**An-Najah National University**
**Faculty of Graduate Studies**

# Performance of Awassi Lambs Fed Citrus Pulp and Olive Cake Silage

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# Dedication

This project is dedicated to the soul of my late father, lovely mother, beautiful wife, brother and my sisters.

The completion of this work was not possible without their support, courage and help.

## Acknowledgment

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## إقرار

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# List of Abbreviations

| | |
|---|---|
| CP | Crude Protein |
| CF | Crude Fiber |
| NDF | Neutral Detergent Fiber |
| ADF | Acid Detergent Fiber |
| EE | Ether Extract |
| DMI | Dry Matter Intake |
| NFE | Nitrogen Free Extract |
| VFI | Voluntary Feed Intake |
| BWG | Body Weight Gain |
| DCP | Dried Citrus Pulp |
| SBM | Soy Bean Meal |
| Cp | Citrus Pulp |
| OC | Olive Cake |
| OL | Olive Leaves |
| OS | Olive Stones |
| OP | Olive Pulp |
| WS | Wheat Straw |
| GE | Gross Energy |
| DE | Digestible Energy |
| ME | Metabolizable Energy |
| AOAC | Association of Official Analytical Chemists |
| Ca | Calcium |
| P | Phosphorous |

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**Performance of Awassi Lambs Fed Citrus Pulp and Olive Cake Silage**

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## Abstract

This experiment was conducted to investigate the effects of feeding different home made silages on performance of fattening lambs and nutrients digestibility. Sixteen uniform males of Awassi lambs were used in feeding trial that was lasted for 77 days. The trial was followed by a 6-day digestion trial. Lambs were divided into four experimental groups. Lambs in each group were fed and had free access to water. Three types of silages were prepared using wheat straw (WS), olive cake (OC) and citrus pulp (Cp). The three by-products were respectively used as the following: silage 1, 60/27/13; silage 2, 20/54/26 and 0/48/52, silage 3. The silages were offered to lambs along with fixed amount of a commercial fattening concentrate which was 78% of total rations fed. Performance of lambs was significantly ($P<0.05$) improved by feeding all three silages. Dry matter intake and daily gain were higher than those in the control treatment. Better performance was associated with feeding silages contained low levels of wheat straw. Cost per kg gains was lower for lambs fed the three types of silages indicating that these by-products are potential livestock feed ingredients. Values of nutrient digestibility was increased ($P<0.05$) for all types of silages, especially when wheat straw was excluded from the rations. The results of this study indicate that silages of wheat straw, olive cake and citrus pulp can be used for lambs in fattening operations.

# Chapter One

# Introduction

## Introduction

Population in Palestine is increasing at high rate. The population growth rate was estimated to be 3% (Palestinian Central Bureau of Statistics, 2006). This growth is accompanied by harsh economic conditions and long dry periods. Growth of human population is also accompanied by a simultaneous increase in the demand for feed ingredients. This has already resulted in the deterioration of natural grazing areas, and lead to a marked decrease in animal performance.

It is therefore important to study the utilization of agricultural by-products as feed ingredients for farm animals especially ruminants.

To achieve greater and improved use of by-products, there is a need to have data on type, the quantity, seasonal availability, alternative uses and relative costs of these by-products. Utilization of by-products as feed, for ruminants, needs more research.

Making silage among the best methods for utilizing by-products as feed for ruminants without harmful effects. Silage making eliminates pathogens, and reduces the effect of drugs and pesticides that are used locally without a serious control or discipline (Hadjipanayiutou, 1998; Azmouti, 2003).

Silage made of either certain field crops or agricultural by-products is considered as a good feed ingredient. It is used in livestock operations world wide, especially in feedlot operations (Azmouti, 2003).

The fattening operations are among the important activities within animal production sector. The income from such operations is estimated to be 50% of the total income of animal production (Palestinian Ministry of Agriculture, 2006).

In Palestine, feed contributes about 75% of the total cost of animal production, where most of ingredients are imported from foreign sources at high cost (Azmouti, 2003; Nierat, 2006). Utilizing by-products as components of animal feeds would decrease the total cost of feeding, which could increase the profitability of livestock producers.

Large amounts of local agricultural by-products are available. It varies in amounts, nutritive value and location. Among these are olive cake, field crops and citrus by-products. Each of these ingredients is available in local market. More than 40 thousand tons of raw olive cake is produced each year. However, huge amounts at reasonable price of citrus by-products are available from Israeli sources.

Several types of agro-industrial by-products are fed to animals individually with variable effects on performance. However, little or no information available on utilizing silage made from local by-products in livestock operations. When mixed together at different proportions, silages from these by-products are a potential feed for lambs.

The objectives of this research were to investigate the effect of silage made from wheat straw, citrus pulp and olive cake on the performance, feed intake, cost of gain and nutrient digestibility of Awassi lambs.

# Chapter Two

# Literature Review

## 2.1 Literature review

Livestock sector plays a significant economic role in most developing countries and is essential for the food security of their rural population. Livestock farming is increasingly being limited by the restriction of grazing lands. During long dry seasons, animals are put on poor quality feeds which have low palatability, intake and nitrogen concentration. However, crop residues (straw) play a key role in animal feeding mainly in the region (Kayouli and Lee, 1993).

The importance of roughage as a feed resource is declining at the expense of cereals and agro-industrial by-products (Steinfeld *et al.*, 1998). Several crops leave a variety of residues (straws) that are utilized for animal feeding. Poor quality roughage comprises the sole part of the diet for ruminant animals in most Middle East countries, for a considerable part of the year.

Feeding crops agro-industrial by-products to livestock is a practice as old as the domestication of animals by humans. It has two important advantages (Grasser *et al.*, 1995), these being to diminish dependence of livestock on grains that can be consumed by humans (which was almost certainly the primary original reason), and to eliminate the need for costly waste management programs (which has become very important in recent years as the world human population has increased and the amount of crop and food by-product has increased too, particularly in developed countries).

Some Mediterranean countries are characterized by harsh climate conditions. In these regions, pasture is available only for a short period or is not available at all. Moreover, the use of cereals in animal diets creates a competitive conflict with human nutrition. Meanwhile, the use of soybean is expensive.

## 2.2 Agro industrial by products

A number of agro-industrial by-products is available for animal feeding (Qureshi, 1987). Although these by-products constitute the main feed resources in many developing countries (Qureshi, 1993), they are not reported in statistical series of any country in the region (Nordblom and Shomo, 1995).

Crop residues and agro-industrial by-products can play an important role in sheep and goats feeding under different management systems. These residues can supply a substantial part of the maintenance requirements of small ruminants in the Asian region (Jayasuriya, 1985).

Crop residues, particularly cereal straws and few agro-industrial by-products such as olive cake, citrus pulp have gained an importance due to the increasing demand for feed and to competitive prices as a consequence of removing feed subsidies.

The need to make better use of local feeds (crop residues, agro-industrial by-products) is considered as promising means to overcome the feed deficit.

Huge amounts of agro-industrial by-product are produced in various countries but most of which are not fully utilized in animal feeding thus contribute to the environment pollution. Difficulty in using most of these by-products when they are fresh and for long times is one of the constrains for their wider use. The low nutritive value and the imbalanced nutrient profile of these by-products is another constraint, which limits their use as components of small ruminant diets. Olive cake as a typical case is abundant in the Mediterranean countries, however, due to its low nutritive value (i.e. low in energy, digestible proteins and minerals and high in lignin) and the rapid development of mould, it is seldom integrated into livestock feeding (Nefzaoui, 1999).

## 2.3 Citrus Pulp

Citrus pulp is the residues of citrus juice canning industry. Oranges, tangerines, lemons or grapefruits are used for this purpose. The common raw material for juice industry, particularly in countries not only around the Mediterranean basin but also elsewhere in the world, is orange fruit (*Citrus sinensis*).

Total world citrus production averaged 69.4 million tones/ year (USDA/FAS, 2003). The genus *Citrus* includes several important fruits (Kale and Adsule, 1995), with the most important one worldwide basis being sweet orange (67.8% of world citrus production; 17.9% tangerine; 6.3% lemon; and 5.0% grapefruit) (USDA/FAS, 2003).

Citrus pulp consisting of a mixture of peels, inside portions, seeds and culled fruit which represent approximately 50-65 % of the whole fruit weight depending on the variety of fruit, the processing methods and environmental factors (Ashbell and Donahaye, 1984; Grasser *et al*., 1995).

## 2.4 Nutrient composition of citrus by-products

The composition of citrus fruit is affected by growing conditions, maturity, rootstock, variety and climate (Kale and Adsule, 1995). The nutrient content of citrus by-products is also influenced by the source of the fruit and method of processing (Ammerman and Henry, 1991).

The nutritional value of citrus pulp is high owing to its high content of readily fermentable carbohydrates. However, the protein content is modest, and of low digestibility and biological value (Lanza, 1982; Fegeros *et al*., 1995). Because citrus pulp has high moisture content (80%), it is bulky and therefore, it is difficult to store or transport it. Moreover, dumping of citrus pulp may raise serious environmental concerns (Hutton, 1987). It is rich in readily fermentable substrates such as sugars, non-starch polysaccharides and organic acids but poor in nitrogen (Cervera *et al*., 1985; Rehani *et al*., 1986; Caro *et al*., 1990). These characteristics make citrus pulp a suitable by-product to ensile with high dry matter (DM) cereal-crop residues such as wheat straw, while poultry litter may be included as a non-protein nitrogen source. Citrus pulp ensiled with wheat straw and poultry litter has been reported to produce silage of a relatively high fermentation quality (Migwi *et al*., 2000).

Citrus pulp contains a variety of energy substrates for ruminal microbes, including both soluble carbohydrates and a readily digestible neutral detergent fiber (NDF) fraction (Ghedalia *et al*., 1989; Ammerman and Henry, 1991; Ben- Miron *et al*., 2001).

Citrus pulp is a widespread by-product used mainly in ruminant diet (Gohl, 1981). Citrus pulp can be used in animal feeding either fresh or after ensiled or dehydrated (Caparra *et al*., 2000; Scerra *et al*., 2001; Bueno *et al*., 2002).

Citrus pulp has been previously used as a high energy feed in ration for supporting growth and lactation of cattle (Hadjipanayiotou and Louca, 1976; Martinez-Pascual and Fernandez-Carmona, 1980; Chapman *et al*., 1983; Hadjipanayiotou, 1988; Ammerman and Henry, 1991; Belibasakis and Tsirgogianni, 1996; Hadjipanayiotou and Sanz-Sampelayo, 1997; Caparra *et al*., 2000; Solomon *et al*., 2000; Lanza *et al*., 2001).

A large number of the citrus by-products are suitable for inclusion in ruminant diets because of the ability of ruminants to ferment high fiber feeds in the rumen (Grasser *et al*., 1995). An important benefit of citrus by-products feeding is it's relatively low cost. However, citrus pulp can also be fed fresh or as silage. Both are generally very rapidly accepted by ruminants, but pulp and peels from lemons are somewhat more acceptable than those from oranges and grapefruit (Bath *et al*., 1980). Fresh citrus is readily consumed by dairy cattle, but has transportation, storage and handling is a problem (Lundquist, 1995). Indeed, fresh citrus pulp is generally only transported for short distances because of its high moisture content and resulting high transportation costs (Grasser *et al*., 1995), it must be utilized rapidly as high levels of residual sugars often support secondary fermentation and/or mold growth as well as attracting flies, and its wet and sticky nature makes it difficult to store in sheds, bunkers or silos. Fresh citrus can supply part of the water requirements of ruminants, which can be important in some areas of the world.

The intake of a ration containing dried citrus pulp(DCP) by Awassi lambs was reported to be the same as that containing corn grain (400 g DCP/kg DM), but declined at higher levels (Bhattacharya and Harb, 1973). Ammonization of a ration containing 450 g DCP/kg DM, either with urea or ammonium hydroxide, did not alter palatability for sheep (Rihani *et al*., 1993b).

Previous studies reported that olive cake has been successfully fed to heavy lambs (Accardi *et al*., 1976; Abo Omar and Gavoret, 1995).

### 2.5 Olive by-products

By-products derived from the olive trees and olive oil extraction is generally known as "olive by-products". These by-products are defined as follows:

### 2.5.1 Olive leaves (OL)

This product refers to a mixture of leaves and branches from both, the pruning of olive trees as well as the harvesting and cleaning of olives prior to oil extraction. The production of OL from pruning has been estimated to be 25 kg per olive tree, to which can be added 5% of the weight of harvested olives that is collected at the oil mill (Delgado-Pertin˜ez *et al*., 1998).

### 2.5.2 Olive Cake (OC)

The area cultivated by olive orchards has increased in recent years, largely in response to the worldwide rise in olive oil consumption (International Olive Oil Council, 2006). Of the World's area cultivated by olives, 65% is located in the Mediterranean countries. It is estimated that 76% of these trees are in production while 74% of total olives are harvested (International Olive Oil Council, 2006).

Huge amounts of olive cake are available in the Mediterranean basin where olive crop is a key agricultural sector. The pressure (traditional) and centrifuge systems are the main processes used for oil extraction.

Olive cake consists of olive pulp, skin, stone and water. Different terms may be given depending on composition and oil content (crude or extracted OC), stones or moisture (fresh or dry OC). The different oil extraction procedures and resulting by-products have been recently documented (Sansoucy, 1987; Alburquerque *et al*., 2004).

Olive cake is characterized by high variability of residual water (25-30%), in relation to the extraction method, and by high percentage of crude fiber (27-41%).

Although olive cake has a high lignin content, it is also characterized by a good oil percentage, approximately 6-8% in the crude olive cake, which represents a valid energy supplement.

Despite the severe shortage of animal feedstuffs in most Mediterranean countries, the use of olive cake in ruminant animal diets is limited because of its low nutritive value and seasonality. Deep stacking of olive cake near the processing plants resulted in a considerable deterioration (mold formation) of the material and in leaches of nutrients. Crude olive cake is high in water (24%) and oil content (3%), which cause rapid fermentation. Therefore, the period of utilization of crude olive cake as fresh material is short. The olive cake obtained through solvent extraction differs substantially in composition (low in fat and moisture). Evidently, the nutritive value of these by-products varies greatly with the processing system. The integration of this feed source in sheep and goat is limited. The main limiting factor is its low energy and digestible protein contents and its richness in lignin. Depending upon the processing, crude protein in olive cake varies between 8 and 12% of DM, but almost 80 to 90% of nitrogen is fixed in lignocelluloses, thus not digestible. The high intake of olive cake as consequence of low particle size renders its digestibility low. The result of these nutritive characteristics is a low energy (0.21-0.35 feed units for meat production/kg DM) and digestible crude protein content [10-30 g/kg DM, acid detergent fiber (ADF) bound nitrogen is 80 to 90% of total nitrogen]. Therefore, studies seem to suggest that the contribution of olive cake to the diet of sheep should not exceed 30-40%, otherwise animal performance (growth and reproduction) will be drastically depressed (Nefzaoui, 1999).

The possibility of using byproducts of the olive oil industry represents an interesting and profitable opportunity, especially for our region which plays a leading role in the production of olive cake.

### 2.5.3 Other olive by-products

Olive stones (OS) may be a single by-product when they are well separated from pulp either before or after oil extraction. This separation results in another by-product, olive pulp (OP). Oil extraction also produces watery waste, which is sometimes dried and transformed into a concentrate known as “olive molasses”.

## 2.6 Utilization of olive cake in ruminant rations

Different ways to include OC in animal diets have been described, varying from feeding it fresh, ensiled, dried or as a component of concentrate pellets and multi-nutrient feed blocks. The latter may be a practical and economical possibility since it has been found that multi-nutrient blocks allow farmers to decrease the daily cost of feeding lambs by 38% (El Hag *et al*., 2002) and 18% (Ben Salem *et al*., 2003). Shqueir and Qawasmi (1994) Hadjipanayiotou (1999) also reported an economic advantage of using OC silage in lactating Chios ewes and both Damascus and East Friesian sheep. In the three species, the partial replacement of conventional roughage (barley hay and barley straw) with OC silage did not negatively affect milk yield. Milk fat content was increased by 3.1–5.8 g/kg milk. Although OC silage constituted only 0.15 of the total diet, it raised the fat content of the total diet by 65%. These results agree with previous studies (Hadjipanayiotou and Koumas, 1996) in which young ewe lambs utilized OC silage more effectively than goat kids, however, the latter were more effective than heifers.

It is indicated that, depending on energy value, the market price was underestimated by up to six-fold to that of conventional feeds.

Olive cake, in which the oil has been extracted, has also been used in practical diets, either included in concentrates or as a component of multi-nutrient blocks. Aguilera *et al*. (1992) used a mixture of extracted OC and olive molasses to replace part of the conventional feedstuffs, such as sunflower meal and barley grain, in the diets of ewes in late pregnancy and lactation. The basal diet was comprised of alfalfa hay and barley straw. Roughage intake was not reduced and the contribution of the OC-molasses mixture to the metabolizable energy content of the concentrate ranged from 0.16% to 0.25% and 0.05% to 0.12% in pregnancy and lactation, respectively. The performance of the ewes offered the concentrates with OC-molasses was similar or better than those fed the standard concentrate. Lamb growth rate during suckling was similar for those with mothers receiving an OC-molasses mixture, as for those fed a conventional concentrate (Aguilera *et al*., 1992).

## 2.7 Crop residues

Crop residues are mainly fibrous material that is by-products of crop cultivation. Due to the intensity of and emphasis on crop production in Africa and Asia, great amounts of several by-products are produced annually. While these feed sources, particularly cereal straws, provide the bulk of livestock feed, their nutritive value is low so that farmers must supplement them with grains and other concentrates. Crop residues available in the target area include, mainly, cereal straws, stubbles, olive tree leaves and twigs (Ben Salem *et al*., 2000).

Most common crop residues (i.e. straws and stubble) have low crude protein content (2-5%) on DM basis. This is a basic limitation in the value of some of the residues (e.g. wheat and barley straw) around the border line of the 6-7 per cent dietary crude protein level required for promoting voluntary feed intake (VFI). Most of the residues are deficient in fermentable energy, as reflected by the relatively low organic matter digestibility, and also by the limited availability of minerals (Ben Salem *et al*., 2000).

**2.8 Cereal straws**

Straw correspond to the residues (leaves, awns, stems) that are remained after the mature crop (i.e. grains) is harvested. Straws may have high market values in times of drought and other harsh conditions when roughages are scarce and grains have to be imported. For example, in Tunisia the sale price of straw bales in such conditions may reach 3 to 4-fold of that in periods of good harvest. Residues of cereal crop provide energy for ruminants in the form of digestible fiber. It is generally agreed that they should be accompanied by small amounts of suitable nitrogen supplement, such as oilseed cakes. If nutritive value of these residues is low or the animal's production is well above maintenance, farmers, must in addition, feed an energy supplement such as cereal grain to ensure biological and economical efficiency. Such supplements are often more expensive than crop residues. Improving the nutritional value of straws and the efficiency of their use in mixed rations is an attractive option for increasing livestock production (Ben Salem *et al*., 2000).

**2.9 By-products silage**

Numerous agro-industrials by-products, although available in large amounts and some of them being rich in certain nutrients (e.g. tomato pulp is high in crude protein, orange and citrus pulps are high in energy, etc.), are not widely used in livestock feeding. Because of there high moisture, fresh olive cake and tomato pulp, for example, become rancid and moldy. Ensiling technique can be safely used for extended storage of these by-products alone or combined with other by-products (molasses, wheat bran, etc.). Hadjipanayiotou (1999) found that well preserved olive cake silage has acceptable aroma, color, pH and is free of moulds.

Drying fresh by-products is an expensive procedure. On the other hand, fresh by-products, due to its high moisture content, cannot be stored for a long period. In this respect, ensiling fresh by-products is a sensible proposition for the conservation of destined for year-round animal feeding, particularly for the dry season when grass is scarce. In addition, it is more advantageous to mix them with other dry feed materials before ensiled (Ashbell *et al*., 1995; Scerra *et al*., 2001).

However, ensiling the by-product alone results in the formation of drippings/effluents which lead to both loss of important soluble substances (such as sugars, organic acids and minerals salts) as well as considerable impact on the farm environment.

It has been demonstrated that silage of citrus pulp together with cereal straw or other feed materials is an excellent alternative to minimize the negative aspects linked to the ensilage of the by-product alone (D`Urso *et al*., 1984; Licitra *et al*., 1988; Scerra *et al*., 2001).

In previous studies, high moisture agro-industrial by-products like citrus pulp, grape marc and sugar beet pulp were successfully ensiled with screened poultry litter (Hadjipanayiotou, 1984; Hadjipanayiotou *et al*., 1993).

Furthermore, silage made from poultry litter, olive cake and wheat bran (45:45:10 w/w) has been used without any deleterious effect as partial replacement for concentrates in diets of sheep (Kayouli *et al*., 1993).

It has been demonstrated (Hadjipanayiotou, 1994b) that the ensiling technique can be safely used for extended storage of olive cake alone or in combination with other by-products (molasses, screened poultry litter) or conventional feedstuffs (ground barley or corn grain).

Ensiled OC was either used at different rates (10, 20, 30, 40, 50, 78%) in urea blocks (Hadjipanayiotou, 1996), and/ or as partial replacement (30%) for conventional feedstuffs (barley hay, straw, concentrate) in diets of dry mature or growing ruminants (Hadjipanayiotou and koumas, 1996).

Conversely, the main constraints to preserve crude OC are its high water and oil contents. However, silage has been reported to be a simple, cheap, and efficient procedure to preserve OC, either alone (Hadjipanayiotou, 1999) or with poultry manure (Nefzaoui, 1991), conventional feedstuffs (Hadjipanayiotou, 1994a), urea (Al-Jassim *et al*., 1997) or an alkali (Nefzaoui and Vanbelle, 1986).

Additionally, Volanis *et al*. (2004) reported that ensiled sliced oranges at 309 g/kg DM of the total mixed ration was palatable to lactating dairy sheep, possibly due to its pleasant odor, while Migwi *et al*. (2001) suggested that the level of citrus pulp, ensiled with wheat straw and poultry litter, in the ration of sheep should be maintained between 150 and 200 g/kg DM to avoid depressed intake that may arise with higher citrus pulp levels, presumably due to low palatability. Finally, orange has been used as a food flavor for sheep (Ralphs *et al*., 1995).

The intake of ensiled citrus pulp by Damascus goats and kids as well as Chios lambs was measured (Hadjipanayiotou, 1988; Hadjipanayiotou and Sanz-Sampelayo, 1997).

Replacing part of barley hay and straw, given to lactating ewes goats and cows, with olive cake silage had no effect on milk yield and fat-corrected milk yield. Citrus pulp and wheat straw silage was incorporated by Scerra *et al*. (2000) in lambs diet to replace oat hay and 30% of commercial concentrate. Live weights and carcass weights were similar among treatments. Lambs on silage produced carcasses with a better muscular conformation and with a lower fatness score. The use of agro-industrial by-products silage seems to be a convenient and economically viable method for producing sheep with similar or better performance than that obtained with common feed resources. In practice, however, the adoption of silage technique is still limited.

# Chapter Three

# Materials and Methods

### 3.1 Preparation of silage

Fresh citrus pulp was mixed with olive cake and wheat straw and ensiled in a trench silo of approximately 1 m high and .5 m wide that was coated with a plastic sheet. After filling the silo, the mass was air-tight, closed with a plastic sheet and covered to secure anaerobic conditions for fermentation and the protection of silage from being exposed to solar radiation. After 30 days, the silo was opened and silage samples were taken for chemical analysis.

Three kinds of silages containing different levels of wheat straw, citrus pulp and olive cake were prepared (Table 1).

**Table (1).** Silages composition

| Ingredient | Silage 1 | Silage 2 | Silage 3 |
|---|---|---|---|
| **Wheat straw (%)** | 60 | 20 | 0 |
| **Citrus Pulp (%)** | 27 | 54 | 48 |
| **Olive Cake (%)** | 13 | 26 | 52 |
| **Total** | 100 | 100 | 100 |

### 3.2 Feeding trial

The trial involved 16 weaned Awassi male lambs, obtained from a local farm in Tulkarm. Soon after lambs were received at the experimental site, they were randomly divided into four groups and were allotted in collective pens (four animals per pen). Lambs had free access to fresh water and mineral blocks. The distribution of the lambs between the different groups was done in such a way that the average body weight in each group was similar to that in the other groups. An adaptation period of 14 days was allowed. During the adaptation period, the lambs were treated against common parasites and diseases.

The first diet (control) was based on wheat straw and a commercial concentrate (Table 2) in a ratio 22/78 (on DM bases). The other diets were based on silage and a commercial concentrate (Table 3). The silage was a mixture of wheat straw, citrus pulp and olive cake in a ratio of 60/27/13 (silage 1) and 20/54/26 (silage 2) and 0/48/52 (silage 3).

The diet consisted of straw supplied once daily (8:00 h) and concentrate supplied twice daily (9:00 and 6:00h). Water was always available. The lambs were weighed at weekly intervals prior to feeding in order to calculate average weight gain (BWG) and feed conversion efficiency.

Sub-samples from each treatment group were bulked and stored for chemical analysis.

**Table ( 2).** Concentrate ingredients and chemical composition

| **Ingredients** | **Percent %** |
|---|---|
| **Corn** | 38.5 |
| **Wheat** | 5.0 |
| **Wheat bran** | 5.0 |
| **SBM** | 20.2 |
| **Sunflower Meal** | 7.0 |
| **Barley** | 20.0 |
| **Premix*** | 0.1 |
| **Chemical Composition** | |
| **CP %** | 18 |
| **CF %** | 6.1 |
| **NDF %** | 22.5 |
| **ADF %** | 12.5 |
| **EE %** | 3.3 |
| **Ash %** | 5.2 |
| **Moisture %** | 12 |
| **ME(MJ/Kg)** | 12 |
| **Ca %** | 1.2 |
| **P %** | 0.6 |

* Premix(Vit. A-8mg, Vit. D3-1.6mg, Vit. E-20mg, Cobalt-1gm, Manganeze-30gm, Iodine-½gm, Selenium-.1gm, Calcium-440gm, Antioxidant-15gm).

**Table(3).** Experimental rations used in the feeding trial and nutrient composition (%)

| | Control | Silage 1 | Silage 2 | Silage 3 |
|---|---|---|---|---|
| **Concentrate** | 78 | 78 | 78 | 78 |
| **Wheat Straw** | 22 | 14 | 7 | - |
| **Citrus Pulp** | - | 6 | 9 | 12 |
| **Olive Cake** | - | 3 | 6 | 9 |
| **Chemical composition (%)** | | | | |
| **DM** | 87.8 | 84.8 | 81.9 | 78.7 |
| **Crude protein** | 14.7 | 15.1 | 15.6 | 16 |
| **Crude fiber** | 14.6 | 13.2 | 11.9 | 10.6 |
| **NDF** | 73.0 | 74.0 | 75.5 | 76.0 |
| **ADF** | 52.1 | 46.6 | 43.4 | 47.0 |
| **EE** | 2.4 | 2.6 | 2.8 | 3 |
| **Ash** | 7.6 | 7.4 | 7.3 | 7.1 |

### 3.3 Digestibility trial

Following the growth trial, three lambs from each treatment were placed in metabolic cages especially designed for urine and feces collection. Feeding was done as in the preceding growth trial. The animals were allowed to adapt in their cages for a period of 3 days, following which total faces and urine were collected for 6 days .The daily output of faces by each lamb was recorded and 10% was sub-sampled, pooled on animal basis and frozen pending chemical analysis. The urine was collected in plastic buckets.

### 3.4 Chemical analysis

Feed, fecal silage samples were analyzed utilizing the AOAC (1990) methods for dry matter, crude protein, crude fiber, ADF, NDF and crude ash. Gross energy was determined via a bomb calorimeter (Appendices).

### 3.5 Data analysis

The experiment was designed according to the complete randomized design (CRD). All data were analyzed by ANOVA using the linear model procedure of SAS (SAS, 1988) to determine the effect of feeding different silages on the target parameters.

# Chapter Four
# Results and Discussion

## 4.1 Composition of silage

Table (4) shows the chemical composition of the three types of silage prepared and used in the feeding trial. Values reported here in are similar to those reported by previous research using similar by-products (Bath *et al*., 1980; NRC, 1985; Brown and Johnson, 1991; Arosemena *et al*., 1995; Marten-Gracia *et al*., 2003).

**Table (4).** Chemical composition of the experimental silage.

| | **Silage 1** | **Silage 2** | **Silage 4** |
|---|---|---|---|
| **DM** | 54.0 | 56.7 | 54.9 |
| **Crude Protein** | 5.2 | 6.5 | 7.0 |
| **Crude Fiber** | 7.8 | 6.5 | 5.1 |
| **ADF** | 30.2 | 30.0 | 34.0 |
| **NDF** | 47.0 | 40.1 | 37.0 |
| **Gross Energy Cal./g** | 4327 | 4418 | 4591 |
| **Ash** | 6.1 | 5.3 | 4.2 |

It seems that the silages were palatable, possibly due to its pleasant odor. The dry matter contents of the three silages were higher compared to values reported by McDonald *et al*. (1988). The high dry matter values reported here in give advantage to the quality of silages. It was previously reported that when dry matter content of ensiled material is low, it may result in dry matter losses (McDonald *et al*. 1988). Cervera *et al*. (1985) reported losses of dry matter as high as 32% in ensiled citrus pulp.

The pH of used silages ranged from 4.2 to 5.5. These values agree with results reported by Volanis *et al*. (2004). However, Martinez-Pascual and Fernandez-Carmona (1978) reported pH values for citrus pulp silage ranging from 3.2 to 3.6.

## 4.2 Feeding trial

Data presented in (Table 5) shows that type of silage had no effect on lamb’s average body weight gain.

**Table (5).** Average body weight gain of lambs (kg).

| Weeks | Control | Silage 1 | Silage 2 | Silage 3 |
|---|---|---|---|---|
| **Week 0** | 23.1 | 23.1 | 23.0 | 23.1 |
| **Week1** | 25.7 | 25.8 | 26.0 | 25.4 |
| **Week2** | 28.4 | 28.4 | 28.6 | 27.5 |
| **Week3** | 30.7 | 31.0 | 31.0 | 29.7 |
| **Week4** | 33.0 | 33.4 | 33.3 | 32.0 |
| **Week5** | 35.2 | 35.9 | 35.7 | 34.2 |
| **Week6** | 37.7 | 38.5 | 38.1 | 36.4 |
| **Week7** | 40.0 | 41.0 | 40.5 | 38.6 |
| **Week8** | 42.4 | 43.3 | 42.9 | 40.7 |
| **Week9** | 44.6 | 45.6 | 45.0 | 43.0 |
| **Week10** | 46.5 | 48.0 | 47.1 | 45.1 |
| **Week11** | 48.4 | 50.4 | 49.1 | 47.1 |

Incorporation of different types of silage in lamb's rations had some advantages through its effect on lamb's average weights. However, lambs fed the third type of silage that contained only citrus pulp and olive cake had the lowest final average weights. In general, lambs fed the first type of silage had the highest final average weights compared to other feeding groups. These trends were observed for each week of the feeding trial.

These finding are in agreement with those of Bampidis and Robinson (2006) who reported that the low performance in lambs fed high citrus pulp was due to hydration. Hydration can affect bulk density by causing swelling of the feed matrix due to absorption of water, so hydration rate is important in determining the effective bulk density in the rumen. On the other hand, the high levels of olive cake in silages 2 and 3 may have influenced patterns of fermentation which in turn negatively effected lambs performance (Bampidis and Robinson, 2006; Molina and Yanez-Ruiz, 2007). The improvement in performance might be due to the presence of easily digestible cell walls in citrus pulp as containing (Madrid *et al*., 1997) which has positive effect on rumen microflora (Flackowsky *et al*., 1993).

Ben-Ghedalia *et al*. (1989) showed that citrus pulp improved the utilization of dietary fiber due to its positive effect on rumen microflora activity. Moreover, it has been proposed that the highly digestible fibrous fraction of citrus pulp, like pectin, may increase the number of bacteria ruminal fluid (Moss, 1994).

### 4.3 Feed intake

Dry matter intake by lambs was increased in all of the experimental groups (Table 6). The increase in dry matter intake was affected by composition of silage. Dry matter intake increased as level of wheat straw decreased. However, the highest intake was observed in the lambs fed rations without wheat straw. This can be explained by the improvement of palatability that is associated with high levels of citrus pulp regardless of bulkiness of rations. Utilization of silage made from olive cake and other by-products such as citrus pulp improved silage quality and resulted in a well-preserved palatable feedstuff, and voluntary feed intake (Kayouli and Lee, 1993). Feed intake was always higher by lambs fed silage compared to that of lambs fed the control ration. In contrast, the feed intake of lambs was not affected by silage (Kayouli, 1989). Generally, levels of intake observed in this experiment were similar to that in other reports (Abo Omar and Gavoret, 1995; Azmouti, 2003 ).

**Table(6).**Average daily feed intake in Kg/Lamb throughout the feeding trial

| Weeks | Control | Silage 1 | Silage 2 | Silage 3 |
|---|---|---|---|---|
| **Week1** | 1.00a | 0.92a | 0.88a | 0.94a |
| **Week2** | 1.10a | 1.00a | 0.97a | 1.00a |
| **Week3** | 1.16a | 1.13a | 1.10a | 1.20a |
| **Week4** | 1.24a | 1.18a | 1.22a | 1.30a |
| **Week5** | 1.34a | 1.30a | 1.34a | 1.40a |
| **Week6** | 1.42a | 1.42a | 1.44a | 1.53a |

| | | | | |
|---|---|---|---|---|
| **Week7** | 1.48a | 1.51a | 1.56a | 1.64a |
| **Week8** | 1.54a | 1.60a | 1.68a | 1.73a |
| **Week9** | 1.62a | 1.67a | 1.78a | 1.85a |
| **Week10** | 1.68a | 1.76a | 1.90a | 1.97a |
| **Week11** | 1.72c | 1.83b | 2.00a | 2.10a |

[abc] Rows of different superscripts are significantly different (P<0.05).

### 4.4 Body weight gain

The average total gain in lambs fed the four rations was 25.3, 27.4, 26.0, and 24 kg for the four diets, respectively (Table 7). The highest gain was noted in lambs fed type one silage which contained the three silage components (wheat straw, citrus pulp, olive cake). Similar findings were reported earlier (D' Urso *et al*., 1984; Licitra *et al*., 1988; Scerra *et al*., 2001; Capparra *et al*., 2007). Gain observed in this research was higher than gains reported by previous research (Harb, 1986; Abo Omar and Gavoret, 1995; Abo Omar, 2001; Hammad, 2001; Abo Omar, 2002).

### 4.5 Average daily gain

The average daily gain in the four rations used was 329, 355, 337 and 312 g (Table 7). The highest daily gain was the highest (P=0.05) in lambs fed silage 1. This result contrasted those reported by Caparra *et al*. (2007) who showed that such type of silage used may decrease the absorption of certain metabolites then resulted in some metabolic disorders. Values reported here are in agreement with previous research (Harb, 1986; Abo Omar and Gavoret, 1995). The duration of the feeding trial was 77 days.

### 4.6 Feed conversion efficiency

The efficiencies of feed conversion were 4.6, 4.5, 4.7 and 4.9 kg for the four rations used in the feeding trial (Table 7). The highest (P<0.05) feed conversion ratio was for lambs fed silage 1. The large portion of citrus pulp might be the reason as explained by Caparra *et al*. (2007). However, using dried olive cake as in silage 3 resulted in poor feed conversion efficiency (Scerra *et al*., 2001). These values feed conversion efficiencies reported here were similar to previous research (Harb, 1986; Abo Omar and Gavoret, 1995; Abo Omar, 2001; Hammad, 2001; Abo Omar, 2002). This indicated that feeding silages that was made of the examined by-products proved to be practical and economically feasible.

**Table (7).** Economic impacts of the fattening trial

| **Parameter** | **Control** | **Silage 1** | **Silage 2** | **Silage 3** |
|---|---|---|---|---|
| **Number of lambs** | 4a | 4a | 4a | 4a |
| **Duration of the experiment, day** | 77a | 77a | 77a | 77a |
| **Average initial weight, kg** | 23.1a | 23.1a | 23.05a | 23.06a |
| **Average final weight, kg** | 48.4a | 50.4a | 49.1a | 47.1a |
| **Average total gain, kg** | 25.3a | 27.4a | 26.03a | 24.0a |
| **Daily feed intake, kg/Lamb** | 1.515d | 1.579a | 1.565b | 1.532c |
| **Average daily gain, kg** | 0.329a | 0.355a | 0.337a | 0.312a |
| **Feed conversion efficiency** | 4.61c | 4.45d | 4.64b | 4.91a |
| **Cost of kg diet, NIS** | 1.71a | 1.67b | 1.63c | 1.59d |
| **Cost of total gain, NIS** | 218.7a | 210.2b | 203.3c | 191.0d |

[Abcd] Rows of different superscripts are significantly different ($P<0.05$).

### 4.7 Cost of gain:

The cost per kg gain is shown in Table (7). The highest ($P<0.05$) cost of gain was observed in lambs fed the control ration. Cost of gain was reduced through silages from 1 to 3. This can be explained by the significant differences in price per kg among these rations. The reported figures from this experiment show the economic feasibility of feeding such type of ingredients and saving that can be achieved. A net of 27.7 NIS can be saved when using silage 3. Numerically, more than 5, 5 million NIS can be saved assuming that number of lambs under fattening is 200 thousands.

**4.8 Digestibility trial:**

Digestibility of all nutrients was improved by the incorporation of silage in lambs rations (Table 8).

**Table (8)**. Digestibility of nutrients in the experimental rations.

| Digestibility | Control | Silage 1 | Silage 2 | Silage 3 |
|---|---|---|---|---|
| **Dry matter** | 58.0c | 67.0b | 76.0a | 78.0a |
| **Crude protein** | 77.0c | 78.0b | 81.0a | 83.0a |
| **Crude fiber** | 74.0b | 78.0a | 80.0a | 80.0a |
| **Crude fat** | 77.0a | 77.0a | 79.0a | 82.0a |
| **Ash** | 76.0b | 77.0b | 80.0a | 82.0a |
| **NFE** | 69.0c | 76.0b | 83.0a | 84.0a |
| **ADF** | 70.0a | 75.0a | 79.0a | 83.0a |
| **NDF** | 69.0d | 78.0b | 77.0c | 81.0a |
| **Digestible energy** | 75.0b | 78.8b | 80.0a | 82.4a |

[Abcd] Rows of different superscripts are significantly different ($P<0.05$).

The digestibility of dry matter significantly increased ($P<0.05$) where both levels of citrus pulp and olive cake are higher in the rations. Similar increase ($P<0.05$) in the digestibility of crude protein was observed. In all of the nutrients tested, digestibility was improved by feeding silage, especially in rations where wheat straw was excluded. The availability of readily fermented NDF fraction caused the high ($P<0.05$) degree of improvement of this fraction. The digestibility of NDF in silage 3 was the highest ($P<0.05$) due to absence of wheat straw. This is in agreement with results reported by other research (Ghedalia *et al*., 1989; Ammerman and Henry, 1991; Ben- Miron *et al*., 2001).

Our results suggested that nutrient digestibility in general was improved by reduction of wheat straw levels. It seems that there is a positive associative effect that improves digestibility when only citrus pulp and olive cake were the ingredients in silage.

# Chapter Five

# Conclusion and Recommendations

## 5.1 Conclusion

The following conclusions can be reported out of this research:

1. Different types of silages can be made safely under small households utilizing wheat straw, olive cake and citrus pulp.

2. Quality of silages was good as indicated by the research results.

3. Silages used improved general performance of lambs as indicated by average body weight development.

4. Silages improved levels of dry matter intake and average daily gain. However, best results were associated with silages low or free of wheat straw.

5. Utilizing by-products silages reduced cost of gain by lambs showing the potential of these silages as livestock feed.

6. Feed conversion efficiency was improved when different types of silage were fed to lambs.

7. Nutrient digestibility was increased in all types of silages, especially when wheat straw was excluded from the rations.

## 5.2 Recommendations

It is economically feasible to make silage out of available by-products, especially wheat straw, olive cake and citrus pulp. Rations prepared using silages prove to be practical and farmers can use them in their fattening operations.

However, more comprehensive research is needed to evaluate the effect of the proposed silages especially when larger numbers of lambs are used.

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# Appendices

**Appendix 1:-** Determination of Moisture (A.O.A.C., 1995)

**Procedure**

1. Heat the crucible for four hours in an oven at 105 c, cool and weigh.
2. Weigh by difference 2g into the can.
3. Place it in the oven at 105 c overnight.
4. Remove the can from the oven then transfer to a desiccators.
5. Allow to cool to room temperature then weigh.

% Moisture =(weight of can + sample before drying)-(weight of can + sample after drying) × 100% weight of wet sample

**Appendix 2:-** Determination of Ash (A.O.A.C., 1995)

**Procedure**

1. Heat the crucible for one hour in a muffle furnace at 500c, cool and weigh as quickly as possible.
2. Weigh by difference 2g into the crucible.
3. Place it in a cool furnace and slowly bring the temperature up to 600c, leave to overnight.
4. Remove the crucible from furnace then transfer to a desiccators.
5. Allow to cool to room temperature then weigh.

**Calculation**

% Ash = (Weight of ash) ×100% Weight of sample (dry matter)

**Appendix 3:-** Crude Protein Determination (Kjeldahl Method, O.A.C., 1995)

**Reagents:-**

1. Sulfuric acid (concentrated 98%)
2. Boric acid 4% solution. (Dissolve 4g boric acid in 100ml volumetric flask and complete to the mark).
3. Sodium hydroxide dissolves 500g. sodium hydroxide in 100ml volumetric flask cools and make up to 1000ml.
4. Indicator solution screened methyl red indicator solution. (Dissolve 2g. methyl red in 100ml of 96% v/v ethanol. Dissolve. 1g. methyl red in 100 ml of 96% v/v ethanol).
5. Digestion mixture add to each digestion flask. 19g of CuSo4 0.5g. H2O and 9.7g. K2SO4 and mix.
6. Anti foaming granules.
7. Hydrochloric acid solution.01N.

**Procedure:-**

1. Weigh about 1.0g sample into 100 ml Kjeldahl flask.
2. Add 20ml of concentrated sulfuric acid, then add 10g of digestion mixture and few antifoaming granules into the digestion flask.
3. Digestive the mixture until the solution becomes clear.
4. Transfer the digestion tube to connect the distillation unit, add 50ml of distilled water into the cooled digestion tube.

5. Add 40ml of sodium hydroxide 50% to digestion tube.

6. Place a receiving flask containing 30ml of 4% boric acid with few drops of mixed indicator.

7. Allow distillation to proceed to assure ammonia is free from the sample.

8. Titrate the ammonia collected in the receiving flask with standard 0.1N HCL solution.

**Calculation**

% Nitrogen = V0.1 HCL×N.HCL×14.007×100×100

100×Weight of dry sample

%Crude protein =%Nitrogen×6.25

**Appendix 4:-** Crude Fat Determination (Ether Extract, A.O.C., 1995)

1. Weigh 2g sample into the extraction thimble.

2. Clean and dry solvent flasks in 105c for one hour, then cool to room temperature and weigh.

3. Place thimble at the extraction apparatus.

4. Add 40ml diethyl ether to the solvent flask.

5. Turn on water that cools the hot plates until they are in contact with the flasks and on the heaters.

6. After the extraction is completed, remove the thimble and allow the solvent to evaporate.

7. Dry the flask at 105c for 30 minutes, cool to room temperature and weigh.

**Calculation**

%Crude Fat = Weight of flask after extraction – Weight of flask before extraction ×100/Weight of dry sample.

**Appendix 5:-** Crude Fiber Determination

**Reagents:-**

1. Sulfuric acid solution 0.255N.
2. Sodium hydroxide 0.313N.(Dissolve 1.25g fresh sodium hydroxide in 100ml volumetric flask and complete with distilled water to the mark).
3. Methyl alcohol and diethyl ether.

**Procedure:-**

1. Weigh 2g sample and transfer to 600ml flask.
2. Add 200ml of 0.255N sulfuric acid.
3. Place the beaker on the heating unit, turn heat on, and boil for exactly 30 minutes.
4. Filter through filter paper.
5. Transfer to 600ml beaker and add 200ml 0.313 sodium hydroxide.
6. Boil for 30 minutes from the onset of boiling.
7. Filter through a new filter paper.
8. Rinse the filter with 15ml of alcohol and then with about 15ml of diethyl ether.
9. Dry the filter paper at 105c, cool and weigh.

**Calculation**

%Crude Fiber = M1-M0×100/M2

Where, M0=Weight of filter paper and the sample before drying.

M1=Weight of filter paper and the sample after drying.

M2=Weight of the sample (dry matter basis).

**Appendix 6:-** Neutral Detergent Fiber (Robertson and Van Soest, 1981)

1. Neutral detergent solution (

   -Dissolve 18.61g ethylene diamine tetra acetate dehydrate and 6.81g sodium borate decahydrate in distilled water.

   -Dissolve 30g sodium lauryl sulphate and 10ml 2-ethoxy ethanol in distilled water.

   -Dissolve 6.81g disodium hydrogen phosphate in some water.

   -Put all the above solution in 1 litter volumetric flask and fill to the mark with distilled water.

   -Adjust the ph to range 6.9-7.1.

**Procedure:**

1. Weigh 1.00g sample and put in a beaker.
2. Add in order, 100ml neutral detergent solution, and 2ml

   Decahydronaphthalene and 0.5g sodium sulfite.
3. Heat to boiling and reflux for 60 minutes from the onset of boiling.
4. Filter using glass crucible and rinse with hot distilled water.

5. Wash twice with acetone.

6. Dry the crucible at 105c overnight and weigh.

**Calculation**

Neutral Detergent Fiber = M1-M0×100/M2

Where, M0=weight of the crucible.

M1=weight of the crucible and sample after drying.

M2=weight of the sample.

**Appendix 7:-** Acid Detergent Fiber (Robertson and Van Soest, 1981)

Dissolve 20g of cetylmethylammonium bromide in 1L Sulfuric acid (1N).

**Procedure:-**

1. Weigh 1g sample and put into a 600ml beaker.

2. Add 100ml of acid detergent solution using a measuring cylinder.

3. Add 2ml of decahhyronphalene.

4. Heat to boiling and reflux for 60 minutes from the onset of boiling.

5. Filter using glass crucibles and with hot distilled water.

6. Wash the fiber with acetone.

7. Wash the fiber with hexane.

8. Dry at 105c overnight, cool and weigh.

9. Ash at 600c overnight cools and weigh.

**Calculation**

Acid Detergent Fiber =M0-M1×100/M2

Where, M0=weight of crucible and fiber.

M1= weight of crucible and ash.

M2=weight of sample.

**Appendix 8:-** Gross Energy Content (A.O.A.C., 1984)

Gross energy was determined using bomb calorimeter.

**Equipment:-**

1. Oxygen bomb and accessories.

2. Balance with a accuracy of 1g.

**Reagents:-**

-Standard sodium carbonate solution.

-Methyl orange indicator.

-Benzoic acid composition tablets.

**Procedure:-**

1. Weigh about 1g sample.

2. Weigh the metal crucible and put sample in it.

3. Cut off a 10cm length of fuse wire, thread through the two holes of the oxygen bomb lid.

4. Assemble the bomb.

5. Fill the bomb with oxygen.

6. Press test button to see if it is ready to fire.

7. Measure 2000ml and have it always at the same temperature to 22-23c.

8. Put the bomb in the bucket and close the cover.

9. Put the heaters on.

10. When ready to fire press the firing button.

11. Read the amount of energy value on the assembly panel.

12. Take the bomb, release the oxygen out, open it and measure the length of the remaining fuse.

13. Rinse the bomb with distilled water, collect the washings then titrate it with sodium carbonate ($Na_2CO_3$) with methyl red indicator.

**Calculation**

GE (cal/g) = final T-initial T × hydrothermal equivalent of bomb-length of fuse wire burned × cal. $Na_2CO_3$ .

Weight of dry sample.

جامعة النجاح الوطنية
كلية الدراسات العليا

# أداء خراف العواسي المغذاة على سيلاج جفت الزيتون ومخلفات عصر الحمضيات

إعداد
أحمد إسماعيل أحمد زعزع

إشراف
أ.د. جمال ابو عمر

قدمت هذه الأطروحة استكمالا لمتطلبات درجة الماجستير في الإنتاج الحيواني بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.
2008

**أداء خراف العواسي المغذاة على سيلاج جفت الزيتون**

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## الملخص

تم إجراء هذه التجربة للتعرف على اثر استخدام أنواع من السيلاج المصنع محليا على خراف العواسي من حيث الأداء ومعاملات الهضم للعناصر الغذائية المختلفة والتي احتوتها العلائق. استخدم في التجربة 16 خروفا ذكرا من خراف العواسي مع مراعاة تماثل الوزن الابتدائي بين المجموعات التي استخدمت في تجربة التغذية لمدة 77 يوما. اتبعت هذه التجربة بتجربة هضم لمدة ستة أيام جمع براز حيث قسمت الخراف إلى 4 مجموعات تجريبية بما فيها مجموعة الشاهد، احتوت كل منها 4 خراف. تم تحضير ثلاثة أنواع من السيلاج باستخدام قش القمح وتفل الحمضيات و جفت الزيتون، المجموعات جهزت على النحو التالي السيلاج الأول باستخدام 60/27/13 والسيلاج الثاني باستخدام 20/54/26 والسيلاج الثالث باستخدام 0/48/52. تم تقديم السيلاج للخراف مع كميات محددة من العلف المركز والذي يشكل 78% من إجمالي الوجبة الغذائية. حسن السيلاج الذي استعمل ($p<.05$) الكفاءة العامة للخراف كما هو مشار إليه من خلال معدل تطور الوزن، السيلاج حسنت ($p<.05$) معدل المادة الجافة المأكولة ومعدل الزيادة اليومية، على كل حال أفضل النتائج مرتبطة بالسيلاج الذي يحتوي على نسبة اقل أو خالية من قش القمح. الاستفادة من السيلاج يقلل سعر الكسب ($p<.05$) من قبل الخراف التي تعتمدها كتغذية قطعان. كفاءة التحويل الغذائي تم تحسينها بمختلف أنواع السيلاج، هضم المواد الغذائية ارتفعت ($p<.05$) في الأنواع السيلاج وخاصة عندما استبعد قش القمح من العليقة. انه من الناحية الاقتصادية يفضل استخدام السيلاج بشكل عملي من المخلفات المتوفرة وخاصة قش القمح، جفت الزيتون وتفل الحمضيات. العلائق المجهزة باستعمال السيلاج أثبتت أنها عملية ويُمكّن المزارعين استعمالها في مزارع التسمين الخاصة بهم.