FORESTRY UNIVERSITY
FACULTY OF VETRINARY MEDICINE
DEPARTMENT OF ANATOMY, PHYSIOLOGY AND ANIMAL SCIENCE

RAMI ABDALLAH YACCOUB

THE EFFECT OF FEEDING WEANED LOCAL MALE KIDS GOATS OF "BALADI BREED" AND AWASSI MALE LAMBS FAVA BEANS AS COMPARED TO SOYBEAN MEAL ON BODY PERFORMANCE AND MEAT QUALITY

ABSTRACT
of a dissertation for the acquisition
of educational and scientific degree "Doctor"

Professional field: 6.3. Livestock breeding
Scientific specialty "Selection of farm animals, biology and biotechnology of reproduction"

Under the direction of
Scientific supervisors:
Prof. Dr. Andrey Aleksandrov Kurtenkov
Prof. Dr. Boulos Hanna Al Jammal,

Sofia

2024

ЛЕСОТЕХНИЧЕСКИ УНИВЕРСИТЕТ
ФАКУЛТЕТ „ВЕТЕРИНАРНА МЕДИЦИНА"
КАТЕДРА „АНАТОМИЯ, ФИЗИОЛОГИЯ И ЖИВОТНОВЪДНИ НАУКИ"

Рами Абдаллах Яакуб

ЕФЕКТ ОТ ИЗХРАНВАНЕ С БАКЛА И СОЕВ ШРОТ ВЪРХУ ТЕЛЕСНОТО СЪСТОЯНИЕ И КАЧЕСТВОТО НА МЕСОТО ПРИ УГОЯВАНИ МЪЖКИ ЯРЕТА ОТ МЕСТНАТА ПОРОДА БАЛАДИ И МЪЖКИ АГНЕТА ОТ ПОРОДА АВАСИ

АВТОРЕФЕРАТ
на дисертационен труд за получаване на образователна и научна степен „доктор"

Професионално направление: 6.3. Животновъдство
Научна специалност „Развъждане на селскостопанските животни, биология и биотехника на размножаването"

Научни ръководители:
доц. Андрей Александров Куртенков, дсс
проф. д-р Булос Ал Джамал, phD

София

2024

Дисертационният труд е написан на 131 страници и съдържа 10 таблици и 23 фигури и 1 приложение от 2 страници. Списъкът с литература включва 389 заглавия. Направени са общо 1 заключение и 3 препоръки и 2 научно-приложни приноса. Учебният материал е разпределен в 5 раздела.

Защитата на дисертационния труд ще се проведе на 14/06/2024 г. в 09:30 ч. в Лесотехнически университет - София, бул. Климент Охридски" № 10 на открито заседание на Научното жури в състав:

Председател: доц. д-р Георги Георгиев

Членове:

проф. ДН Димо Пенков

проф. д-р Запрянка Шиндарска

проф. д-р Мая Игнатова

проф. Теодора Ппоова

Рецензенти:

проф. ДН Димо Пенков

проф. д-р Запрянка Шиндарска

The dissertation is written on 131 pages and contains 10 tables and 23 figures and 1 appendix including 2 pages. The list of references includes 389 titles. A total of 1 conclusion and 3 recommendations were made and 2 scientific and applied contributions. The study material is outlined in 5 sections.

The defense of the dissertation will be held on 14/06/2024 at 09:30 in the University of Forestry - Sofia, Blvd. Kliment Ohridski ”№ 10 at an open meeting of the Scientific Jury composed of:

Chairman:

Prof. Assoc.prof. Georgi Georgiev, PhD

Members:

Prof. Dimo Penkov, DSc

Prof. Zpryanka Shindarska, PhD

Prof. Maya Ignatova, PhD

Assoc. Prof. Teodora Popova, PhD

Reviewers:

Prof. Dimo Penkov, DSc

Prof. Zpryanka Shindarska, PhD

The materials on the defense (dissertation, abstract, reviews and opinions) are available to those interested on the website of the University of Forestry (www.ltu.bg) and in the Dean's office of FVM - Sofia, 10 ‘Sveti Kliment Ohridski’ Blvd.

I. INTRODUCTION

The need for alternative protein sources to soybean meal (SBM) in domestic animal feeding has recently gained focus. The main reasons include the attempt to limit SBM import from extra-EU Countries, which represents a negative voice of the commercial balance; an effort to decrease costs of animal production and contemporarily reduce the loss of N-compounds in the environment and the search to prevent the presence of GMO (Genetically modified foods) in the food chain (Formigoni *et al.,* 2007). Among the possible protein sources, lupins, peas and fava beans *(Vicia fava L.)* were successfully used in ruminants and nonruminants (Burel *et al.,* 2000; Keller *et al.,* 2021).

Demand for pulses for stock feed both locally and in export markets is likely to have a major influence on prices. Pulses are valuable stock feeds because of their high protein levels and palatability (Henchion *et al.,* 2017). They can be used as part of intensive livestock rations or as supplements for stall reared stock. In some countries lupines are generally the preferred pulse for sheep and cattle because of their higher protein, higher fiber and lower starch levels, but peas and fava beans (FBS) are also useful and are commonly used overseas (Zagorakis *et al.,* 2018).

In intensive rations pulses are used to complement other feedstuffs to produce nutritionally balanced rations (Beigh *et al.,* 2017). Pulse's strong points are their high protein content compared to cereal grains, particularly proteins which can be digested easily by the animal for high production rates. Stock feeds make up over 75 percent of the cost of intensive animal production so most intensive animal producers and stock feed manufacturers compare and select between ingredients to use the cheapest combination of ingredients for each particular stock diet. This means that pulse use (and all other ingredients) depends on nutritional value, cost and local availability. Pulses are used in intensive rations to provide energy and essential amino acids for growth (Poutanen, 2021).

Animals need both energy and protein in their food. BSE or mad cow disease, which led to the removal of animal derived protein from livestock feed, has highlighted the shortfall in vegetable protein sources (Brookes, 2001). Europe imports 75% of its plant-derived protein, mostly as soy bean meal. For this reason, the European Union wants to encourage farmers to grow protein-rich legume crops like peas and fava beans for animal feeds. Existing protein sources are primarily hindered by their negative environmental impacts with some concerns around health. However, they offer social and economic benefits, and have a high level of consumer acceptance (Henchion *et al.,* 2017; Małecki *et al.,* 2021). Magoda & Gous (2011) noted that *Vicia fava* is an important crop in those areas of the world where cereal monoculture is practiced and soybeans cannot be produced economically as it requires a cool season for best development.

II. PURPOSE AND TASKS

Small ruminant's production contributes to the livelihoods of a large number of farmers and accounts for 28-58 % of agricultural output in the Middle East (Iniguez, 2005). In Lebanon it is mainly conducted by small farmers in marginal lands, where milk constitute an important source of income (Hosri and El khoury, 2004; De Rancourt *et al*., 2006; Hosri, *et al.,* 2016). Awassi lamb-fattening and goat-fattening systems in Middle Eastern countries are popular because they can rapidly generate income. Nevertheless, feed costs constraining these systems and seasonal fluctuations in feed prices expose farmers to risk. Despite the important relative size of the small ruminant's flock in Lebanon (330000 head of sheep and 450000 head of goats; FAO, 2010), the sector is facing many difficulties.The lack of landscape legislations can be partially compensated by the introduction of certain rules when planning and designing and following them.

To our knowledge, the present study is among the firsts to focus on the effect of feeding FBS (fava beans) on body performance in Lebanese local "Baladi" goat and Awassi sheep breeds in fattening production. Therefore, data on the effect of FBS on body performance of fattening and meat quality of locally reared small ruminants are scarce.

The aim of our experiment was to:

- Evaluate the influence of replacing totally or partially soybean meal with fava beans in rations fed to weaned lambs and kids of local Awassi sheep and local goat breeds (Baladi) on health and some traits of body performance. Thus, in our 8-weeks trials we used different inclusions of soybean meal: fava bean.
- Evaluate the physical quality of meat whose animals were fed different proportions of fava bean meal: soybean meal.
- Study the feasibility of using rations fed daily to Awassi lambs during fattening, containing different proportions of soybean meal: dry fava bean seed meal coarsely milled.

III. MATERIALS AND METHOD

III.1. Description of the experimental site

This experiment was divided into 2 trials:

I. 1st trial was conducted on weaned male lambs of Awassi sheep breed raised locally for fattening.

II. 2nd trial was conducted on weaned male kids of "*Baladi*" goats raised locally for fattening.

A. Site description, animal's distribution and feeding.

Trial I

This trial was conducted at "*Jarrah sheep farm*" at West Bekaa/Lebanon 5 Km of Zahleh (Bekaa district), 75 km from Beirut/Lebanon during May-June 2015. Relative humidity (RH %) and environmental temperature (TºC) that were recorded during this period of the year ranged between 50.3 - 76.9 and 26.6 - 24.6, respectively.

Fifteen weaned Awassi male lambs weighing 23.33 ± 0.52 kg started a fattening experiment at the age of 100-120 days. The lambs were born with an average birth weight (BWT) of 4.23 ± 0.73 kg.

Trial II

The trial was conducted during May-June months- 2015 for eight consecutive weeks on weaned male kids of local "*Baladi*" goat kids in Bziza at "*Ghattas animal farm*" in North-Lebanon (North district) 100 km from Beirut. Relative humidity (RH %) and environmental temperature (TºC) that were recorded during this period of the year ranged between 57.6 – 79.1 and 28.5 - 25.1, respectively.

Fifteen Kids with 13-14 weeks of age were fattened having an average live body weight (LBW) and at the beginning of the experiment (data collection) of 14.90 ± 0.259 Kg.

At the beginning of the trial and with the initiation of the preparatory period (adaptive period) animals were dipped and treated for all kinds of helminthic worms. The animals were in good health (veterinary examination).

All experimental animals (Trials I & II) were distributed randomly into five groups by 3 animals each under typical ecological and management conditions of environment (humidity and temperature) and fed five experimental rations as shown in Table 2. A combination (1:1) of good quality wheat straw and green hay was fed *ad libitum*; clean fresh water and mineral blocks (lickers) were available all the time inside the animal pens (2 x 2 m^2/group).

During the preparatory period (2 weeks) of adaptation the animals were ear tagged and vaccinated against Anthrax and FMD; Albendazole was administered with drinking water as prevention for digestive tract parasites. Veterinary inspection was repeated every week where intramuscular injections of multivitamin dozes (A, D & E) were administered.

Each animal-group was fed daily free choice forage feeds and around one and a half kg of the experimental mix-rations in feeding troughs and fresh water.

All rations were isocaloric (2.9 Kcal/kg ME) and adjusted to the same level of crude protein (17%) as recommended by NRC (1989) and based on cotton seed meal (CSM), wheat bran and corn, fed continuously with different levels of Soybean meal (SBM) : Dry milled Fava bean seeds (FBS) for the whole experimental period.

Animals were assigned to the following five experimental rations (See table 2 below):

- S25 (Sheep) & G25 (Goat)- FBS (Fava Bean meal seeds) partially replaced 25% of the Soybean meal (SBM) used in the daily allowance and adjusted to the recommended levels of crude protein and Energy by adding different levels (%) of CSM (Cotton seed meal), wheat bran and corn.
- S50 (Sheep) & G50 (Goat)- FBS (Fava Bean meal seeds) partially replaced 50% of the Soybean meal (SBM) used in the daily allowance and adjusted to the recommended levels of crude protein and Energy by adding different levels (%) of CSM (Cotton seed meal), wheat bran and corn.
- S75 (Sheep) & G75 (Goat)- FBS (Fava Bean meal seeds) partially replaced 75% of the Soybean meal (SBM) used in the daily allowance and adjusted to the recommended levels of crude protein and Energy by adding different levels (%) of CSM (Cotton seed meal), wheat bran and corn.
- S100 (Sheep) & G100 (Goat)- FBS (Fava Bean meal seeds) totally replaced 100% of the Soybean meal (SBM) used in the daily allowance and adjusted to the recommended levels of crude protein and Energy by adding different levels (%) of CSM (Cotton seed meal) , wheat bran and corn.
- SC0 (Sheep) & GC0 (Goat)- FBS (Fava Bean meal seeds) – This control ration was composed of 100 % SBM and no inclusion of FBS adjusted to the recommended levels of crude protein and Metabolizable Energy by adding different levels (%) of CSM (Cotton seed meal), wheat bran and corn. This ration represents commercial feeding in fattening lambs and kids used at the Lebanese farms following the indoor keeping system.

Roughages (commercial wheat straw and green hay) were fed free choice. Experimental concentrate mixtures were fed starting with half kg/head daily (average) and adjusting the amounts given as the animals progressed in growing (in calculation to 3% of live body weight). Since it was very difficult to construct animal pens with individual feeding boxes it was agreed to have group- feeding (3 lambs and 3 kids in each group with one common feeding trough). In order to know properly the amount of concentrate mix to be fed daily to each group during the whole week, it was allowed to adjust the amount once per week in the morning after each weighing by multiplying the 3% of the highest live body weight in each group by 3 (animals) and by 7 (days) and then at feeding time one of seven equal proportions was distributed in each animal group for seven consecutive days of the week.

Calculation of NET energy for growth (NEG) of both fodders:

NEG (MJ/kg) = [ME*(0.04+0.1*q)]*6 (adapted from INRA, 1988; Todorov and Darjonov, 1997), where: q= ME/GE. For recalculation MJ-Mcal – MJ/4.186.

GE (MJ/kg) = 0.0242*CP + 0.0366*CF + 0.0177*CFib + 0.017*CNPE (Schiemann et al., 1971)

ME (MJ/kg) = 0.0152*DigP + 0.0366*DigF + 0.0177*DigFib + 0.017*DigNPE (Schiemann et al., 1971)

Where C/DigP, C/DigF, C/DigFib and C/DigNPE are in grams.

ON this base and the chemical composition ad digestibility coefficients (see the literature review):

For faba (90%DM): GE – 17.01 MJ/ ME – 11.62MJ/ q= 0.68/ **NEG = 7.67 MJ (1.83 Mcal)**

For soybean meal (44-90%DM) GE-17.94 MJ/ ME – 11.64MJ/ q= 0.65/ **NEG = 7.45 MJ (1.79 Mcal)**

The coefficient q shows that, despite the higher value of metabolizable energy in the soybean meal, it is transformed into net energy for growth less well than that of the faba bean, because the intermediate exchange of the protein requires a greater energy resource. Therefore, the net energy values of the two feeds are identical (in contrast to the crude protein contents), which made it easier to equalize the different concentrate feeds by adding different percentages of corn, cotton seed meal and wheat brain (see Table 2 below).

Computing the amount of concentrate mix /week (kg) = Full portion of mix /group/ week = the highest LBW in each group x 3% x 3 (Lambs/Kids) x 7 (days)

Half of the daily ration was offered in the morning and the other half in the late afternoon.

It was very significant to have knowledge of the cost price of the different ingredients used in the daily rations to figure out any profit in using them. Table 2 shows the actual prices in $USD paid ($/ton) for purchasing the ingredients during April-May months of the 2015 year prices at the Lebanese market and the calculations per ton of the rations prepared ($/Ton).

Refused feeds (what was left behind in the feeding troughs) from each pen if existed were collected, weighed and recorded each week in the morning before the start of group-feeding. The trial proceeded for 8 weeks (collection of samples for analyses) after a preparatory period of 2 weeks to become adapted and acclimatized with the new experimental conditions.

Table 1. Experimental ration composition (% as fed basis) fed to each animal-group with their cost-prices ($/ton)

		S25/G25	S50/G50	S75/G75	S100/G100	SC0/GC0 (Control)
Cost price of Ingredients ($/ton)	**Ingredients**	**75% SBM+ 25%FBS**	**50% SBM+ 50%FBS**	**25% SBM+ 75%FBS**	**100% FBS**	**100% SBM**
600	**SBM**	**11.1**	**7.4**	**3.7**	**0.0**	**14.8**
325	**CSM**	**7.4**	**10.0**	**13.0**	**15.8**	**5.1**
350	**FBS**	**3.7**	**7.4**	**11.1**	**14.8**	**0.0**
150	**Wheat bran**	**16.0**	**15.0**	**12.7**	**12.3**	**14.7**
250	**corn**	**61.7**	**60.1**	**59.4**	**57.1**	**65.4**
	Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
	CP	**17.9**	**18.0**	**17.9**	**17.9**	**18.0**
	NEg MJ/kg	6.12	6.11	6.13	6.12	6.19
	Cost price of rations ($/ton)	**282**	**276**	**271**	**264**	**291**

III. 2. Experimental design.

The animals were distributed into five animal-groups (S100 & G 100, S75 & G 75, S50 & G 50, S25 & G 25 and SC0 & GC0) and arranged in a randomized complete block design with three animals per treatment using individual lamb/kid as replicate with 5 levels of supplementation with FBS: SBM (100: 0%, 75: 25, 50: 50, 25: 75 and 0: 100%, respectively).

III. 3. Measurement of samples and calculation of Variables.

- Before initiation of the experiment all rations under investigation were chemically analyzed for (AOAC, 1995):
    a. Dry matter content of the ration and each ingredient used (%)
    b. Crude protein (%)
    c. Ether extract (%)
    d. Crude fiber (%)
    e. Ash (%)
- Health problems were inspected daily for indigestion and possible malnutrition and levels of mortality (if exist)
- Live body weights of each animal were recorded using typical balances:
    a. At the beginning of the preparatory period
    b. At the initiation of the experiment.
    c. At the beginning of each week.
    d. At slaughter.
- Weight of the weekly feed intake/animal group (kg or grams of concentrates).
- Weight of the daily concentrates left behind of the rations in troughs (*No left behind concentrate mix).*
- The weekly average of estimated feed intake (waFI/head) was calculated by subtracting the amount of refused feeds (wRF) at the end of each week from the amount of rations distributed each week (wAF) divided by 3 (animal heads).
- The weekly cumulative feed intake in each group (wcFI/group) which is the total feed intake during the whole experimental period (8 weeks) was calculated by accumulating the weekly feed (wFI) intakes for each group.
- Weekly live body weight (wLBW) of each animal was measured at the start, end and during the experimental period on weekly basis (in the morning before feeding).
- Cumulative live body weight gain (cLBWG) was calculated by accumulating wLBW for the whole period or by subtracting the initial weight at the beginning of trial (W_0) from the final weight (W_f).
- Weekly feed conversion ratio in each animal-group (wFCR) was obtained by dividing wFI in each animal-group by wLBWG of each group.
- Feed conversion ratio (FCR) at the end of the trial in each group was achieved by dividing total feed intake for the 8 weeks (FI) by total LBWG for the whole period.

III. 4. Feasibility study and profitability calculations

Feasibility calculation of using the ingredients in concentrate mix rations containing SBM with/without FBS and meat profitability was achieved to show whether it is feasible and profitable using FBS, taking into consideration prices paid during May-June/2015 (Table 2).

III. 5. Physical analysis of meat quality

In order to study the effect and impact of feeding on physical quality composition of meat the following procedure was taken:

At the termination of the experiment (slaughtering) all animals were weighed before sacrificing and after blood streaming. All internal organs were inspected by veterinary specialists to inspect (if any) any symptoms of illness or malnutrition.

For further investigation on physical analyses, ribs sections of mutton and kids meat between 9th and 11th rib location of the left half (Loin eye or HH section) were collected (about 2 x 100 g) from each animal after skinning and eviscerating and packed after immediate weighing by 100g in 2 polyethylene sheets. One of the two sheets was stored in refrigerators for 24 hours of cooling at 4°C - 5°C while the other polyethylene sheet was stored below -27ºC to freeze for 7 days.

III. 5.1. pH measurements:

At 24h (hours) *post mortem* and 7 days of freezing muscle slices of 2 g each were removed from each polyethylene envelop and immediately homogenized in 18 ml of 5 mM iodoacetate buffer (Jeacocke, 1977). The pH of the homogenate was measured using a portable pH meter (HI 8424 Microprocessor pH Meter, HANNA Instruments, Woonsocket, RI.) equipped with a combined electrode.

III. 5.2. Color

Loin samples of 1.0 to 1.5 cm thick were taken from 9-11 rib location at the lumbar vertebra. These samples were used to determine color measurements, water loss cooking loss, and tenderness of the meat.

There are many options available for instrumental color analysis, however; according to Stevenson *et al.* (1991), the CIELab color space (CIE, 1976), expressing color by the coordinates L*, a* and b*, are appropriate color measures. Lightness in meat color is represented by L* on a scale from 0 to 100, where 100 corresponds to pure white and 0 corresponds to pure black. A negative a* value indicates greenness and a positive a* value represents redness. A positive b* value indicates yellowness, while a negative b* value corresponds with blueness.

At 24 hours *post mortem* of cooling and 7 days of freezing, meat color was determined using a chromameter (ADCI - 60 - C). The instrument was set to measure using the CIE system (International Commission on Illumination; abbreviated CIE for its French name) values of luminance (L*), redness (a*), and yellowness (b*) using illuminate D and 65° standard observer (C.I.E., 1978). All measurements (3 replicates on each 3-cm thick muscle slices) were carried out on the surface of the left muscle slice, in an area free of obvious color defects (over scalding, blood spots, and hemorrhages) using a Chromometer (ADCI-60-C; Beijing Chentaike Instrument Technology, CO, LTD) calibrated to a standard white tile.

III. 5.3. Meat water holding capacity

Water holding capacity was evaluated as the cooking loss measured according to Boccard *et al.* (1981).

Cooking loss (CL %) was determined immediately after cooling and thawing in meat samples vacuum packed in polyethylene bags and cooked in a water bath at 80°C for 15 minutes (corresponding to an internal temperature of 70°C (Honikel, 1998). Care was taken to ensure that all samples were of similar dimensions. Samples were cooled for 45 minutes under running tap water at room temperature. After that, they were taken from the bags, dried with filter paper and weighed. Cooking loss was expressed as the percentage loss relative to the weight immediately before cooking.

Cooking loss was determined by weighing a 1.0- 1.5 cm thick sample and placing the raw meat in a plastic bag in a pre-heated water bath (80°C) for 1h (Cloete *et al.*, 2005). The cooked meat sample was removed after 1h from the water bath and placed in a cooler for 24h at 4°C. Samples were blotted with tissue paper to remove the excess water before the final weight was recorded. The weight loss of each sample was expressed as a %age of the initial weight of the raw sample.

III. 5.4. Drip loss (DL %):

Drip loss was determined by the method of Offer and Knight (1988). Left raw muscle slices were weighed after cooling at 24 hours *post-mortem*, placed in a polystyrene tray, wrapped in an oxygen permeable film and kept at 5-7°C for the 2nd day. Slices were reweighed at 48 hours post mortem and the drip loss was expressed as percentage of initial weight.

III. 5.5. Thawing loss (TL %):

After 12 hours thawing in a refrigerator at 5-7°C, Muscle slices were taken from bags, dried with filter paper, and reweighed before cooking. Thawing loss was expressed as a percentage of the frozen weight (Honikel, 1998).

III. 5. 6. Meat texture

Cooked meat texture was measured using a penetrometer (interface RS232C) with a needle of 2.5g on a weight of 47.5 g, thus attaining a total weight of 50 g. The penetration was carried out on meat slices (3 x 2 x 1 cm) prepared in a way the longest dimension was parallel to the fiber axis. The slices were placed on a horizontal support and a force of the needle was applied perpendicularly to the muscle fibers for 5 seconds (Becila, 2002). The penetrometer needle depth (PND), mm) was recorded (in mm) and calculated as the average of 3 replications of each sample. The procedure was conducted on cooked meat after 24 hours of cooling and after cooking after 7 days of freezing.

III. 6. Statistical analysis.

Data were analyzed using the analysis of variance (ANOVA) procedure (Statistica, 2020). The experimental design was a randomized block design, with 3 replicates per treatment (3 x 5). Analysis of variance techniques were used to assess the statistical significance ($P<0.05$) of treatment effects. Feed intake (FI) and food conversion ratios (FCR) in each animal group were analyzed as apparent feed intake (aFI/head) and apparent feed conversion ratio (aFCR/head). Interaction and comparison among means was tested using the All Pair wise Multiple Comparison Procedures (Bonferroni test method) at a level of 5% significance. Mean ± SD (Mean values of the traits ± Standard Deviation) is used in all obtained statistical studies.

IV. RESULTS

<u>TRIAL I</u>

1. Animal health and feed palatability

No health problems were noticed. The animals were in good health. No signs of indigestion or diarrhea or any blood signs in manure were observed. Moreover the appetite as observed in all groups was acceptable where no left behind ration remaining was collected. The feed intake (FI) by all lambs in all groups fed the different rations was 100 % palatable (personal observations). Besides, no remaining was noticed in all over the period of the experiment. In the morning and before distribution of rations on animals the troughs were found empty.

2. Experimental animals and Feeding.

Random distribution of all animals resulted in almost equal average weight among the five animal groups. As shown in table 3 difference in the average initial Live Body weight (23.09 ± 0.52 kg) was statistically insignificant, where it ranged from the lowest as 22.8 ± 0.70 kg in group S100 whose animals were fed ration mix containing 100% fava bean seed meal (FBS) and 0% soybean meal (SBM) as the only source of legumes in the daily feed intake and the highest as in S50 (23.70 ± 0.60 kg) where FBS and SBM inclusions were on the level of 50% for each ingredient (P>0.05).

Table 3. Variations of the initial live body weight among lamb groups, Kg

GROUPS	LBW AT BEGINNING OF 1ST WEEK, KG – MEANS N=3	LBW AT BEGINNING OF 1ST WEEK, KG - STD.DEV. (SD)
S25	**23.10000**	**0.300000**
S50	**23.70000**	**0.600000**
S75	**22.93333**	**0.416333**
S100	**22.76667**	**0.702377**
SC0 (CONTROL)	**22.96667**	**0.115470**
AVERAGE	**23.09333**	**0.521627**

The results of the chemical analysis (Table 4) analyzed on ration samples before the initiation of the experiment coincides with the proposed rations constructed.

Table 4. Proximate chemical analysis of the experimental rations

Rations	**Average % of DM**	**Crude protein**		**Ether extract**		**Crude Fiber**		**Crude Ash**	
		As fed basis	**% to DM**	**As fed basis**	**% to DM**	**As fed basis**	**% to DM**	**As fed basis**	**% to DM**
S25	**92.56**	**16.6**	**17.9**	**4.6**	**4.97**	**12.1**	**13.09**	**5.6**	**6.05**
S50	**92.75**	**16.7**	**18.0**	**4.8**	**5.18**	**12.8**	**13.82**	**5.5**	**5.94**
S75	**92.59**	**16.6**	**17.9**	**5.1**	**5.51**	**12.9**	**13.96**	**5.4**	**5.78**
S100	**92.71**	**16.6**	**17.9**	**4.9**	**5.29**	**13.0**	**14.00**	**5.4**	**5.86**
SC0	**92.72**	**16.7**	**18.0**	**5.2**	**5.61**	**12.1**	**13.09**	**5.2**	**5.57**

**** Calculated mathematically as from NRC 1989. Nutrient requirements of sheep.***

The amount of concentrate mix fed to animals did not exceed 49.35 ± 0.91 kg/ animal group for the whole period of the experiment. In 1st week the apparent daily feed intake (adFI) per animal in all groups averaged to 0.703 ± 0.01kg where as at the end of 8th week this value increased to 0.959 ± 0.02 kg/head as 3% of live body weight recalculated as an average after weighing all the animals at the beginning of each proceeding week.

3. **Measurement of samples and calculation of Variables.**

3.1. Feed Intake (FI)

3.1.1. Weekly estimation of feed intake (weFI/head)

Figure 4 shows the weekly average variation among groups from 1st week till the end of the experiment where the highest weekly average feed consumption for the 8 weeks was registered in group S50 (ration containing 50% FBS added to 50% SBM as legume sources) and the lowest intake was noticed in group S100 (ration containing only FBS as legume source) attaining statistically significant levels of 6.17 ± 0.72 kg/head and 5.49 ± 0.44 kg/head, respectively ($P<0.05$).

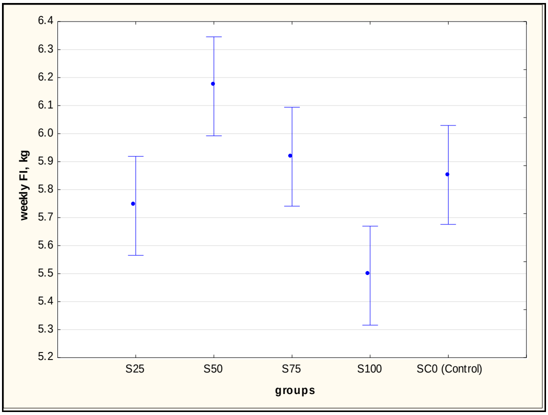

Figure 4. Estimation of weekly average variation in feed intake (weFI/head) per lamb among the experimental groups.

3.1.2. Weekly average feed intake (waFI, kg/group) and cumulative feed intake (cFI, kg/group)

Table 5 shows the calculated results of the weekly average of feed intake in every experimental group for the whole period of the experiment (8 weeks). Although the obtained results show no significant differences ($P>0.05$) among all experimental groups, we can still observe a tendency in group S50 having higher consumption level (26.2 kg) followed by animals of groups S75 (25.09 kg), SC0 (24.92 kg), S25 (24.62 kg) and the lowest among all groups in S100 (23.78 kg) where animals of this group were fed a ration with 100% FBS with no SBM.

Table 5. Variations in Weekly average Feed Intake per group (waFI, kg/group) and cumulative Feed Intake per group (cFI, kg/group only for the concentrates)

	S25		S50		S75		S100		SC0	
	Mean	**±SD**	**Mean**	**±SD**	**Mean**	**±SD**	**Mean**	**±SD**	**Mean**	**±SD**
***waFI**	**24.62**	**13.73**	**26.2**	**14.86**	**25.09**	**14.22**	**23.78**	**13.1**	**24.92**	**14.04**
cFI	**45.94bc**	**0.42**	**49.35a**	**1.55**	**47.34ac**	**1.22**	**43.94b**	**1.24**	**46.82abc**	**0.66**

** The difference in mean values are non-significant ($P>0.05$)*

abcMean values with different letters are significantly different (P<0.05)

Table 5 shows that the highest cumulative feed intake (cFI) at the termination of the experiment was in group S50 (49.35 kg) significantly higher (P<0.05) than S100 (43.94 kg) and S25 (45.94 kg) with a tendency to be higher (P>0.05) in groups S75 (47.34 kg) and SC0 (46.82 kg). In other words animals of group S50 that consumed ration consisting of 50% FBS and 50% SBM was higher by 7.4%, 4.2%, 12% and 5.4% than that in S25, S75, S100 and SC0, respectively.

Giovanni (1984), Surra *et al.* (1992) and Massimiliano *et al.* (1999), observed the same increase in concentrates intake containing Fava bean. The latter suggested that the level and activity of anti- nutritive factors in Fava bean, mainly tannins, have less effect on ruminants than monogastric animals.

Our achieved results coincides with the findings of Surra *et al.* (1992), El Maadoudi (2004), Delmotte and Rampanelli (2006), Lanza *et al.* (2007) noted that fava bean is highly palatable for lambs, which prefer it to barley. In growing lambs and fattening sheep, including fava beans in isoprotein and isoenergetic diets in substitution for soybean meal did not affect intake, performance and digestibility. They also added that in lambs, including fava beans up to 50% in the diet did not affect meat quality when compared to soybean meal.

3.2. Live body weight (LBW).

In Table 6 it is noticed that after the start of the experiment, where all live body weights were almost the same with no significant difference (P>0.05) between animals in each group and the average weight among groups, live weights continued to grow beginning with the 1st week. Whereas the average weight of lambs in the group S50 (25.28 ± 0.88 kg) was significantly higher (P<0.05) than S100 (23.51 ± 0.68) but this increase in group S50 was insignificant in comparison with S25, S75 and SC0 (P>0.05).

Table 6. Variations in Live body Weight (LBW) of the experiment, Kg

	S25	**S50**	**S75**	**S100**	**SC0**
	75% SBM+ 25%FBS	**50% SBM+ 50%FBS**	**25% SBM+ 75%FBS**	**100% FBS**	**100% SBM**
LBW at beginning of 1st week, kg					
Mean	23.1	23.7	22.93	22.77	22.97
± SD	0.3a	0.6a	0.42a	0.7a	0.12a
LBW end 1st week, kg					
Mean	24.02	25.28	24.15	23.51	24.13
± SD	0.35ab	0.88a	0.42ab	0.68b	0.14ab
LBW end 4th week, kg					
Mean	27.21	29.45	28.14	25.94	27.81
± SD	0.23ab	0.99a	0.78a	0.74b	0.42a
LBW end 8th week, kg					
Mean	31.63	34.59	33.76	29.22	32.9
± SD	0.12ab	1.23a	1.21a	0.72b	0.89a

abMean values (M ± SD) with different letters in the same row differ significantly (P<0.05)

Results observed at the end of 4th and 8th (end of the experiment) weeks showed a significant increase (P<0.05) in average animal weight of S50 group (29.45 and 34.59 Kg, respectively) where animals received 50% FBS and 50% SBM in comparison with S100 (25.94 and 29.22 Kg, respectively) where animals did not receive SBM in concentrate mix. More over Group S50 recorded the best body weight increase among all groups (P>0.05). This shows that feeding concentrate mix containing different combinations of SBM: FBS to lambs gives better results than feeding animals with mix containing SBM or FBS alone.

It seems, after all that concentrate mix containing any combination of SBM to FBS has more palatability and at the same time more digestibility in animal digestive tract and consequently in all over nutrient metabolism of the body resulting in higher LBW values.

This reflects the fact that neither antinutritional factors nor any toxins found in FBS influenced negatively the absorption of nutrients from the body gastro-intestinal tract from stimulating the animals to gain more weights.

The increase in body weight continued to grow reaching the maximum in the 8th week of the experiment. Whereas fattening the weaned lambs with concentrate mix consisting of 100 % FBS as a sole legume ingredient as in group S100 gave the least significant (P<0.05) results (29.2 kg) if to compare with the results obtained in S50 (34.6 kg), S75 (33.8 kg) and SC0 (32.9 kg).

It is worthy to point out the fact that higher body weights (32.9 kg) were obtained in animals of group SC0 (control) fed 100 % SBM as a sole legume ingredient showing higher productive effect than 100 % FBS in ration fed to group S100 (29.2 kg) (P<0.05) and S25 (31.63 kg) (P>0.05) but did not exceed the results (P>0.05) obtained in group S50 (34.6 kg) and S75 (33.8 kg) where 50% SBM : 50% FBS and 25% SBM: 75% FBS were included in the daily ration, respectively.

3.3. Live body weight gain (LBWG)

3.3.1. Weekly average Live Body Weight Gain (waLBWG/group).

Figure 5 shows the evolution of weekly live body weight gain (waLBWG) as it was registered from the beginning up to the end of the experiment.

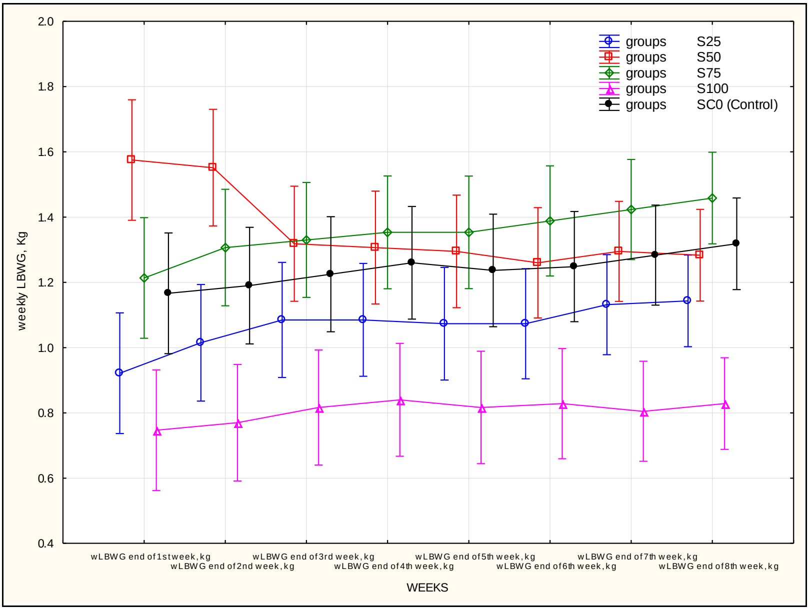

Figure 5. Variations in Weekly average Live Body Weight Gain (waLBWG/lamb group).
(For statistical significances refer to Appendix Table 11)

The same tendency of increase and decrease in body weight gains as in Figure 5 is observed throughout the experiment. Here once more we can establish the obvious increase (P>0.05) in all groups (S25, S75, S100 and SC0) in comparison with S50 where it showed an intensive decrease from week one to week three and continued until week six. Even though better absolute average live weights were obtained in this group at the end of the experiment, no explanation was found to clarify this phenomenon;

Once more Figure 5 shows that a combination of soybean meal and fava seed meal fed together with daily rations gives better results. Whereas feeding solely SBM or FBS result in lighter weights (see table 7) and minimum body weight gain.

3.3.2. Average live body weight gain for each group for the whole period of the experiment

Figure 6 shows the average group variation in live body weight gain (aLBWG/grpoup/period) of all weeks of the experiment.

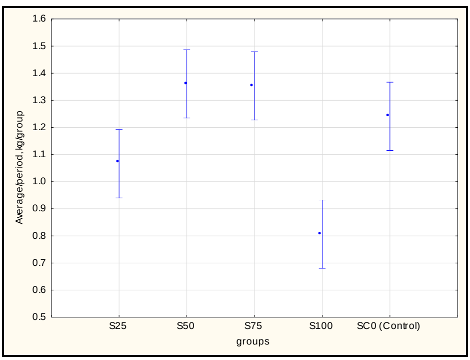

Figure 6. Average variations of Live body weight gain, kg (aLBWG/lamb group) for the whole period of the ex
significances refer to Appendix Table 11).

As seen from this figure that aLBWG for the whole period of the experiment was significantly (P<0.05) at minimum in group S100 (0.81 kg) in comparison with S25 (1.06 kg), S50 (1.36 kg). S75 (1.35 kg) and control group SC0 (1.24 kg). It is worthy to mention that results of aLBWG in S25 (25% FBS) was lower than those obtained from S50 (50% FBS) an S75 (75% FBS) and higher than S100 with 100 % FBS as sole inclusion in the daily rations of lamb (P<0.05).

3.3.3. Cumulative live body weight gain (cLBWG).

Table 7 shows the results obtained as accumulation of body weight gain during the Eight weeks of the trial.

Table 7. Cummulative Live body weight gain, kg/head

		S25	S50	S75	S100	SC0
At the end of:		75% SBM+ 25%FBS	50% SBM+ 50%FBS	25% SBM+ 75%FBS	100% FBS	100% SBM
1st week	Mean	0.9	1.6	1.2	0.7	1.2
	± SD	0.05ad	0.2b	0.05ce	0.1d	0.08ea
2nd week	Mean	1.9	3.1	2.5	1.5	2.4
	± SD	0.02ac	0.5b	0.1e	0.1da	0.1ec
3rd week	Mean	3.0	4.4	3.9	2.3	3.6
	± SD	0.05a	0.4b	0.3c	0.2d	0.2ec
4th week	Mean	4.1	5.8	5.2	3.2	4.8
	± SD	0.08a	0.4bc	0.4ce	0.2d	0.4e
5th week	Mean	5.2	7.0	6.6	4.0	6.1
	± SD	0.1a	0.6bc	0.5ce	0.2d	0.5e
6th week	Mean	6.3	8.3	7.9	4.8	7.3
	± SD	0.1a	0.7be	0.7cb	0.3d	0.6ec
7th week	Mean	7.4	9.6	9.4	5.6	8.6
	± SD	0.1a	0.9be	0.8cb	0.3d	0.7eca
8th week	Mean	8.5	10.9	10.8	6.5	9.9
	± SD	0.2a	1.1be	0.9cb	0.3d	0.8eca

Abcde Mean values (M ± SD) with different letters in the same row differ significantly (P<0.05)

It is observed from Figure 7, in contrast to dLBWG (Fig. 4) and wLBWG (Fig. 5) that cumulative live body weight gain cLBWG initiated with the end of the 1st week or beginning of the 2nd week increased from week to week attaining the highest score after one week of the initiation of the experiment to increase (P<0.05) by 1.6 kg/week in group S50 *Vs* 0.9 kg/week, 1.2, 0.7 and 1.2 kg/week in groups S25, S75, S100 and SC0, respectively.

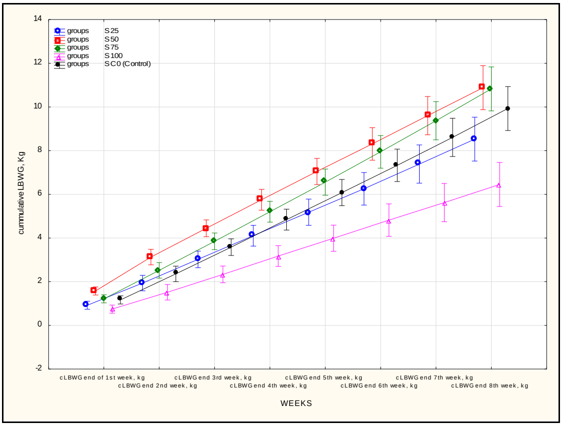

Figure 7. Cumulative Live body Weight gain of lambs, kg (cLBWG)
(For statistical significances refer to Appendix Table 12)

Animals of group S50 (50% SBM: 50% FBS) kept in increasing in body weight (P<0.05) where they accumulated 5.8 kg/1st month *Vs* 4.1, 3.2 and 4.8 kg/1st month in groups S25, S100 and SC0, respectively followed by 5.2 kg/1st month in group S75 (P>0.05). It seems that the best combination used in the experimental ration was in concentrates mix fed to group S50, where the highest results were obtained.

This variable for group S50 continued to increase in the same pattern reaching the highest cLBWG at the end of the 2nd month where the experiment was terminated attaining the level of 10.9kg vs. 8.5 and 6.5 kg in groups S25 and S100, respectively and 10.8 and 9.9 kg in groups S75 and SC0 (P>0.05), respectively.

Our results obtained were in contrast with the findings achieved by Keller *et al.* (2021) who stated that the use of a lamb fattening diet largely based on fava bean gave similar growth performance and meat characteristics compared to the traditional diets based on soybean meal as main protein source .

Antongiovanni *et al.* (2002), Martinez *et al.* (2004) and Morbidini *et al.* (2005) obtained results similar to ours on young growing lambs fed fava bean seeds (50-60% of the diet) as the sole protein source in concentrate mix increased daily weight gain demonstrating the already high protein value of fava beans for growing lambs.

Duke (1981) suggested the fact that to reduce reliance on imported soybean meal (SBM) in temperate environments, fava bean may be alternative protein sources for small ruminant diets. Fava bean is used as an important source of protein rich food in developing countries and as both food and feed for animals in industrialized countries.

As was shown by Edwards (2004) that, tannins present in the seed coat of fava beans have limited effect on broilers, pigs or ruminants. The trypsin inhibitor activity in fava beans is not well documented but appears to be low.

In agreement to what was proposed by Liener (1976), Dvořák *et al.* (2006) and Esenwah and Ikenebomeh (2008) who stated that the nutritional value of leguminous proteins may be limited by the presence of antinutritional factors. The protease inhibitors, trypsin and chymotrypsin, are perhaps the most widely distributed of all antinutritional factors in legumes. Monogastrics are thought to be more susceptible to the effects of antinutritional factors than ruminants. In fact, for ruminants, trypsin inhibitors are not considered to be important (McDonald *et al.*, 1973). In contrast to Cerioli *et al.* (1998) who concluded that beans have a lower content of trypsin inhibitors than the soybean and can be used as proposed by Matthews and Marcellos (2003) in dairy rations at inclusion levels of up to 35%.

4. Feed conversion ratio (FCR) – for the concentrate fodders

4.1. Weekly feed conversion ratio (waFCR)

The highest values (inefficient) in body retention per week (wFCR) were observed in group S100 that calibrates between 60.3% at the end of the 1st and 40.3% by the end of the 8th week in comparison with results obtained in group SC0 (Fig. 8). This can be explained by consuming more feeds to convert them to body weight gain and at the same time getting less live body weights due maybe to the overall effect of antinutritional factors found in fava bean seeds which was included as a sole legume ingredient (100 FBS) in ration fed to S100 which needs to be more investigated in the future studies on feeding fava bean seeds to ruminant animals. Moreover, more efficient results was achieved in groups S50 and S75 whose animals were fed a combination of SBM: FBS in different proportions.

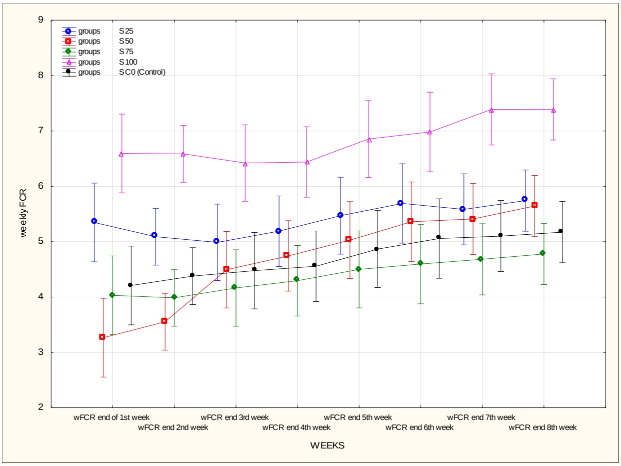

Figure 8. Weekly average feed conversion ratio (waFCR) in lamb groups
(For statistical significances refer to Appendix Table 13)

If to compare the overall average results among groups for the whole period we observe that wFCR in group S75 (4.36) was less than what was obtained in groups SC0 (4.67), S50 (4.71), S25 (5.31) and S100 (6.89).

Figure 8 shows that lambs of group S100 less efficiently converted feeds into body weight gain than animals of the other groups. It was noticed that from the end of the 1st week wFCR in S100 was inefficiently ($P<0.05$) higher (6.71) than groups S50 (3.31), SC0 (4.17), S75 (4.01) and S25 (5.34) as well ($P>0.05$).

This can be explained by the findings reported by Miller (1980) that fava bean protein is highly soluble in the rumen. Whereas, Emiola and Gous (2011) agreed that Fava bean feeding at various levels did not affect digestibility. However, Fulpagare (1993) reported that as the level of fava bean increase (from 25 to 100%) in the diet of lambs, the digestibility of dry matter (Ether extract and crude fiber) increase, while that of nitrogen-free extracts (NFE) decreases.

4.2. Cumulative feed conversion ratio (FCR)

The best results accumulated (P<0.05) at the end of the experiment, as shown in Table 8 was in S100 (6.82) followed by S25 (5.39), SC0 (4.74), S75 (4.39) and the most efficient S50 (3.92).

Table 8. FCR at the end of the experiment

	S25	S50	S75	S100	SC0 (Control)
Mean	5.39	3.92	4.39	6.82	4.74
d Dev	0.18b	0.43b	0.3b	0.41a	0.36b

ab Mean values with different letters differ significantly (P<0.05)

5. **Feasibility study**

Table 9 shows the overall profit of using legumes of FBS in combination with 50% and 25% SBM leveled to 53.61 and 51.95 $, which is better than group SC0 (45.74 $) by 17.20 and 13.57 %, respectively. Whereas the lowest profit was achieved in S100 (27.28 $) and S25 (38.08 $) animal groups reaching a, negative effect by -40.37 and -16.76 %, respectively.

The results obtained show that feeding FBS with combination with SBM as 50: 50 % as in groups S50 and S75 gave the best and higher results. Moreover feeding FBS (S100) and SBM as 100% (SC) as the sole legume ingredient or 75% (S25) as in combination with 25% FBS did not succeed in giving more profit than other animal groups. Besides feeding rations containing 50 % FBS: 50 % SBM and 25 % FBS: 75 % SBM gave better profit than feeding with 25 % FBS: 75 % SBM by 96.54 and 90.44 %, respectively.

Table 9. Feasibility and profit of feeding SBM Vs FSM to lambs, $

Groups	cost price , $/1kg of rations	FCR	cost price of 1kg of meat related to cFCR only, $/1kg	overall LBWG, kg	cost price of kg LBWG, $/kgs	selling price $/1kg of meat	Income, $ / LBWG	*profit $ = overall cost of FI ($)- Income of selling meat ($)*	Profit in comparison with SC0, %	Profit in comparison with S100, %	Profit in comparison with S25, %
S25	**0.28**	**5.39**	**1.52**	**8.5**	**12.92**	**6**	**51.0**	**38.08**	**-16.76**	39.58	
S50	**0.28**	**3.92**	**1.08**	**10.9**	**11.79**	**6**	**65.4**	**53.61**	17.20	96.54	40.81
S75	**0.27**	**4.39**	**1.19**	**10.8**	**12.85**	**6**	**64.8**	**51.95**	13.57	90.44	36.44
S100	**0.26**	**6.82**	**1.80**	**6.5**	**11.72**	**6**	**39.0**	**27.28**	**-40.37**		**-28.36**
SC0	**0.29**	**4.74**	**1.38**	**9.9**	**13.66**	**6**	**59.4**	**45.74**		67.69	20.14

<u>TRIAL II</u>

1. **Animal health and feed palatability**

No health problems were noticed. The animals were in good health. No signs of indigestion or diarrhea or any blood signs in manure were observed. Moreover the appetite as we noted in all groups was acceptable (personal observations) where residues of left behind concentrate mixtures were collected (if found). The feed intake (FI) by all male kids in all groups fed the different rations was 100 % palatable on our own observations.

The results of the proximate chemical analysis (Table 3) conducted on ration samples before the initiation of the experiment coincides with the proposed rations constructed.

It is worthy to mention that all rations were isoproteinic (~18 % CP) and isocaloric (3.32-3.41 Mcal ME/ kg of concentrates).

2. Experimental animals and Feeding.

As shown in figure 9 that the difference in the initial live body weight (LBW) of all experimental animals (14.90 ± 0.259 Kg) were statistically non-significant (P>0.05) calibrating

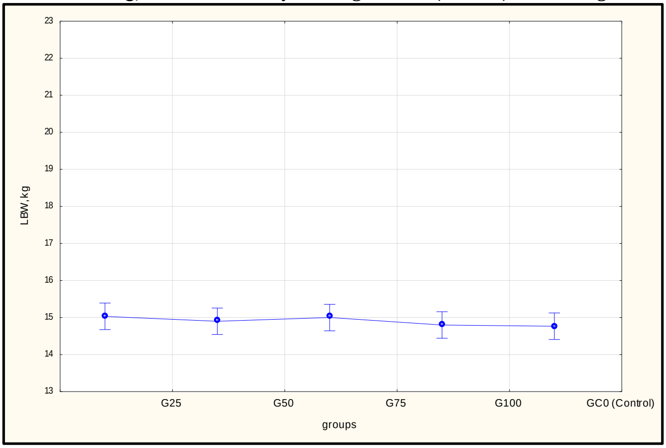

Figure 9. Average Live body weight at the initiation of the experiment, kg/head

from 14.77 kg in SC0 (control group) to 15.03 kg as in group G25 whose animals were fed daily ration containing 25% FBS and 75% SBM.

3.1. Feed Intake (FI)

The amount of concentrate mix fed to animals did not exceed 30 kg/ animal group for the whole period of the experiment. In 1st week the apparent daily concentrate mix intake (adFI) per animal in all groups averaged to 450 g where as at the end of 8th week this average value increased to 550-600 g as 3% of live body weight recalculated as an average after weighing all the animals at the beginning of each proceeding week.

3.1.1. Apparent weekly feed intake/ animal/week (awFI/head/week)

Figure 10 shows the evolution of apparent feed intake per animal per week (awFI). As all animals consumed equally the feeds distributed at 1st week of the experiment insignificant differences (P>0.05) started to appear beginning from 4th week and continued to the end of the experiment. The lowest averaged level of awFI/animal was attained in group G100 (3.46 kg/head/week) and the highest was in group G75 (3.62 kg/head/week) at the 4th week of the experiment.

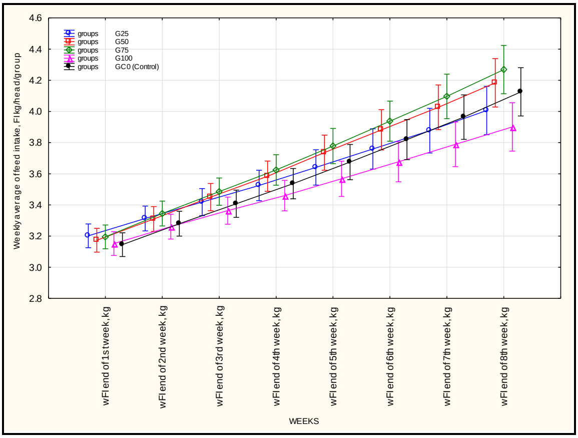

Figure 10. Evolution of apparent weekly average of feed intake/animal, awFI/head, kg concentrates

This tendency continued as figure 10 shows, to grow to the end of the trial with the same ratio, whereas the highest level still was noticed (P>0.05) in G75 (4.3 kg/head/week) where the ratio fed in rations consisted of 25 % SBM to 75 %FBS and the lowest in G100 (3.9 kg/head/week) where SBM was excluded from the daily rations. It is worthy to mention that the result obtained from the control group (GC0) was in the mid-way (4.1 kg/head/week) among the highest and the lowest of all groups (P>0.05).

This might be related to the fact that as Fava bean seeds (FBS) increases in the ration feed intake (FI) as in group G100 decreases where the best was optimized in group G75 whose animals were consuming SBM on the level of 25 % of FBS in concentrate mix. Close to this level was observed in animal group GC0 where FBS was not added (0 %).

3.1.2. Cumulative (overall) feed intake (cFI/head)

Figure 11 shows the overall accumulation of feed intake for the whole period of the experiment, whereas cFI/head of animals of group G100 attained the least values by 28.2 kg and G75 the highest level of cFI/head (29.7 kg) at the end of the experiment (P>0.05).

Once more this might be related to the fact that rations fed to animal-group G100 did not contain SBM and only 100 % FBS making the consumption of rations for goats lower than any other legume-ingredients combination. In other words 14.8 FBS: 85.2 concentrate mix shows the influence of legume to concentrates effect.

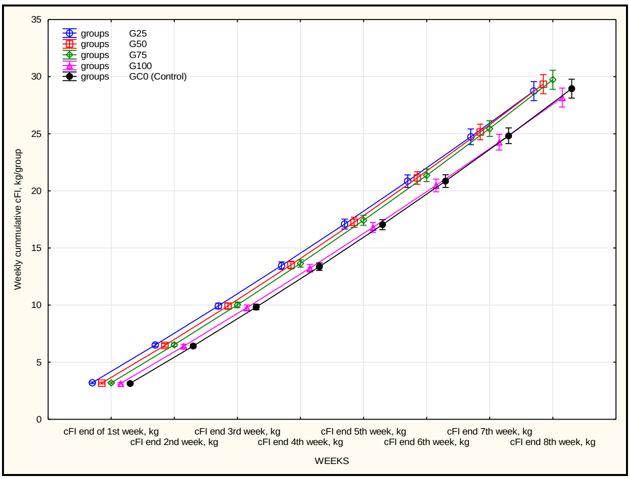

Figure. 11. Cumulative overall average feed intake, cFI/animal, kg

As SBM decreases and FBS increases in rations we observe an increase (P>0.05) in feed intake as in G25 (28.7± 0.42 kg), G50 (29.3 ± 0.75 kg) and G75 (29.7 ± 0.70 kg).

Most properly that inclusion of big amounts of FBS in rations fed to goat kids has a positive effect on feed consumption relating this to the good flavor and taste and anti-nutritional factors contained in Fava bean.

3. Body weight

3.1. Live body weight (LBW).

Figure 12 shows the evolution of live body weight (LBW) at the end of each week from the initiation (fig. 4) of the experiment and till the end. We can clearly notice that during the first 3 weeks of the experiment we recorded insignificant difference (P>0.05) in average LBW among the five treatments attaining the highest in group G75 (16.8 ± 0.38 kg) and the lowest in group G100 (16.1± 0.24 kg). The difference in data between groups G75 and G100 started to grow significantly from 4th week and on attaining the level of 20.7 ± 0.65 and 18.8 ± 0.30 kg/head at the end of 8th week, respectively (P<0.05).

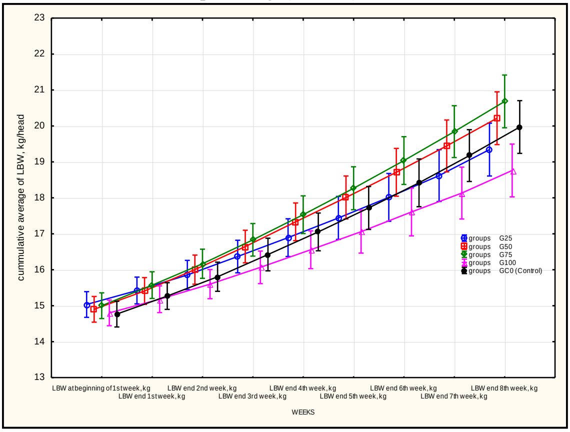

Figure 12. Evolution of Live Body Weight (LBW), kg/head

Our results obtained were in contrast with the findings achieved by Caballero *et al.* (1992) who stated that the use of a small ruminant fattening diet largely based on faba bean gave similar growth performance and meat characteristics compared to the traditional diets based on soybean meal as main protein source.

3.2. Weekly Live Body Weight Gain (wLBWG).

Figure 13 shows weekly live body weight gain (wLBWG), where the best results were achieved in G75 and the least in G100 at the end of the 1st and 8th weeks by 0.57 ± 0.07 kg Vs 0.38 ± 0.04 kg and 0.84 ± 0.03 kg Vs 0.63 ± 0.04 kg, respectively (P<0.05).

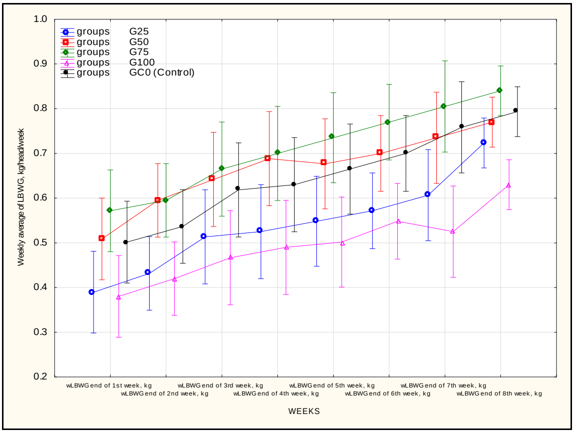

Figure 13. Evolution of weekly average live body weight gain, waLBWG, kg

At the end of the 8th week of the experiment we obtained a significant weekly difference ($P<0.05$) in group G100 (0.63 kg) in comparison with other groups, G50 (0.77), GC0 (0.79) and G75 (0.84 kg).

3.3. Cumulative live body weight gain (cLBWG).

As it is shown in Figure 14 animals of group G75 that were fed a ration containing 25% SBM and 75% FBS gained the highest cumulative weight gain (cLBWG) at the end of the trial attaining the level of 5.68 ± 0.49 kg in comparison with G100 and G25 ($P<0.05$), GC0 and G50 ($P>0.05$) by 3.96 ± 0.30 kg, 4.31 ± 0.25 kg, 5.20 ± 0.75 kg and 5.32 ± 0.44 kg, respectively.

Antongiovanni *et al.* (2002), Martinez *et al.* (2004) and Morbidini *et al.* (2005) obtained results similar to ours on young growing lambs fed faba bean seeds (50-60% of the diet) as the sole protein source in concentrate mix increased daily weight gain demonstrating the already high protein value of faba beans for growing lambs.

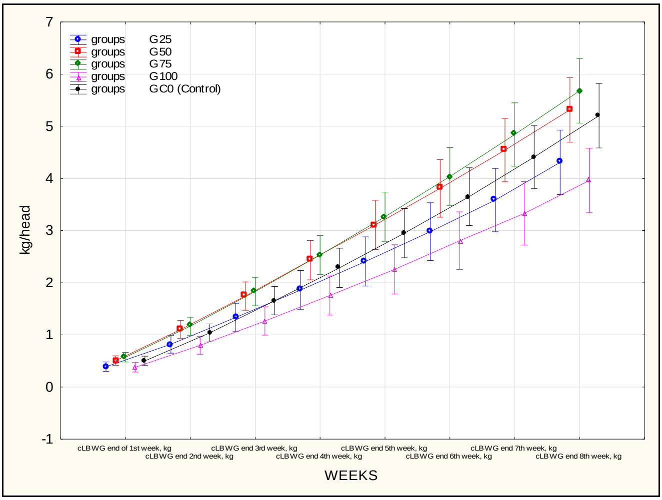

Figure 14. Cumulative live body weight gain, cLBWG, Kg

Duke (1981) suggested the fact that to reduce reliance on imported soybean meal (SBM) in temperate environments, faba bean may be alternative protein sources for small ruminant diets. Faba bean is used as an important source of protein rich food in developing countries and as both food and feed for animals in industrialized countries.

As was shown by Edwards (2004) that, tannins present in the seed coat of faba beans have limited effect on broilers, pigs or ruminants. The trypsin inhibitor activity in faba beans is not well documented but appears to be low.

In agreement to what was proposed by Liener (1976), Dvořák *et al.* (2006) and who stated that the nutritional value of leguminous proteins may be limited by the presence of antinutritional factors. The protease inhibitors, trypsin and chymotrypsin, are perhaps the most widely distributed of all antinutritional factors in legumes. Monogastrics are thought to be more susceptible to the effects of antinutritional factors than ruminants. In fact, for ruminants, trypsin inhibitors are not considered to be important (McDonald *et al.*, 1973). In contrast to Cerioli *et al.* (1998) who concluded that beans have a lower content of trypsin inhibitors than the soybean and can be used as proposed by Matthews and Marcellos (2003) in dairy rations at inclusion levels of up to 35%.

4. Feed-mix Conversion Ratio (FCR)

Figure 15 shows the evolution of feed conversion ratio from week to week. The best results were achieved in group G75 where 25% SBM with 75 % FBS are added to daily ration in the 1st week (5.64) as well as at the end of the 8th week (5.25) in comparison with G100 (8.37 Vs 7.14) and SC0 (6.4 Vs 5.72), respectively.

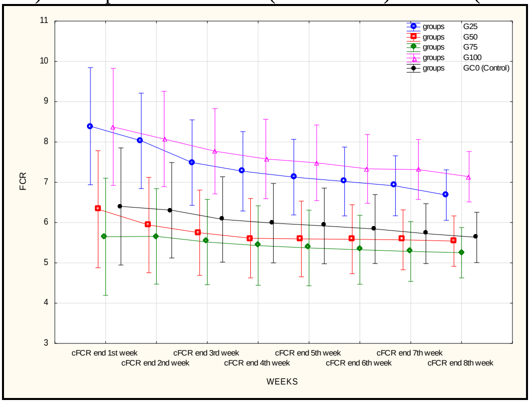

Figure 15. Evolution of cumulative feed conversion ratio, cFCR

Note that this decrease in the efficiency of feed conversion to meat at the 8th week of the experiment was significantly ($P<0.05$) greater in group G100 (7.14 ± 0.56) than G50, G75 (the most efficient) and SC0 attaining the levels of 5.54 ± 0.35, 5.25 ± 0.34 and 5.63 ± 0.72, respectively. Moreover, results achieved at the end of the experiment in groups G25 (6.68 ± 0.33) and G100 (7.13 ± 0.56) were almost insignificantly the same ($P>0.05$).

Once more it was shown that rations containing no SBM like in group G100 have negative effect on conversion of rations to meat by eating more feeds and gaining less weight. On the contrast treatment G75 whose animals were fed rations containing only 25% of SBM with 75 % FBS has maximum positive effect on conversion of feeds to meat.

This can be explained by the findings reported by Miller (1980) that fava bean protein is highly soluble in the rumen. Whereas, Emiola and Gous (2011) agreed that Fava bean feeding at various levels did not affect digestibility.

Although in the trial conducted by Brand *et al.* (1995) performance was not reduced when faba beans were included at 0.2 kg of the diet which was in contrast with our findings. Nevertheless, Results obtained by Abbey *et al.*, 1979; Guillaume, 1977; Rubio *et al.*, 1990; Reddy *et al.*, 1985; Marquardt, 1989; Wiseman & Cole, 1988; Jansman *et al.*, 1995; and Knox *et al.*;1995) were in agreement with our findings. Where performance has been reduced by the inclusion of faba beans this has been attributed to the content of condensed tannins and non-starch polysaccharides (NSP) in the seeds.

5. Feasibility and profit of using FBS vs SBM in rations

Table 10 shows the overall profit of using different combinations of FBS with/without SBM. The most feasible combination to be used is 25 % SBM in combination with 75% FBS (G75) followed by G50 (50 % SBM in combination with 50% FBS) ranging from 14.64 $ to 13.14 $, respectively. Besides the least profit was obtained from G100 (8.37$) where FBS inclusion was 100% followed by G25 (9.12$). In contrast to what was obtained in group G100 where FBS inclusion was 100%, we notice that GC0 where SBM addition to ration was 100% gave acceptable profitable results (12.28 $).

It is worthy to mention that the profit in group G75 was higher than GC0, G100 and G25 by 19.15%, 74.89% and 60.59%, respectively.

Negative profit was calculated in groups G25 and G100 in comparison with GC0 by -25.80% and -31.87%, respectively. Moreover negative profit was realized in group G100 in comparison with G25 by -8.18%

Table 10. Feasibility and profit of feeding SBM Vs FSM to goats, $

Groups	**cost price , $/1kg of rations**	**FCR**	**cost price of 1kg of meat related to cFCR only , $/1kg**	**over all LB WG, kg**	**cost price of kg LB WG, $/kgs**	**selling price $/1kg of meat**	**Income, $ / LB WG**	***profit $ = over all cost of FI ($)-Income of selling meat ($)***	**Profit in comparison with SC0, %**	**Profit in comparison with S100, %**	**Profit in comparison with S25, %**
G25	**0.28**	6.68	**1.88**	4.31	**8.12**	**4**	**17.2**	**9.12**	**-25.80**	8.91	
G50	**0.28**	5.54	**1.53**	5.32	**8.12**	**4**	**21.3**	**13.14**	6.95	56.98	44.14
G75	**0.27**	5.25	**1.42**	5.68	**8.09**	**4**	**22.7**	**14.64**	19.16	74.89	60.59
G100	**0.26**	7.14	**1.89**	3.96	**7.48**	**4**	**15.8**	**8.37**	**-31.87**		**-8.18**
GC0	**0.29**	5.63	**1.64**	5.20	**8.53**	**4**	**20.8**	**12.28**		46.77	34.77

Thus, the development of untraditional protein crops may be a solution to improve the valorization of products and forage grown on the farm. Among alternative protein sources to soybean, lupine and pea seeds have been successfully used in diets for dairy cows in European and American countries (Murphy *et al.* 1987). In addition to these legumes, field beans (FB, *Vicia faba* L.) could represent another interesting alternative, as recently suggested by Volpelli *et al.* (2010) in a study with dairy cows fed organic diets.

6. Physical meat quality of mutton and goat meat

Smith *et al.* (1970), Sañudo *et al.* (1998) and Vergara *et al.* (1999) illustrated a great number of factors affecting carcass traits and meat quality.

6.1. pH indicator of meat

Figure 16 shows the total variations in *post-mortem pH* indicator on meat among all animal groups, mutton as well as Goat.

There was insignificant (P>0.05) *pH* level differences after 24 h *post-mortem* and 7 days of freezing in both types of meat.

In other words pH indicator after 7 days of freezing in both trials (I & II) was more acidic for both types of meat. Nevertheless goat meat was more consistent in being more acidic than mutton calibrating from 6.22 as in GC0 group to 6.29 (P>0.05). Moreover if to compare meat obtained from animals fed 25% FBS in daily ration we notice less acidity than other groups attaining the levels of 6.37 and 6.29 in groups S25 and G25, respectively (P>0.05).

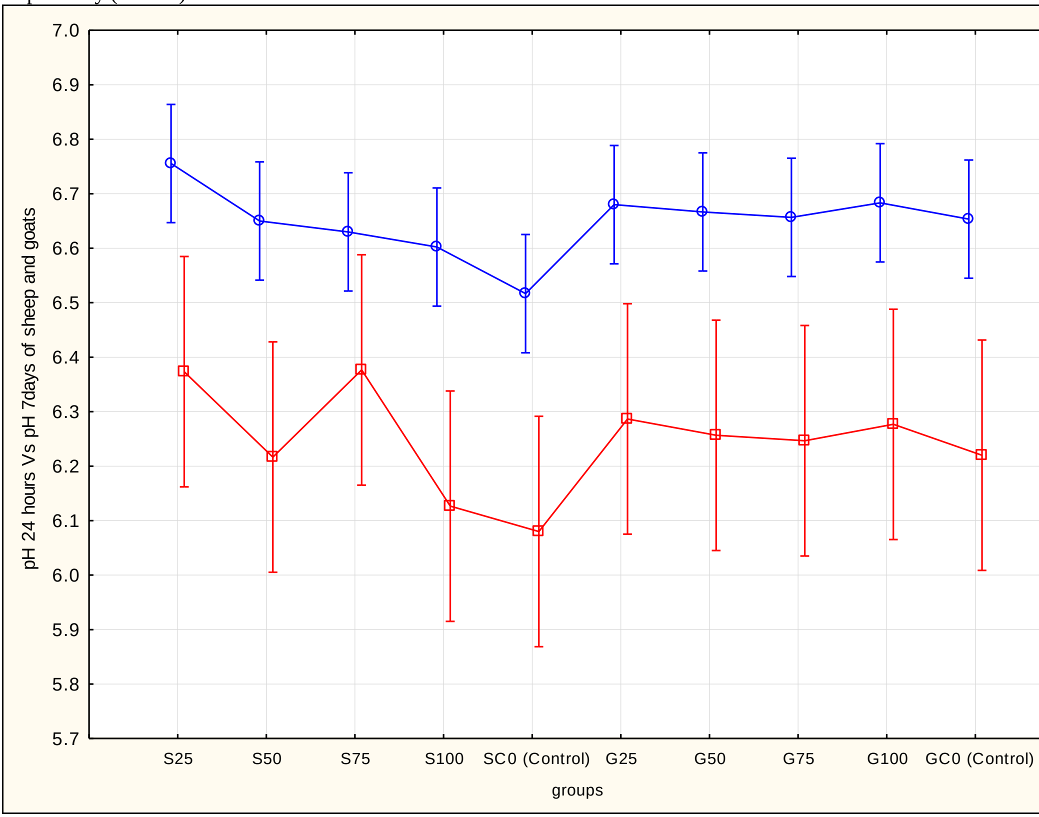

Figure 16. pH indicators after 24 hours *post- mortem* Vs. 7 days of freezing among all groups of mutton and goat meat

6.2. Color

The characteristic color is a function of two factors: the meat pigments and the light-scattering properties (Miller, 1994; Varnam and Sutheland, 1995).

6.2.1. Luminosity (L)

Figure 17 shows the results obtained after testing Luminosity (L) using the Chromometer of goat meat before and after 7 days of freezing. It was noticed that there is no significant differences before (P>0.05) or after (P>0.05) freezing in goat meat among all samples in all animal groups. But it is worthy to mention that raw meat samples taken from the loin eye of animals of G100 (animal group fed rations containing milled Fava bean seeds-FBS as 100% with 0 % soy bean meal- SBM) were lighter in color (51.03) on 0 – 100 scale measurement followed by G75 (50.67) where as in this group animals were fed 25% SBM + 75% FBS (P>0.05).

Data in figure 17 illustrates the comparison in meat quality of Sheep Vs Goats 24 hours after cooling post-mortem and 7 days after freezing. It shows that after cooling results of L* are higher than those obtained after freezing in all animal-groups of both sheep and goats. Lighter in color meat L* on 0-100 scale was scored in groups consuming the highest proportion of SBM: GC0, SC0, G25 and S25s, where it attained the levels of 54.90, 54.54, 54.41 and 55.64, respectively.

Even though meat quality was darker at 24 h post-mortem in all animal groups of both species goats and sheep if compared to that data achieved after freezing we notice that the lowest levels (darkest color of meat) were attained in sheep in group S25 (40.34) whereas the lightest (lighter color of meat) scores was obtained (P<0.05) in G100 (51.02) and G75 (50.67).

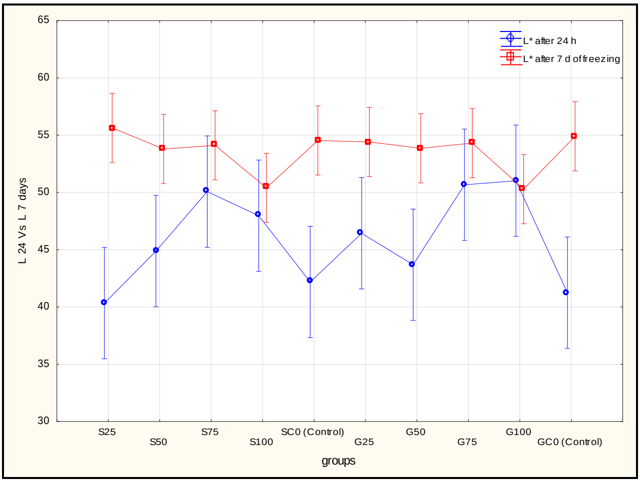

Figure 17. Comparison of luminosity L* between Goat and sheep meat.

Data obtained from figure 17 on raw goat meat before freezing at 24 h *post-mortem* shows that as the %age of SBM increases in rations as in G50- 50 % SBM, G75- 75% SBM and GC0- 100% SBM) meat color (L) becomes relatively darker (P>0.05).

In contrast to what was observed in before freezing, the after freezing Chromometer tests show that as the %age of SBM increases in rations, lighter (L) in color meat was obtained. The highest score was observed in group GC0 attaining the level (P>0.05) of 54.9 (100 % SBM) Vs G100 with 50.29 (100 % FBS).

Moreover Figure 17 shows that raw meat before freezing taken from animal-groups fed SC0 ration containing 100 % SBM followed by S25 with 75 % SBM : 25 % FBS were insignificantly (P>0.05) darker than S50 (44.88), S75 (50.07, P<0.05) and S100 (47.97).

Even though this tendency was seen in after freezing results it was statistically insignificant (P>0.05). The highest scores were attained in groups S25 (55.64) and SC0 (54.54) and GC0 (55.1).

Vasta *et al.* (2008) reviewed the quality of meat from sheep and goats offered alternative feeds legume seeds and pods as a replacement for concentrates. They found that many of these alternative feed resources (AFR) contain secondary compounds, such as tannins. Tannin-containing feeds result in meat of a lighter color and tend to increase protein content, probably because they protect dietary proteins from ruminal degradation.

Kerry *et al.* (2000) and Lawrie (1998) stated that when consumers purchase meat, the color of the meat is the most important attribute associated with freshness of red meat

6.2.2. Redness (a)

Statistically non-significant results are shown in Figure 18 in measuring the redness of goat meat before freezing. The highest redness (a*) of goat meat was achieved in GC0- animal group whose kids were fed rations with 100 % SBM attaining the level of 21.09 (P>0.05) in comparison with all other groups. Although redness in G100 was the lowest (7.75) before freezing, we notice that after freezing this indicator was the highest in this group (13.08) when compared with all experimental animal groups (P>0.05): GC0 (11.20), G75 (8.89), G50 (7.46) and G25 (6.89) in the results obtained for after freezing in animal group.

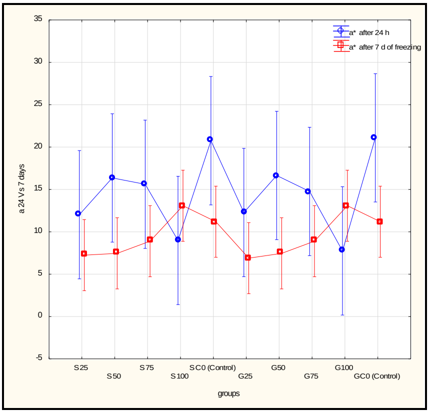

Figure 18. Comparison of redness (a*) between Goat and sheep meat before and after freezing

Note that there is a tendency of reducing the red color of goat meat after freezing as the concentration (%) of SBM increases in the ration to attain the highest level in group G100 with 0 % SBM.

Figure 18 shows the results obtained after testing for sheep meat redness (a*). The same tendency in this trait was shown also in sheep meat (mutton) after freezing revealing the fact that as %age (%) of FBS portion increases in rations fed to Awassi lambs redness goes up attaining the highest score (13.91) in group S100 whose animals were fed 100 % FBS in concentrate mixture followed by S75, S50 and S25 reaching 7.96, 7.21 and 6.74, respectively (P<0.05).

The results obtained before freezing shows a highest level in SC0 whose animals were fed 100 % SBM in daily concentrate mix in comparison with all other groups (P>0.05).

Meat quality as seen in figure 18 shows that better results for redness (a*) were achieved in animal groups GC0 (100 % SBM) before freezing at 24 h *post-mortem* and SCO (100 % FBS) after 7 days of freezing in meat of goat and sheep as well, attaining 21.09, 20.75, 13.08 and 13.91, respectively (P>0.05).

It seems as proposed by Kerry *et al.* (2000) and Lawrie (1998) that the oxygenation of myoglobin, when meat is exposed to air, is responsible for the bright red color of lamb meat. The concentration of hemo-proteins such as hemoglobin, myoglobin and cytochrome C, their chemical states, the type of myoglobin present and the light scattering properties of meat are all factors influencing meat color.

6.2.3. Yellowness (b)

Figure 19 shows the results of Chromometer on yellowness of goat meat achieved before and after freezing. The color indicator b* was higher before freezing in G75 (19.07) animal group fed 25 % SBM: 75 % FBS in daily concentrate mix than all other groups G100 (17.77), G50 (15.15), GC0 (13.16) and G25 (12.44) whose animals were fed with daily rations 100 % FBS, 50% SBM: 50 % FBS, 100 % SBM and 75 % SBM: 25 % FBS, respectively (P>0.05).

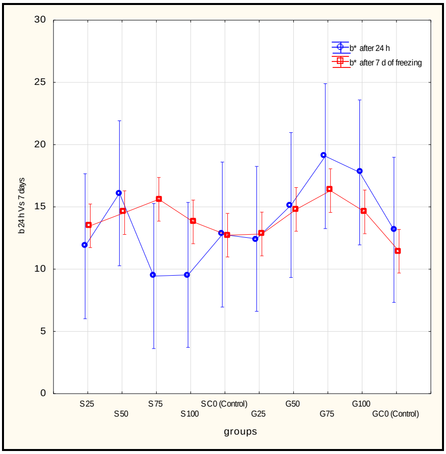

Figure 19. Comparison of yellowness (b*) between goat and sheep meat before and after cooking

Results of group G75 before and after freezing and S75 after 7 days of freezing reveal the fact that meat originating from animals fed 25 % SBM: 75 % FBS contains more fat than other groups fed different proportions of SBM: FBS.

The highest level (P>0.05) of yellowness after 7 days of freezing was obtained in mutton of group S75 (15.61) whereas the lowest level was in group SC0 (12.73). This illustrates the fact that feeding 100 % SBM with rations as in group SC0 results in less fat in meat than other groups like in S75.

Despite the fact that the level of yellowness (b*) indicating stored tissue fat was decreased as shown in S75 (P>0.05) after freezing, we notice that this indicator was pertained in group SC0 in after freezing (12.78) as it was at 24 h of cooling. It is worthy to mention that the lowest level (P>0.05) of yellowness before freezing in sheep meat was obtained in group S75 (9.44) and S100 (9.54) where animals were fed rations containing 75 % and 100 % FBS respectively.

In comparing the data obtained yellowness (b*) between goat and sheep meat before and after freezing shows that the highest level of b* was achieved in goat meat in group G75 before (19.08) and after (16.31) freezing (P>0.05) and GC0 (11) after freezing (P<0.05).

Even though yellowness before freezing was high in both species it was observed that this indicator decreases after freezing on much higher rates in mutton than goat meat (P>0.05).

6.3. Drip loss

Figure 20 shows the variations in the drip loss (DP, %) after 24 hours of refrigerating at 7° C between all animal groups of both sheep and goat meat.

As it is observed from fig. 20 that the largest water loss was realized in both groups SC0 and GC0 fed daily rations containing no FBS, averaging to 22.69 and 24.27 %, respectively (P>0.05). The lowest losses was achieved in all groups containing different proportions of FBS: SBM as in S25, S50, S75, S100, G25, G50, G75 and G100 averaging to 9.15%, 12.80, 12.97, 13.05, 17.11, 13.57, 13.69 and 13.68, respectively (P>0.05).

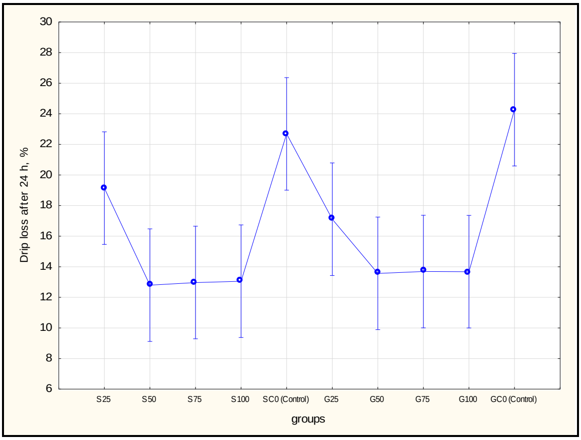

Figure 20. Variations in the drip loss (DL, %) after 24 hours of cooling between sheep and goat meat.

It is worthy to mention that SC0 and GC0 attained statistically significant ($P<0.05$) higher level of drip loss in meat water after 24 h of cooling in comparison with all animal groups except S25 and G25 where this decrease was insignificant ($P>0.05$).

6.4. Thawing Loss

Lawrie (1998) reported that water is generally held between the thin filaments of actin/tropomyosin and the thick myosin filament within muscles. He added that water can be either 'bound' or 'free' in muscles and a total of 75% of muscles are composed of water.

Figure 21 shows that as FBS proportion in rations fed to goat kids increases thawing loss increases, attaining the highest level 10.93 % in the 100 % SBM: 0 % FBS diet such as in group GC0. Despite the fact that neither G25 nor GC0 were significantly different with the results obtained in G25, G50, G75 and G100 ($P>0.05$) we observed that the difference between G25 (5.8 %) and SC0 (12.21%) was statistically significant ($P<0.05$).

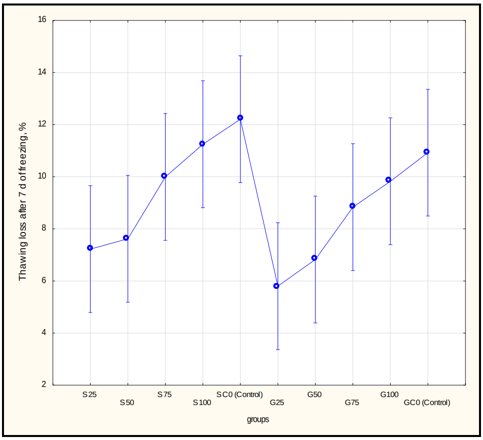

Figure 21. Variations in the thawing loss (TL, %) of meat after 7 days of freezing among sheep and goat meat.

The same tendency as in Goat meat was observed in thawing loss concerning mutton as shown in Figure 21, where the highest level of TL was attained in sheep group SC0 (12.21 %) fed with 100 % SBM and the lowest in group S25 (7.22 %) fed with 75 % SBM: 25 % FBS in rations (P>0.05).

Thawing loss (%) in sheep was higher than that obtained in goat meat as shown in Figure 21 when comparing each two different animal groups fed with the same ingredients as in S25 and G25, S50 and G50, S75 and G75 and S100 and G100, SC0 and GC0 (P>0.05).

The highest values (P>0.05) were in groups SC0 (12.21 %) and GC0 (10.93 %) and the lowest in S25 (7.22 %) and G25 (5.80 %).

6.5. Cooking Loss

Sales (1996**)** and Lawrie (1998) stated that the ability of meat to retain this water during the presence of external factors such as mincing, cutting and storage is known as the water holding capacity (WHC) of meat.

Figure 22 show the different trends in cooking loss after 24h of cooling Vs after 7 days of freezing. It was noticed that water loss after cooking of those samples obtained after 24 h of cooling was highly significant (P<0.05) with those cooked after 7 days of freezing. On the graph we notice the same tendency in variations of high and low spots in both conditions. The least losses in water after cooking was registered in S50, S25, S100, S75 and SC0 losing weight after cooking averaging to 26.18% Vs 11.09%, 27.54 Vs 11.96, 28.25 Vs 12.28, 32.47 Vs 14.27 and 33.15 Vs 13.09% in both conditions, 24 h Vs 7 days, respectively (P<0.05).

Although we observe a statistical significance (P<0.05) in some groups (G25, and G50) of cooking goat meat in both conservative conditions we notice a contradictory increase in groups G100 and GC0 where the loss increases P>0.05).

As long as rations fed to goats contain solely FBS% or SBM% as in groups G100 and GC0 we achieve higher losses in weight of goat meat after cooking after 24 h Vs 7 days, 18.88% Vs 21.38% and 29.47% Vs 27.13%, respectively (P>0.05).

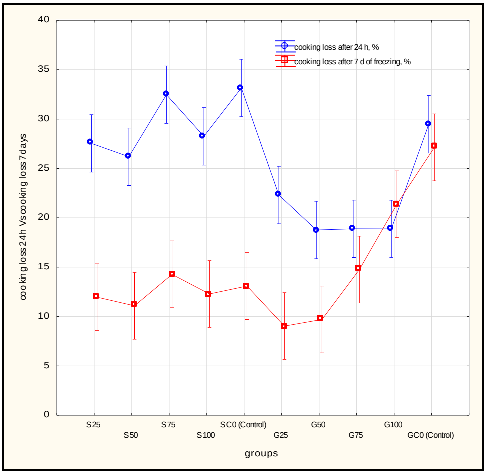

Figure 22. Variations in the sheep and goat meat cooking loss after 24 h of cooling and 7 days of freezing, %

There is a positive significant (P<0.05) correlation (r = 0.424) between color of meat before cooking and water holding capacity after cooking.

6.6. Tenderness

Juiciness is related to the water-holding capacity (WHC) and fat content of the meat. Dry meat is undesirable and excessive drip and exudation is a specific quality defect. Because, meat is sold by weight, drip loss must be minimized for economic reason. Meat from females is juicier than that of males, and meat from lambs slaughtered at medium weights is juicier than that of lambs slaughtered at lighter weights (Miller, 1994; Varnam and Sutherland, 1995; Vergara *et al*., 1999).

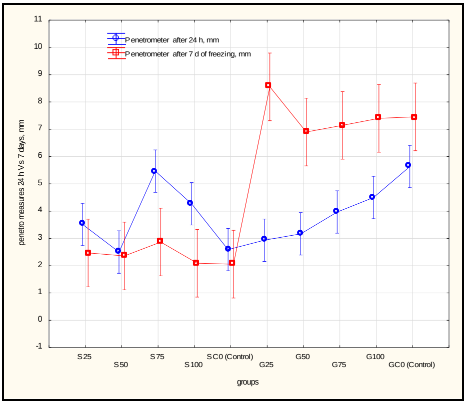

Figure 23. Comparison in penetration force between goat and sheep meat (mm)

Figure 23 shows that at 24 h *post mortem* meat after cooking attained lower level of tenderness (Penetrometer) than those obtained after 7 days of freezing. It was observed that in group G25 the penetration level of the needle after cooking attained the lowest level among the five goat groups (2.93 mm) and attaining the highest (8.56 mm) after thawing and cooking after 7 days of freezing ($P<0.05$).

The lowest level (6.90 mm) of tenderness of goat meat was noticed in group G50 ($P>0.05$) after cooking after 7 days of freezing whose animals were fed rations containing equal proportions of SBM: FBS (50: 50) next to G75 (7.14 mm), G100 (7.40 mm) and GC0 (7.45 mm). Whereas this trait after 24 h for sheep the lowest was obtained in group SC0 (2.06 mm) in comparison with all other groups, S100, S50, S25 and S75 attaining the levels of 2.08, 2.36, 2.47 and 2.87 mm, respectively ($P>0.05$).

It was noticed that as the amount of milled SBM increases in ration fed to sheep groups as in SC0 penetration level decreases attaining the lowest score after cooking in both refrigerating conditions, 24 h Vs 7 days ($P>0.05$).

Comparing the obtained results between goat and sheep meat as shown in Figure 23 we conclude that penetration force of cooked goat meat Vs cooked sheep meat before and after freezing was higher in all animal groups revealing more tenderness of goat meat.

DISUSSION

Feeding and Growth Performance

The choice of selecting Fava Beans as a repalacement for SBM in our experiment agreed with the findings of many researchers as they proposed various species of home-grown grain legumes, such as pea, fava bean, and lupin that represent strategically important alternatives to soybean. They are widely available in Mediterranean areas and increase the sustainability of crop–livestock systems by safeguarding soil fertility and reducing greenhouse gas emissions and use of nitrogen fertilizer (Bonanno *et al*., 2012; Calabrò *et al*., 2015).

Recently, Calabrò *et al.* (2015) noted in their studies that seed legumes have been regarded as alternatives to soybean as sources of protein in animal feeding owing to disputes about the use of genetically modified organisms (GMOs). In addition, Bonanno *et al.* (2012) considered that legume grains have attracted attention as alternative vegetable protein components for feedstuffs that are used in organic production of meat.

The acceptability of fava bean seeds as partial or full replacement for soybean meal in fattening small animals (lams and kids) feeds was investigated in this study. Of interest was whether a significant trend in performance would be evident as a result of the changing proportions of soya and fava beans in the experimental feeds, and whether the animals would consume one of the rations excessively in preference to the other. The results suggest that the nutritional quality of the five rations for lambs as well as kids was sufficiently similar in all respects eventhough performance was not the same on all experimental feeds, but neither of the rations was excessively consumed in preference to the other. Figure 8 shows that lambs of group S100 less efficiently converted feeds into body weight gain than animals of the other groups. It was noticed that from the end of the 1st week wFCR in S100 was inefficiently ($P<0.05$) higher (6.71) than groups S50 (3.31), SC0 (4.17), S75 (4.01) and S25 (5.34) as well ($P>0.05$).

Metabolizale energy (ME) value calculated for all rations containing FBS and SBM was almost identical to the analyzed value (3.32-3.41 Mcal/kg). Moreover, the crude protein content of the lambs and kids rations (~180g/kg) measured in Trials I and II was in good agreement with the values reported by Committee on Animal Nutrition (2007).

Good results were obtained from experiments on Awassi sheep and Sannen kids conducted by Negesse *et al.* (2001), Muruz *et al.* (2017), Burçak and Yalçın, (2018), Yaccoub and Aljammal (2018), Yaccoub *et al.* (2018), Ramos *et al.* (2019) and Yateem *et al.* (2021) in using the same levels of Energy and Protein in their experiments in comparison with the levels that were used in our trials.

Surra *et al.* (1992) conducted two experiments on weaned lambs feeding in rations lentils (Vicia ervilia) and faba (Vicia faba) beans were substituted (50% or 100%) for soybean cake in diets for weaned lambs. Substituting fava beans for soybean cake had no effect on performance of lambs.

Feed Intake

Lamb animals of group S50 that consumed ration consisting of 50% FBS and 50% SBM have higher cumulative feed intake by 7.4%, 4.2%, 12% and 5.4% than that in S25, S75, S100 and SC0, respectively. The highest cumulative feed intake (cFI) at the termination of the experiment was in group S50 (49.35 kg) significantly higher ($P<0.05$) than S100 (43.94 kg).

As for kids the overall accumulation of feed intake for the whole period of the experiment was the highest in goat kids group G75 attaining the level of 29.7 kg at the end of the experiment ($P>0.05$). Moreover the daily average of FI for the complete period calibrated between 0.96kg/head/day for Awassi lambs and 0.59 kg/head/day for Baladi goat kids.

Once more, this might be related to the fact that rations fed to animal-group G100 did not contain SBM and only 100 % FBS making the consumption of rations for goats lower than any other legume-ingredients combination. As SBM decreases and FBS increases in rations we observe an increase ($P>0.05$) in feed intake. Most properly that inclusion of big amounts of FBS in rations fed to goat kids has a positive effect on feed consumption relating this to the good flavor and taste and anti-nutritional factors contained in Fava bean.

Generally, the type of dietary legume supplementation has no effect on growth, animal health and feed palatability in both lambs and kids as well, where no health anomalies or malnutrition were noticed. Whereas no left behind concentrated mix was collected in all over the period of the two trials.

In the present experiment feed intake in both trials increased linearly with fava bean inclusion, suggesting that the animals needed to consume more of this ingredient to meet their nutrient requirements in energy and protein. Similarly, feed intake is unlikely to increase with fava bean content, as it did in our trials, if there is a toxin present in the fava beans.

Giovanni (1984), Surra *et al.* (1992) and Massimiliano *et al.* (1999), observed the same increase in concentrates intake containing Fava bean. The latter suggested that the level and activity of anti-nutritive factors in Fava bean, mainly tannins, have less effect on ruminants than monogastric animals.

In reference, our achieved results coincides with the findings of Surra *et al.* (1992), Caballero *et al.*, 1992, El Maadoudi (2004), Delmotte and Rampanelli (2006) and Lanza *et al.* (1999, 2007, 2011) noting that fava bean is highly palatable for domastic small ruminants, which prefer it to barley. In growing lambs and fattening sheep and goats, including fava beans in isoprotein and isoenergetic diets in substitution for soybean meal did not affect intake, performance and digestibility. They also added that in lambs, including fava beans up to 50% in the diet did not affect meat quality when compared to soybean meal. The use of a diet based largely on fava bean for fattening lambs resulted in growth and meat characteristics similar to the most frequently used diets containing soybean meal as the main source of protein.

Nevertheless, all the results obtained from our research confirmed the findings of Kung *et al.* (1991), Murphy & McNiven (1994), Stanford *et al.* (1996), Vicenti *et al.* (2009), Facciolongo *et al.* (2014, 2015), Lestingi *et al.* (2015a, 2015b, 2016), Yaacoub and Al Jammal (2018) and Yaacoub *et al.* (2018). In their earlier studies, they confirm the use of diets that incorporated fava bean, alone and in mixtures, as alternative protein sources to soybean in feeding for fattening lambs and kids that did not negatively affect the in vivo performances or carcass yield and quality.

The absence of negative effects on intake, growth, and carcass quality, when replacing SBM with fava beans, support the results of previous studies with Simmental bulls fed a maize-silage based diet (Keller *et al.*, 2021) and Marchigiana bulls fed a diet with >550 g concentrate/kg total diet DM (Cutrignelli *et al.*, 2008a;2008b).

Live body weight (LBW) and Live body weight gain (LBWG)

Overall, average weekly gain for lambs and kids (around 172 and 107g/d/head, respectively) was substantially comparable with the one found in similar previous experiments (Caballero *et al.* 1992; Lanza *et al.* 2003b; Loe *et al.* 2004). In addition, carcass weights at the end of the trials were not affected by dietary treatments. The average values attained for lambs the levels of 32.4 and kids 19.8kg/head) were higher compared to those (<17 kg) reported in previous similar experiments where these differences can be probably attributed to different slaughter ages (Lanza *et al.*, 2007).

More over, Loe *et al.* (2004) did not observe significant differences in carcass weights from lambs fed diets with different peas proportions as well as Surra *et al.* (1992) and Purroy *et al.* (1992) between lambs fed diets including different proportions of fava bean and those fed soybean meal-based diets. Carcass classification according to European regulations showed favorable acceptability by local markets with medium fat coverage and good or optimal muscular conformation. Diets with alternative legume seeds, such as peas and fava bean, did not adversely affect growth performance compared to soybean meal diet.

Difference in the initial LBW between Awassi lambs and Baladi kid goats was related to the difference in species where, Baladi kids (14.9 ± 0.259 kg) were lower in LBW than Awassi lambs (23.1 ± 0.52 kg) of the same age. Despite this fact feed intake was significantly (P<0.05) correlated to LBW taking into consideration the size of the animal (Appendix 1, Table 19). Distribution of all animals were equal (P>0.05) in live body weight in reference to the species used (Sheep and goats).

In agreement, Cutrignelli *et al.* (2008a, 2008b) observed a lower live body weight (LBW) at an earlier fattening period for animals fed fava beans instead of SBM, possibly due to limited rumen undergraded protein (RUP) supply leading to negative protein balance in the rumen. However, in the present study, significant differences were found in growth performance at earlier growing periods and continued to the end of the trial especially in S100 and G100 (100% FBS) Vs S50 and G50 (50% FBS: 50% SBM) and S75 and G75 (75% FBS :25% SBM). This fact revealed that, fava beans in appropriate combination with seem to be an applicable replacement for SBM in the diets of fattening sheep and goats.

Even though S50 showed, an intensive decrease in weekly live body weight gain (waLBWG) from week one to week three, where it continued until week six we noticed better absolute average live weights at the end of the experiment. One of the explanations found to clarify this phenomenon; a combination of soybean meal and fava seed meal fed together with daily rations gives better results due to the positive associative effect of feeds, whereas feeding solely SBM or FBS result in lighter weights and minimum body weight gains.

Once more results show that a combination of soybean meal and fava seed meal fed together with daily rations gives better results. Whereas feeding solely SBM or FBS result in lighter weights and minimum body weight gain.

The cumulative live body weight gain cLBWG initiated with the end of the 1st week increased from week to week attaining the highest score after one week of the initiation of the experiment to increase (P<0.05) by 1.6 kg/week in group S50 *Vs* 0.9 kg/week, 1.2, 0.7 and 1.2 kg/week in groups S25, S75, S100 and SC0, respectively.

Animals of group S50 (50% SBM: 50% FBS) kept in increasing in body weight (P<0.05) where they accumulated 5.8 kg/1st month *Vs* 4.1, 3.2 and 4.8 kg/1st month in groups S25, S100 and SC0, respectively followed by 5.2 kg/1st month in group S75 (P>0.05) . It seems that the best combination used in the experimental ration was in concentrates mix fed to group S50, where the highest results were obtained.

This variable for group S50 continued to increase in the same pattern reaching the highest cLBWG at the end of the 2nd month where the experiment was terminated attaining the level of 10.9kg vs. 8.5 and 6.5 kg in groups S25 and S100, respectively and 10.8 and 9.9 kg in groups S75 and SC0 (P>0.05), respectively.

Animals of group G75 that were fed a ration containing 25% SBM and 75% FBS gained the highest cumulative weight gain (cLBWG) at the end of the trial attaining the level of 5.68 kg in comparison with G100 and G25 (P<0.05), GC0 and G50 (P>0.05) by 3.96 kg, 4.31kg, 5.20 kg and 5.32 kg, respectively.

The best results on weekly live body weight gain (wLBWG), were achieved in G75 and the least in G100 at the end of the termination of the trial (P<0.05).

Importantly, experimental concentrates applied in the present study were always completely consumed by the animals, indicating a high palatability of these concentrates independent of protein source. Loe *et al.* (2004) noted that diets with alternative legume seeds, such as peas and fava bean, did not adversely affect growth performance compared to soybean meal diet.

Our results obtained were in contrast with the findings achieved by Caballero *et al.* (1992) who stated that the use of a lamb fattening diet largely based on fava bean gave similar growth performance and meat characteristics compared to the traditional diets based on soybean meal as main protein source.

Antongiovanni *et al.* (2002), Martinez *et al.* (2004) and Morbidini *et al.* (2005) obtained results similar to ours on young growing lambs fed fava bean seeds (50-60% of the diet) as the sole protein source in concentrate mix increased daily weight gain demonstrating the already high protein value of fava beans for growing lambs.

Duke (1981) suggested the fact that to reduce reliance on imported soybean meal (SBM) in temperate environments, fava bean may be alternative protein sources for small ruminant diets. Fava bean is used as an important source of protein rich food in developing countries and as both food and feed for animals in industrialized countries.

As was shown by Edwards (2004) that, tannins present in the seed coat of fava beans have limited effect on broilers, pigs or ruminants. The trypsin inhibitor activity in fava beans is not well documented but appears to be low.

In agreement to what was proposed by Liener (1976), Dvořák *et al.* (2006) and Esenwah and Ikenebomeh (2008) that stated that the nutritional value of leguminous proteins might be limited by the presence of antinutritional factors. The protease inhibitors, trypsin and chymotrypsin, are perhaps the most widely distributed of all antinutritional factors in legumes. Monogastrics are thought to be more susceptible to the effects of antinutritional factors than ruminants. In fact, for ruminants, trypsin inhibitors are not considered important (McDonald *et al.*, 1973). In contrast to Cerioli *et al.* (1998) who concluded that, beans have a lower content of trypsin inhibitors than the soybean and can be used as proposed by Matthews and Marcellos (2003) in dairy rations at inclusion levels of up to 35%.

Feed conversion ratio (FCR)

The highest values (inefficient) in body retention of lambs per week (wFCR) were observed in animal group fed 100% FBS (S100) that calibrated between 60.3% at the end of the 1st and 40.3% by the end of the 8th week in comparison with results obtained in animal group fed 100 % SBM (SC0). This can be explained, by consuming more feeds to convert them to body weight gain and at the same time getting less live body weights due maybe to the overall effect of antinutritional factors found in fava bean seeds which was included as a sole legume ingredient (100% FBS) in ration. Moreover, results that are more efficient were achieved in groups S50 and S75 whose animals were fed a combination of SBM: FBS in different proportions.

If to compare the overall average results among lamb groups for the whole period we observe that wFCR in group S75 (4.36) was less than what was obtained in groups SC0 (4.67), S50 (4.71), S25 (5.31) and S100 (6.89).

Nevertheless lambs of group S100 inefficiently converted feeds into body weight gain than animals of other groups. It was noticed that from the end of the 1st week wFCR in S100 was inefficiently (P<0.05) higher (6.71) than groups S50 (3.31), SC0 (4.17), S75 (4.01) and S25 (5.34) as well (P>0.05).

This can be explained by the findings reported by Miller (1980) that fava bean protein is highly soluble in the rumen. Whereas, Emiola and Gous (2011) agreed that Fava bean feeding at various levels did not affect digestibility. However, Fulpagare (1993) reported that as the level of fava bean increase (from 25 to 100%) in the diet of lambs, the digestibility of dry matter (Ether extract and crude fiber) increase, while that of nitrogen-free extracts (NFE) decreases.

The best results accumulated (P<0.05) at the end of the experiment for lambs was in S75 (4.39) followed by S100 (6.82), S25 (5.39), SC0 (4.74), and the most efficient was S50 (3.92).

In reference, the evolution of feed conversion ratio for goat kids from week to week achieved the best results in group G75 where 25% SBM with 75 % FBS were added to daily ration in the 1st week (5.64) as well as at the end of the 8th week (5.25) in comparison with G100 (8.37 Vs 7.14) and GC0 (6.4 Vs 5.72), respectively.

Once more it was shown that rations containing no SBM like in group G100 have negative effect on conversion of rations to meat by eating more feeds and gaining less weight. On the contrast treatment G75 whose animals were fed rations containing only 25% of SBM with 75%, FBS has maximum positive effect on conversion of feeds to meat.

This can be explained by the findings reported by Miller (1980) that fava bean protein is highly soluble in the rumen. Whereas, Emiola and Gous (2011) agreed that Fava bean feeding at various levels did not affect digestibility of protein. However, Fulpagare (1993) reported that as the level of fava bean increases (from 25 to 100%) in the diet of animals, the digestibility of dry matter (Ether extract and crude fiber) increase, while that of nitrogen-free extracts (NFE) decreases.

Although in the trial conducted by Brand *et al.* (1995) performance was not reduced when fava beans were included at 0.2 kg of the diet, which was in contrast with our findings. Nevertheless, Results obtained by Abbey *et al.*, 1979; Guillaume, 1977; Rubio *et al.*, 1990; Reddy *et al.*, 1985; Marquardt, 1989; Wiseman & Cole, 1988; Jansman *et al.*, 1995 and Knox *et al.*, 1995) were in agreement with our findings. Where performance has been reduced by the inclusion of fava beans this has been attributed to the content of condensed tannins and non-starch polysaccharides (NSP) in the seeds.

Physical characteristics of meat

However, during *post mortem* period, some meat quality parameters may be modified, e.g. pH, Water Holding Capacity (WHC), color and lipid oxidation (Tarsitano *et al.*, 2013). The Meat freshness determines the choice of the product by the consumer (Xiong *et al.*, 2015).

Obtained results on meat pH24 (24 h *post mortem*) show average values between 6.6 for lamb meat and 6.7 for kid meat that can be evaluated as an acceptable quality level and therefore these values might be considered within the range of acceptable values (Hoffman *et al.*, 2003).

In a related context, Calnan *et al.* (2014) found in their obtained results that increasing pH24 across a range of 5.4 to 6 reduced meat redness (a*) in lamb meat. In contrast to what was achieved by the previous researchers, our findings showed a negative correlation (r=-0.4, P<0.05) between pH7 and a* (Appendix, Table 10) after 7days of freezing and not after 24 hours of cooling.

In general, the freezing duration for 7 days in both lamb and kids meats as well showed significant increase (P<0.05) in meat pH where more acidic levels were illustrated after the period of 24 hours of cooling where pH results were basic. Note that, pH24 of goat meat was more basic than sheep and then decreased to become more acidic after 7 days of freezing than sheep with only exception in groups of sheep fed 25% and 75% FBS attaining more basic levels. Regardless of this fact, we notice more acidic levels in both control groups of sheep (SC0) and goat (GC0) *longissimus* muscle as well whose animals were fed 100% SBM. This is attributed to the presence of Soybean inclusion as the only protein legume source in ration. Time after maturation period of 7 days, pH values decreased. This result can explain about growth of lactic acid bacteria, which optimally grow at pH < 6.

In previous studies, the effect of FBS on meat pH was in conflict. Although some authors (Beriain *et al*., 2000; Díaz *et al*., 2003; Ekiz *et al*., 2019a) observed significant influence of FBS on meat pH24, some other studies found no significant variation among lambs slaughtered at different weight groups (Juárez *et al*., 2009). In the earlier studies, significant meat pH24 differences among different groups were generally attributed to differences in response to pre-slaughter processes (Ekiz *et al.,* 2012a) or differences in glycolytic potential (Hopkins and Fogarty, 1998).

In contrast, Oliveira *et al*. (1998), who tested the maturation of bovine biceps femoris muscle at 24 hours, 14 days, 21 days, and 28 days post-mortem, observed an increase in pH. The authors attributed this increase to the greater susceptibility of this muscle to enzymatic attack during maturation due to the increased osmotic pressure of the medium because of the breakdown of proteins into smaller molecules and the intramolecular reorganization of these proteins, which undergo changes in their electric charges.

Luminosity (L*), the red intensity (a*), and the yellow intensity (b*) displayed an increasing linear effect with maturation time of 7 days. With the increase in the maturation period, the meat becomes clearer with increase in a* and b* scores.

With the increase in the maturation period, the meat became clearer, and there was also an increase in a* and b*.

Live body weight of the animals in all stages of the trials was not seen as a correlated trait based on the findings of Tejeda *et al.* (2008) who found no effect of live weight on meat color. Besides that, Martínez-Cerezo *et al.* (2005) noted that a greater effect in meat color is brought about by a change in diet, than either carcass weight or age.

It is worthy to mention that there is a significantly ($P<0.05$) negative correlation ($r=-0.4$) before freezing between a* and b* indicators after freezing.

In other researches the increase in L* may be related to the decrease in the final pH of these meats, as L* displayed an inverse correlation with the pH, indicating that the lower the pH, the greater the luminosity, i.e., the muscle appears clearer (Maganhini *et al*., 2007).

The red intensity (a*) is directly linked to the state and amount of myoglobin present in the meat. Low-pH conditions, such as those seen in meats with greater maturation times, cause a denaturation of globin, leaving the heme function unprotected, which leads to rapid oxidation of the metmyoglobin. According to Arima *et al*. (1997), the matured meat still displayed a different gradient when compared to the non-matured meat, even after equalizing the color, as the iron present in the myoglobin combined with the low oxygen tension turns into the oxidized form (Fe^{+++}), leading to metmyoglobin, which displays a dark color.

The yellow intensity (b*) increased with the increase in the maturation period. According to Sañudo (2004), the increase in the maturation time of the meat tends to make it darker and browner; in other words, b* tends to increase over time.

Upon analyzing the refrigerated storage time of vacuum-packed pork, Apple *et al*. (2001) also obtained similar results for L*, a* and b*, reporting that the color of the loin becomes more vivid and that there is a greater red intensity when the refrigerated storage time is increased.

Similar results were also found by Frederick *et al*. (2006), who tested vacuum-packed and refrigerated pork for 0, 4, and 8 days. As the maturation period increased, there was a linear increase in the mesophilic and psychrotrophic bacterial counts have led to the oxidation of the myoglobin into metmyoglobin, thus increasing a* (Taylor, 1985).

Low-pH conditions, such as those seen in meats with greater maturation times, cause a denaturation of globin, leaving the heme function unprotected, which leads to rapid oxidation of the metmyoglobin. According to Arima *et al*. (1997), the matured meat still displayed a different gradient when compared to the non-matured meat, even after equalizing the color, as the iron present in the myoglobin combined with the low oxygen tension turns into the oxidized form (Fe^{+++}), leading to metmyoglobin, which displays a dark color.

No evidences of dietary effects on meat physical characteristics as a* and b* were found. Ultimate pH values were higher than those reported by Lanza *et al*. (2003a, 2003b) in lambs fed peas based- or chickpeas based diets (5.78 vs 5.5-5.6). The final pH values reflected that animals were not exposed to severe stress during pre-slaughter handling which is of major concern (Geesink *et al.*, 2001). Nevertheless SBM lambs in comparison with FBS showed average pH-value >5.8 which is considered undesirable (Devine *et al.,* 1993).

The lack of significant differences in ultimate pH probably explained the absence of differences among groups in meat color. Lightness values were lower than those found in similar trials in meat from lambs fed different proportions either of peas or of fava beans (Lanza *et al.*, 1999, 2003b). Probably these differences could be attributed to the lower slaughter ages (around 100 days) compared to the age (139 days) in the trial of Lanza *et al.* (1999 and 2003b). Increasing the slaughter age is a well-recognized cause of lowering meat lightness (Santos-Silva *et al.*, 2002). The mesophilic microorganisms are important, as they are primarily acidifying microorganisms.

Meat color is an important criterion to judge the quality and freshness of meat at purchase by consumers (Ekiz *et al*. 2012a). Redness is closely associated with the state and amount of myoglobin in the meat. The luminosity (L*), the red intensity (a*), and the yellow intensity (b*) displayed an increasing linear effect with maturation time.

Drehmer (2005) observed that the increase in the refrigerated storage of meat (0, 7, and 14 days) without using organic acids caused an increase in the mesophilic bacteria counts (2.72, 7.35, and 9.48 CFU/g with increasing refrigeration time). The bacterial load found in this study is within the standard established for meat fit for consumption. Mesophilic microorganism counts are used to indicate the sanitary quality of foods, yet mesophilic bacteria do not represent a potential risk to human health (Capta *et al.,* 1999).

The prolongation of ageing time up to one week of freezing, significantly affected some of the meat quality traits. Lightness, redness, and yellowness increased with prolonged ageing within SBM while in FBS, only redness was affected. This partially disagrees with Li, *et al.* (2014), who only found an ageing time effect on lightness, but not on red- or yellowness in vacuum aged beef. On the other hand, color changes due to ageing have been previously reported for vacuum aged beef by Boakye and Mittal (1996). However, the meat color remained unaffected by ageing in SBM, which may be attributed to the high content of antioxidant carotenoids possibly transferred to the muscle tissue (Li and Liu, 2012; Soni *et al*., 2014).

The drip loss percentage was obvious in animal groups (SC0 and GC) fed 100% SBM in the basic rations. More over thawing loss was higher after 7 days of freezing in sheep meat rather than in goats. Note that the highest losses were achieved in both control groups (SC0 and GC0) where animals were fed 100% SBM in the basic ration. It is worthy to mention that after strict observation it was found that as percentage of FBS in rations increase thawing loss increases linearly. Water loss represents a decreasing linear effect with maturation time; that is, the water retention capacity of the meat increased with the increase in the maturation time. During maturation, could not in fact be a slight increase in water retention capacity due to the proteolytic action of cathepsins, which break down the enzymes of the myofibrillar structure, causing changes in the electrical charges of these proteins. Furthermore, Lawrie (2005) found that this breakdown in the ion-protein relationship increases the absorption of potassium ions (K+) and the release of calcium (Ca++) and sodium (Na+) ions. Roça (2000) added that this exchange of ions during maturation causes better water absorption.

These results are in agreement with those found by Apple *et al.* (2001), who tested the effect of refrigerated storage on the quality of vacuum-packaged pork loins and identified a reduction in the water loss of the loin with increasing storage time (0, 4, and 8 weeks). The fluid lost in freezing present a decreasing linear relationship with maturation time. Due to the slight increase in the water retention capacity of the ageing meat, the fluid lost in freezing was also reduced. Although maturation may improve the water retention capacity of proteins, the *post-mortem* denaturation of the proteins and the decline in pH considerably contribute to a loss of muscle exudates (Lawrie, 2005). According to Miller *et al*. (1996) there is a greater loss of exudate during the refrigerated storage process, thus increasing the fluid lost during cooking. The fluid lost in cooking presented an increasing linear regression with maturation time. With increasing storage period, the water retention capacity of the muscle increases, and therefore, during cooking, there was a greater percentage of fluid to be released. This result was similar to that found by Apple *et al*. (2001), who reported that the percentage of liquid lost due to cooking increased linearly with increasing maturation.

The water holding capacity (WHC) of the meat can increase with time after finishing due to the proteolytic action of cathepsins, which break down enzymes of the myofibrillar structure and influence physioelectrical charges. These changes increase the absorption of ions such as potassium, calcium and sodium (Sung *et al*., 2017), while maturation time affects meat tenderness. Note that in our experiment maturation time of 7 days was tested where our objectives did not take into consideration more periods of maturation.

It is significant to mention that in our study penetration force in mm was used to test meat tenderness which is a new way that couldn’t be found in literature searches, instead the traditional and most common method was in applying the shear force as Warner-Bratzler shear (WBS).

Comparing the obtained results between goat and sheep meat we conclude that penetration force of cooked goat meat Vs cooked sheep meat before and after freezing was higher in all animal groups revealing more tenderness of goat meat.

Tarsitano *et al*. (2013) *reported that d*uring the *period after full maturation, shear force may decrease due to proteolysis of the myofibrillar structural components. When WHC decreases, shear force was observed to increase.*

However, drip loss value of SC0 and GC0 (100% SBM) animal groups was significantly higher than all other groups in Awassi lambs and Baladi goat kids. In contrast with the current results, Vergara *et al.* (1999) found an increase in expressed juice value with increase in lambs fed FBS.

In some previous studies (Ekiz *et al.* 2012b; Yaranoğlu and Özbeyaz, 2019), it has been reported that levels of expressed juice, drip loss and cooking loss are closely related with meat pH24.

Ekiz *et al.* (2012b) found significant and negative correlation of pH24 with expressed juice and cooking loss.

At higher muscle pH, proteins are able to bind with water more strongly and therefore less water is released (De la Fuente *et al.*, 2010; Ekiz *et al.*, 2019). However, in the current study, the correlation of pH24 with expressed juice, drip loss and cooking loss were not significant.

On the other hand, Rajkumar *et al.* (2014) noted that increased meat water holding capacity in heavier lambs might be related to their higher fatness.

One of the reasons of tougher meat in heavy lambs at slaghter might be the decrease in the amount of soluble collagen with increasing age and the increase in the number of heat-resistant linkages between the collagen fibres (Beriain *et al.*, 2000b). Supporting the current results, Ekiz *et al.* (2019) found no signicant differences among the meat of Kivircik lambs slaughtered at 25 kg, 30 kg and 35 kg weights regarding juiciness, odour and flavour intensity

Results of the study indicate that slaughter weight (SW) of young growing animals (at the termination of the experiment) has an evident influence on carcass and meat quality characteristics in both Awassi lambs (about 30 kg SW) and Baladi goat kids (about 20 kg SW).

Cooking loss values were lower than those reported by Lanza *et al.* (2003b) in meat from lambs fed different percentages of peas (19 and 39% on as fed basis) probably due to higher pH values.

Destefanis *et al.* (2008) attributed tough judgement to meat that showed penetrating force values less than 62.8N. Certainly the different cooking method (waterbath) could have negatively influenced penetrating force values obtained in our experiment (from 2.5 to 5.5 mm).

The physical meat quality was not affected by the diets, including FBS or SBM partially or sololey. In contrast, Cutrignelli, *et al.* (2008a; 2008b) found a reduced water holding capacity in meat of faba-bean fed Marchigiana bulls. Calabrò *et al.* (2013) observed a slight reduction in intramuscular fat content in meat of buffalo bulls fed fava beans instead of SBM. The partial substitution of SBM by Fava bean seed fed to fattening lambs and goat kids did not affect meat color (Calabrò *et al*., 2014), which supports the present results obtained with a complete replacement of SBM by FBS. It also seems that including legume protein supplementation basic diets is without consequence for meat composition, water holding capacity, meat color, and meat tenderness of beef cattle (Geletu *et al*., 2021) which is comparable to the present study.

Prolonging ageing successfully promoted tenderization, as exhibited from the higher penetration levels and reported repeatedly by others (Lestingi *et al*., 2019). Note that all levels obtained in all goat groups after cooking after 7 of freezing days were significantly higher ($P<0.05$) meaning tender than those from sheep meat after 24 h of cooling in groups S25 (3.51 mm), S50 (2.50 mm), S75 (5.47 mm), S100 (4.27 mm) and SC0 (2.59).

The penetration force presented decreasing linear behavior with maturation time; that is, it decreased as a function of the maturation time, making the meat tenderer.

The shear force may have decreased due to proteolysis of the myofibril structural components, which occurs during refrigeration (Koohmaraie and Geesink, 2006). The values found indicate that maturation led to meats with a high degree of tenderness, and according to Boleman *et al*. (1997), shear force values for muscle less than 3.6 kgf/cm^2 indicate extremely tender meat. Evaluating the effect of maturation (0, 8, 12, 24, 48, and 72 hours) on the texture of the meat from broiler chickens, Kriese *et al*. (2005) found that the sheer force increased with the maturation time.

Despite this fact a stable minimal difference was observed in sheep meat after cooking, Koohmaraie *et al.* (1990) and Safari *et al.* (2001) concluded that the meat tenderness is the most important attribute affecting meat quality. Forrest *et al.* (1975), Tornberg *et al.* (1985) and Tshabalala *et al.* (2003) found that the ease of penetration, the ease with which meat breaks into fragments and the amount of residue that remains in the mouth after mastication, all contribute to the impression of meat tenderness. Lawrie (1998) reported that muscle fibers primarily affect tenderness where older animals have coarser muscle fibers and are thus tougher while younger animals have finer fibers. He also added that the connective tissue in young animals also has more soluble collagen linked to lower amounts of cross-bond connective tissue where, as animal age increases, the solubility of the collagen decreases, inducing a decrease in enzyme attack susceptibility.

Meat becomes tendered *post mortem* through either a decrease in calpastatin and/or an increase in calpain activity that regulates protein breakdown (Therkildsen *et al.*, 2002). However, Sazili *et al.* (2004) found that a feed restriction early in life, accompanied by an increase in growth rate before slaughter resulted in more tender meat than animals with a fast growth rate throughout their lives. Sazili *et al.* (2004) concluded that this effect is brought about by the interaction between protein synthesis and protein degradation on calpain and calpastatin activity.

Feasibility study

The overall profit of using legumes of FBS in combination with 50% and 25% SBM leveled to 53.61 and 51.95 $, was better than group SC0 (45.74 $) by 17.20 and 13.57 %, respectively. Whereas the lowest profit was achieved in S100 (27.28 $) and S25 (38.08 $) animal groups reaching a negative effect by -40.37 and -16.76 %, respectively.

The results obtained show that feeding FBS with combination with SBM as 50: 50 % as in groups S50 and S75 gave the best and higher results. Moreover feeding FBS (S100) and SBM as 100% (SC0) as the sole legume ingredient or 75% (S25) as in combination with 25%, FBS did not succeed in giving more profit than other animal groups. Besides feeding rations containing 50 % FBS: 50 % SBM and 25 % FBS: 75 % SBM gave better profit than feeding with 25 % FBS: 75 % SBM by 96.54 and 90.44 %, respectively.

Concerning goat meat the most feasible combination to be used was 25 % SBM in combination with 75% FBS (G75) followed by G50 (50 % SBM in combination with 50% FBS) ranging from 14.64 $ to 13.14 $, respectively. Besides the least profit was obtained from G100 (8.37$) where FBS inclusion was 100% followed by G25 (9.12$). In contrast to what was obtained in group G100 where FBS inclusion was 100%, we notice that GC0 where SBM addition to ration was 100% gave acceptable profitable results (12.28 $).

It is worthy to mention that the profit in group G75 was higher than GC0, G100 and G25 by 19.15%, 74.89% and 60.59%, respectively.

Negative profit was calculated in groups G25 and G100 in comparison with GC0 by -25.80% and -31.87%, respectively. Moreover, negative profit was realized in group G100 in comparison with G25 by -8.18%

Thus, the development of untraditional protein crops may be a solution to improve the valorization of products and forage grown on the farm. Among alternative protein sources to soybean, lupine and pea seeds have been successfully used in diets for dairy cows in European and American countries (Murphy *et al.* 1987). In addition to these legumes, field beans (FB, *Vicia faba* L.) could represent another interesting alternative, as recently suggested by Volpelli *et al.* (2010) in a study with dairy cows fed organic diets.

Conclusions on main study objectives.

The current study's research objectives broadly sought to evaluate the potential of Fava been seeds as alternative protein sources in feeds. The evaluation was designed around the in vivo evaluation the dietary effects of completely and partially substituting SBM with fava been seeds on growth performance and meat quality. It was concluded that:

- The fava been seeds qualified as potential legume protein sources in feeds and could be used /evaluated as feed ingredients with no risk of deleterious effects on growth (body mass, linear growth and physical meat quality) in growing male kids and lambs.
- The development of untraditional protein crops may be a solution to improve the valorization of products and forage grown on the farm. Among alternative protein sources to soybean, Fava bean seeds can be successfully used in diets for small ruminants.
- Field beans (FB, *Vicia faba L.*) could represent another interesting alternative to small ruminants fed organic diets.
- Concerning goat meat the most feasible combination to be used was 25 % SBM in combination with 75% FBS (G75) followed by G50 (50 % SBM in combination with 50% FBS) ranging from 14.64 $ to 13.14 $, respectively.
- Feeding rations containing 50 % FBS: 50 % SBM and 25 % FBS: 75 % SBM gave better profit than feeding with 25 %FBS: 75 % SBM by 96.54 and 90.44 %, respectively.
- The partial substitution of SBM by Fava bean seed fed to fattening lambs and goat kids did not affect meat color
- Obtained results on meat pH_{24} (24 h post mortem) show average values between 6.6 for lamb meat and 6.7 for kid meat fed FBS to substitute partially or fully the addition of SBM that can be evaluated as an acceptable quality level and therefore these values might be considered within the range of acceptable values.
- Rations containing no SBM like in group G100 have negative effect on conversion of rations to meat by eating more feeds and gaining less weight. On the contrast treatment G75 whose animals were fed rations containing only 25% of SBM with 75%, FBS has maximum positive effect on conversion of feeds to meat.
- The best results on weekly live body weight gain (wLBWG), were achieved in G75 and the least in G100 at the end of the termination of the trial.
- Animals of group G75 that were fed a ration containing 25% SBM and 75% FBS gained the highest cumulative weight gain (cLBWG) at the end of the trial.
- As SBM decreases and FBS increases in rations we observe an increase in feed intake. Most properly that inclusion of big amounts of FBS in rations fed to goat kids has a positive effect on feed consumption relating this to the good flavor and taste and anti-nutritional factors contained in Fava bean.

Recommendations for practice

- Based on the present findings, SBM can be replaced by FBS legume protein sources on an isonitrogenous basis in diets comprising 50% SBM with 50% FBS concentrate without impairing performance, carcass and meat quality, thus confirming hypothesis.

- In summary, the 50: 50 and 75: 25 proportion of FBS: SBM improved the meat quality profile compared to values reported for conventional fattening diets, while maintaining reasonable animal performance and carcass and meat quality, without additional metabolizable protein-concentrate supplementation.

List of Publications

Conference papers

1. Participation in a scientific conference (IX-AGROSYM 4-7 Oct 2018) with 2 oral Presentations: The effect of feeding weaned awassi male lambs with faba beans (*vicia faba*) as compared to soybean meal on body performnace and meat quality.

   Two papers were published in IX-AGROSYM Proceedings:

2. **Rami Yaacoub**, Zaprianka Shindarska, Boulos Al Jammal. 2018. Effect Of Feeding Weaned Awassi Male Lambs With Faba Beans (Vicia Faba) As Compared To Soybean Meal On Body Performance. IX International Scientific Agricultural Symposium "Agrosym 2018" Jahorina, October 04-07, 2018, Bosnia and Herzegovina, p. 1712-1717.
3. **Rami Yaacoub**, Boulos Al Jammal. 2018. The Effect Of Feeding Weaned Local Male Kids Goats "Baladi Breed" With Faba Beans (Vicia Faba) As Compared To Soybean Meal On Body Performnace. IX International Scientific Agricultural Symposium "Agrosym 2018" Jahorina, October 04-07, 2018, Bosnia and Herzegovina, p. 1718-1723.

Journal papers

4. **Rami Yaacoub**. 2022. The effect of replacing soybean meal with Fava bean seeds in daily ration of Lebanese Baladi goat kids and Awassi sheep lambs: 1- Body performance. Int. J. Environ. Agric. Biotech., Vol-7, Issue-4: 216- 229. Jul-Aug, 2022. https://ijeab.com/. DOI: 10.22161/ijeab.
5. **Rami Yaacoub**. 2022. The effect of replacing soybean meal with Fava bean seeds in daily ration of Lebanese Baladi goat kids and Awassi sheep lambs: 2- Meat Quality. Int. J. Environ. Agric. Biotech., Vol-7, Issue-4: 230- 247. Jul-Aug, 2022. https://ijeab.com/. DOI: 10.22161/ijeab.

Abstract

The aim of the study was to investigate the partial and complete substitution of imported soybean meal (SBM) with Fava bean seeds (FBS) in Awassi male lambs and local baladi goat kids rations and the consequences on performance and meat physical quality. Fifteen growing lambs and 15 growing kids were fed a cotton-seed meal (CSM), wheat bran and corn-based diet supplemented with a protein legume sources in different proportions, 25% FBS :75% SBM (S25 & G25), 50%FBS :50% SBM (S50 & G50), 75% FBS : 25% SBM (S75 & G75), 0% FBS :100% SBM (S100 and G100-positive control) and 100% FBS : 0% SBM (SC & GC0- negative control) resulting in isoenergaetic and isoproteinic concentrate mix distributed on 5 groups for each animal species. Local baladi goat kids attained a cumulative LBWG levels of 5.7 and 3.96 kg/head and cumulative FI of 28.2 and 29.7 kg/head. Feed conversion ratio (FCR) for lambs attained the best results in group S50 (3.92) and the least in S100 (6.82) and for kids 7.14 in G100 and 5.25 in G75 groups. Physical quality of meat did not differ much among groups. pH indicator after 7 days of freezing in both trials (I & II) was more acidic for both types of meat. Nevertheless goat meat was more consistent in being more acidic than mutton calibrating from 6.22 as in GC0 group to 6.29 in G25 (P>0.05). Moreover if to compare meat obtained from animals fed 25% FBS in daily ration we notice less acidity than other groups attaining the levels of 6.37 and 6.29 in groups S25 and G25, respectively (P>0.05). It shows that after cooling results of L* are higher than those obtained after freezing in all animal-groups of both sheep and goats. Lighter in color meat L* on 0-100 scale was scored in groups consuming the highest proportion of SBM: GC0, SC0, G25 and S25s, where it attained the levels of 54.90, 54.54, 54.41 and 55.64, respectively. The highest redness (a*) of goat meat was achieved in GC0- animal group attaining the level of 21.09 (P>0.05) in comparison with all other groups. Although redness in G100 was the lowest (7.75) before freezing, we notice that after freezing this indicator was the highest in this group (13.08). Better results for redness (a*) were achieved in animal groups GC0 (100 % SBM) before freezing at 24 h *post-mortem* and SCO (100 % FBS) after 7 days of freezing in meat of goat and sheep as well, attaining 21.09, 20.75, 13.08 and 13.91, respectively (P>0.05). By comparing the data obtained yellowness (b*) between goat and sheep meat before and after freezing it shows that the highest level of b* was achieved in goat meat in group G75 before (19.08) and after (16.31) freezing (P>0.05) and GC0 (11) after freezing (P<0.05). Even though yellowness before freezing was high in both species it was observed that this indicator decreases after freezing on much higher rates in mutton than goat meat (P>0.05). Thawing loss (%) in sheep was higher than that obtained in goat meat when comparing each two different animal groups fed with the same ingredients as in S25 and G25, S50 and G50, S75 and G75 and S100 and G100, SC0 and GC0 (P>0.05). The least cooking losses in water was registered in S50, S25, S100, S75 and SC0 losing weight after cooking averaging to 26.18% Vs 11.09%, 27.54 Vs 11.96, 28.25 Vs 12.28, 32.47 Vs 14.27 and 33.15 Vs 13.09% in both conditions, 24 h Vs 7 days, respectively (P<0.05). The lowest level (6.90 mm) of tenderness of goat meat was noticed in group G50 (P>0.05) after cooking after 7 days of freezing whose animals were fed rations containing equal proportions of SBM: FBS (50: 50) next to G75 (7.14 mm), G100 (7.40 mm) and GC0 (7.45 mm). Whereas this trait after 24 h for sheep the lowest was obtained in group SC0 (2.06 mm) in comparison with all other groups, S100, S50, S25 and S75 attaining the levels of 2.08, 2.36, 2.47 and 2.87 mm, respectively (P>0.05). Note that all levels obtained in all goat groups after cooking after 7 of freezing days were significantly higher (P<0.05) meaning tender than those from sheep meat after freezing and 24 h of cooling in groups S25 (3.51 mm), S50 (2.50 mm), S75 (5.47 mm), S100 (4.27 mm) and SC0 (2.59). Most notably, omitting soybean meal with or without additional protein legume as fava bean seeds replacements resulted in comparable meat quality while maintaining a high-performance level. Consequently, the cotton-seed meal (CSM) and wheat bran-based diet supplemented with a grain-based concentrate like corn with 50% SBM and 50% FBS as additional protein legume source was the most sustainable diet for growing animals tested in this study.

Keywords: Soybean meal; fava bean seeds; Awassi lambs; goat kids; physical meat quality.