ($P>0.05$) with increasing fibrolytic enzymes in lambs rations.

5. Economical efficiency

Feed cost/kg weight gain decreased with supplementing ration with fibrolytic enzymes with low fibrolytic enzymes level (about 97.41% of control) and with high fibrolytic enzymes level (about 91.54% of control). So the net revenue was the highest with T2 (high fibrolytic enzymes level) and was the lowest with control group. At the same time the economical efficiency was increased to be the highest with T2 (high fibrolytic enzymes level) and was the lowest with control

From the previous results, it could be concluded that supplementation of fibrolytic enzymes as 2 or 4 g /h/d enhanced productive performance of Assaf lambs, but it was the highest with high level of fibrolytic enzymes supplementation than low fibrolytic enzymes level.

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Utilization of Fiberolytic Enzymes for Improving Digestibility in Assaf Lambs Feed

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