

## Evaluating Production Performance of Tigray Highland Sheep Supplemented with Air Dried Foliages of African Wild Olive and Red Thorn: A Case Study of Carcass Production

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### Abstract

An experiment was conducted at Wukro St. Mary Agricultural, Technical, Vocational Education and Training College to determine effect of feeding foliages from African wild olive and Red thorn on growth performance and carcass production of Tigray Highland sheep and to assess their economic benefits. Chemical composition and supplementation effect of foliages of these indigenous tree species on growth performance of Tigray Highland sheep is available on line. Including air dried foliages of the multipurpose trees as protein supplement to grass hay improved carcass production. Supplemented sheep had significantly ( $P < 0.05$ ) higher slaughter weight, empty body weight, hot carcass weight and dressing percentage on slaughter weight basis than the control treatment. It was economically feasible to poor smallholder sheep owners in the area, but supplementing T4 (mixed air dried foliages) was found as cost-effective with its high net income. The results obtained indicated that feeding foliages from the multipurpose trees alone or mixing at different proportions had potential as protein supplement with less expense.

**Keywords:** Carcass; Economic benefits; Foliages; Sheep

### Introduction

In Ethiopia, sheep are the second most important and numerous species next to cattle. They are dominantly kept by smallholders in the highlands and lowlands for immediate cash income, food (milk and meat) and non-food products such as manure, skin and wool. Besides, sheep are used as savings, and have social and economic importance to the producers. However, their production and productivity potential is very low, of the challenges, inadequate and low quality feed, lack of effective and sustainable breeding programs, absence of institutional and policy makers' commitments are examples.

The main concern of this paper is, however, to evaluate effect of supplementing foliages of selected indigenous multipurpose trees and their mixtures on carcass characteristics and to estimate their economic benefits. Basically, this piece of work is based on the fact that foliages obtained from locally available indigenous multipurpose trees especially African wild olive (*Olea Africana*) and Red thorn (*Acacia lahai*) are used as animal feed mainly during dry season by livestock owners in the study area. Protein rich agro-industrial byproducts are costly and economically not feasible to poor livestock owners. In 1991, Pezo [1] noted that a potential strategy for increasing the quality and availability of feeds for smallholder ruminant animals in the dry season may be through the use of fodder trees and shrub forages.

Thus, determining chemical composition and identifying the appropriate supplementation level or amount of locally adapted multipurpose trees is essential. This helps farmers to get scientific information about the indigenous and drought resistant multipurpose trees as an animal feed. Therefore, the present study was conducted to achieve the following specific objectives:

- To evaluate effect of supplementation with air dried foliages from African wild olive and Red thorn, and their mixtures on carcass production of Tigray Highland sheep.
- To assess economic benefits of supplementation with air dried foliages from African wild olive or Red thorn sole, and their mixtures.

### Materials and Methods

#### Description of the study area

The study was conducted at Wukro St. Marry ATVET College which is located at North East of Ethiopia. The area is found at a distance of 823 km from Addis Ababa. Geographically the study area lies at 13°47'N latitude and 39°35'E longitude at 2075 meters above sea level. The area receives 400 mm annual rainfall, which occurs between Mid June and September of the year. Annual temperature of the study site ranges from 17°C to 23°C.

#### Feed collection and preparation

Leaves of African wild olive (*Olea Africana*) and Red thorn (*Acacia lahai*) were collected and dried under shade. Leave meals, required for the whole experimental period, were thoroughly mixed and stored in well prepared sacks. Grass hay and nouge seed cake were purchased from local markets. In order to avoid malnutrition in controlled animals, sixty gram nouge seed cake (NSC) was provided to all experimental animals equally.

#### Feeding and sampling procedure

All animals were offered grass hay *ad libitum* plus sixty g NSC as a basal diet. Grass hay was offered three times per day at 8:30 am just after leave meals are offered; at 12:00 am and 5:00 pm. Grass hay offered was adjusted every ten days ensuring a refusal of twenty per cent based

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on previous days intake of an individual animal. NSC was weighed and offered to individual animal once a day, in the early morning. At each feeding, the proportion of leave meals required daily as per the treatment were weighed separately, mixed and offered at 0800 and 1600 hours at equal portions to animals accordingly. Samples for chemical analysis were taken from each sack during the experiment at the time when a new sack was opened for feeding from leave meals and NSC. Samples from the offered grass hay and its refusals were also taken during the experimental period. After samples were thoroughly mixed, subsamples were taken for chemical analysis.

### Chemical analysis

Chemical analysis was carried out in order to determine dry matter (DM), crude protein (CP), ash, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL). Feed samples and partially dried fecal samples (60°C for 72 hours) were milled to pass through 1 mm screen for chemical analysis. DM of feeds and feces was determined after oven drying (105°C for 12 hours). Feed offered, refusals and feces were analyzed for DM, Ash and CP following AOAC (1990). CP was estimated as  $N \times 6.25$  and organic matter (OM) by subtracting ash from 100. NDF and ADF contents for feed and feces and ADL for feed only were analyzed according to Van Soest and Robertson [2] procedure.

### Animals and experimental design

The study was conducted on twenty five yearling intact Tigray Highland sheep weighing  $16.70 \pm 2.10$  kg (mean  $\pm$  standard deviation) initial body weight. Age of experimental animals was determined by dentition and information from owners. Experimental animals were quarantined for 15 days and vaccinated against internal and external parasites using broad spectrum antihelminthic (albendazol bolus) and diazole, respectively. Randomized Complete Block Design (RCBD) was used. Just after quarantine period, animals were grouped in to five blocks depending on their initial body weight and randomly assigned to five treatment feeds viz. T1 (control): grass hay *ad libitum* + 60 gram NSC + 0 gram olive leaves and *acacia lahai* leaves; T2: T1 + 300 gram olive leaves + 0 gram *acacia lahai* leaves; T3: T1 + 195 gram olive leaves + 105 gram *acacia lahai* leaves; T4: 105 gram olive leaves + 195 gram *acacia lahai* leaves; T5: T1 + 0 gram olive leaves + 300 gram *acacia lahai* leaves. All animals were under close observation for health problems until the end of the experimental period.

### Carcass characteristics and slaughtering procedure

After the completion of feeding period (ninety days), four animals as per treatment that is twenty sheep were fasted over night, weighed and slaughtered. On slaughtering, the animals were killed by severing the jugular vein and the carotid artery with sharp knife. Blood of all animals was drained in to different thin plastic bags and weighed for each animal separately. After the processes of slaughtering and flaying skin were completed; skin (with ears and by removing legs below the fetlock joints), head, tongue and feet were weighed independently. This was followed by weighing the components of the entire alimentary canal (esophagus, reticulo-rumen, omaso-abomasum, small and large intestines) with and without contents individually. Internal main organs (lung with trachea, heart, liver with gall bladder, spleen and kidney) and other parts such as total fat (omental and kidney), penis, testicles, tail and empty body weight were weighed and recorded separately for each animal.

Non-carcass offal components which represent additional protein and energy sources for human consumption [3], due to differences in taste and eating habit, saleable and edible proportions of the carcass

in one area of a country may not be acceptable in other parts of the country. By considering this fact, categorization of non-carcass offal components as edible and/or non edible was done based on the eating habit and culture of the people in the surrounding area where this study was conducted. The total edible offal components were taken as the sum total weight of blood, head, tongue, heart, liver with gall bladder, kidney, small and large intestines, reticulo-rumen, omaso-abomasum, tail and fat (omental and kidney), while usable products were taken as the sum total weight of hot carcass weight, total edible offal components and skin. On the other hand, non-edible offal components were considered as the sum total of the weight of lung with trachea, skin, penis, testicles, spleen, feet and gut fill.

After the completion of all measurements, carcass weight was recorded to assess dressing percentage on slaughter weight and empty body weight bases. Empty body weight was determined by subtracting weight of gut fill from the slaughter weight. The hot carcass weight was measured after removing weight of skin, head, thoracic, abdominal and pelvic cavity contents as well as legs below the hook and knee joints.

The rib-eye (*longissimus dorsi*) muscle area of each animal was determined by tracing the cross sectional area between the 11<sup>th</sup> and 12<sup>th</sup> ribs [4], after cutting perpendicular to the back bone. The left and right rib-eye muscle area was traced on a transparent waterproof paper and the area was calculated by using planimeter. The mean of the right and left cross sectional areas was taken as a rib-eye muscle area.

### Partial budget analysis

Partial budget analysis was carried out for determination of the potential profitability of the new technology. Purchasing and selling prices of sheep, purchasing price of whole basal diet (grass hay + NSC) and labor cost for supplementary feed (feed collector (s) of leaves of native browses) were recorded. Other expenses such as transport (animals and feed), labor (feeder) and veterinary services were not considered since they remain common for all treatments.

Three well experienced sheep market dealers in the surrounding area were invited in order to estimate selling price of individual sheep. The difference of sheep price in each treatment, before (purchasing price) and after (selling price) the experiment was considered as total return (TR) in the partial budget analysis. The net income (NI) was calculated by subtracting total variable cost (TVC), which includes the cost of all recorded inputs that change due to the change in production technology, from the total return (TR):  $NI = TR - TVC$ .

Change in net income is the most important criterion in deciding acceptance of new technology and therefore, the change in net income ( $\Delta NI$ ) was calculated as the difference between the change in total return ( $\Delta TR$ ) and the change in total variable cost ( $\Delta TVC$ ), and calculated as;

$$\Delta NI = \Delta TR - \Delta TVC.$$

The marginal rate of return (MRR), in order to measure the increase in net income with each additional unit -expenditure was calculated as:

$$MRR = \frac{\Delta NI}{\Delta TVC} \times 100$$

### Statistical analysis

The one way analysis of variance (ANOVA) of data on carcass characteristics was run using the general linear model procedure (GLM) of SAS (2002). Differences between the treatments were tested using least significant difference (LSD) test.

Carcass parameters were analyzed using the ANOVA model for RCBD given below;

$Y_{ij} = \mu + T_i + B_j + E_{ij}$ . Where;  $Y_{ij}$  = the response variable,  $\mu$  = the overall mean,  $T_i$  = the  $i^{\text{th}}$  treatment effect,  $B_j$  = the  $j^{\text{th}}$  block effect and  $E_{ij}$  = the random error.

## Result and Discussion

### Chemical composition

Leave meals and NSC had high CP and low NDF than hay. However, hay refusals were characterized by low CP and high NDF as compared to the hay offered (available online @ [www.globalacademicresearchjournals.org](http://www.globalacademicresearchjournals.org)).

### Feed intake and growth performance

Significantly ( $P < 0.05$ ) higher DM intake of grass hay (basal feed) and significantly ( $P < 0.05$ ) lower total dry matter intake were recorded in control treatment. However, nonsignificant ( $P > 0.05$ ) differences between foliage supplemented groups. Provided NSC was readily consumed by all animals with no refusals.

The average daily body weight gain for the supplemented sheep was 39.25 g/day/head and 7.4 g/day/head in control group. The positive average daily body weight gain observed in T1 supplemented sheep is attributed to the good

quality of basal diet and the inclusion of sixty gram NSC (available online @ [www.globalacademicresearchjournals.org](http://www.globalacademicresearchjournals.org)).

### Slaughter weight, hot carcass weight and dressing percentage

Values for slaughter weight, empty body weight, hot carcass weight, dressing percentage (slaughter and empty body weights bases) and rib eye muscle area of the experimental sheep are given in Table 1. Animals supplemented with air dried leaves of sole or mixtures of the multipurpose trees had higher slaughter weight and hot carcass weight ( $P < 0.01$ ), and empty body weight ( $P < 0.001$ ) than non-supplemented ones, but the supplemented treatments were not statistically ( $P > 0.05$ ) different among themselves.

Dressing percentage is both a yield and value determining factor. In the present study, supplementation improved dressing percentage as calculated on slaughter weight ( $P < 0.001$ ) basis; without significant ( $P > 0.05$ ) difference among the supplemented groups. However, there was no significant ( $P > 0.05$ ) difference between supplemented and non-supplemented groups for dressing percentage as calculated on empty body weight basis. The lack of significant difference in dressing

| Carcass characteristics                | Treatment feeds   |                   |                   |                   |                   | SEM  | SL  |
|--|-------------------|-------------------|-------------------|-------------------|-------------------|------|-----|
|  | T1                | T2                | T3                | T4                | T5                |      |     |
| Slaughter weight (kg)                  | 17.0 <sup>b</sup> | 19.0 <sup>a</sup> | 19.9 <sup>a</sup> | 20.0 <sup>a</sup> | 19.1 <sup>a</sup> | 0.3  | **  |
| Empty body weight (kg)                 | 12.2 <sup>b</sup> | 15.1 <sup>a</sup> | 15.9 <sup>a</sup> | 16.3 <sup>a</sup> | 15.0 <sup>a</sup> | 0.4  | *** |
| Hot carcass weight (kg)                | 6.8 <sup>b</sup>  | 8.5 <sup>a</sup>  | 9.0 <sup>a</sup>  | 9.1 <sup>a</sup>  | 8.5 <sup>a</sup>  | 0.24 | **  |
| <b>Dressing percentage</b>             |                   |                   |                   |                   |                   |      |     |
| Slaughter weight basis (%)             | 39.7 <sup>b</sup> | 44.5 <sup>a</sup> | 45.0 <sup>a</sup> | 45.2 <sup>a</sup> | 44.3 <sup>a</sup> | 0.74 | *** |
| Empty body weight basis (%)            | 55.4              | 56                | 56.4              | 55.7              | 56.4              | 0.71 | ns  |
| Rib eye muscle area (cm <sup>2</sup> ) | 3.9 <sup>b</sup>  | 6.2 <sup>a</sup>  | 6.4 <sup>a</sup>  | 6.3 <sup>a</sup>  | 5.7 <sup>a</sup>  | 0.24 | *** |

<sup>a,b</sup>means within a row not bearing a common superscript letter different significantly; ns = not significant; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$ ; SEM = standard error of mean; SL = significance level

**Table 1:** Carcass characteristics of Tigray Highland sheep fed grass hay and supplemented with air dried leaves of African wild olive, Red thorn and their mixtures at different proportions.

| Parameters                   | Treatments         |                     |                    |                     |                     | SEM   | SL  |
|------------------------------|--------------------|---------------------|--------------------|---------------------|---------------------|-------|-----|
|                              | T1                 | T2                  | T3                 | T4                  | T5                  |       |     |
| Blood (g)                    | 714                | 745                 | 735                | 770                 | 710                 | 7.74  | ns  |
| Head (kg)                    | 1.2                | 1.3                 | 1.2                | 1.4                 | 1.3                 | 0.03  | ns  |
| Tongue (g)                   | 54.8 <sup>b</sup>  | 67.0 <sup>a</sup>   | 73.0 <sup>a</sup>  | 72.0 <sup>a</sup>   | 68.0 <sup>a</sup>   | 1.65  | *** |
| Heart (g)                    | 66.0 <sup>ab</sup> | 61.0 <sup>b</sup>   | 68.0 <sup>a</sup>  | 75.0 <sup>a</sup>   | 64.0 <sup>b</sup>   | 1.33  | *   |
| Liver + bile (g)             | 217.0 <sup>b</sup> | 271.0 <sup>a</sup>  | 286.0 <sup>a</sup> | 293.0 <sup>a</sup>  | 271.0 <sup>a</sup>  | 7.53  | **  |
| Kidney (g)                   | 50                 | 51                  | 50                 | 55                  | 49                  | 0.91  | ns  |
| Total fat (g)                | 45.0 <sup>b</sup>  | 51.0 <sup>a</sup>   | 54.0 <sup>a</sup>  | 55.0 <sup>a</sup>   | 52.0 <sup>a</sup>   | 1.01  | *   |
| Esophagus (g)                | 29                 | 31                  | 33                 | 33                  | 30                  | 0.67  | ns  |
| Reticulo-rumen (g)           | 390                | 425                 | 435                | 440                 | 420                 | 5.82  | ns  |
| Omaso-abomasum (g)           | 130.0 <sup>b</sup> | 142.0 <sup>ab</sup> | 178.0 <sup>a</sup> | 168.0 <sup>ab</sup> | 161.0 <sup>ab</sup> | 5.22  | *   |
| Small + large intestines (g) | 423                | 470                 | 488                | 532                 | 473                 | 11.85 | ns  |
| Tail (g)                     | 61.0 <sup>b</sup>  | 86.0 <sup>a</sup>   | 92.0 <sup>a</sup>  | 94.0 <sup>a</sup>   | 88.0 <sup>a</sup>   | 3.23  | **  |
| TEOC (kg)                    | 3.2 <sup>b</sup>   | 3.7 <sup>a</sup>    | 3.7 <sup>a</sup>   | 3.9 <sup>a</sup>    | 3.7 <sup>a</sup>    | 0.1   | **  |
| TEOC (% SW)                  | 19                 | 19.3                | 19.1               | 19.4                | 19.2                | 0.39  | ns  |

<sup>a,b</sup>means within a row not bearing a common superscript letter significantly different; \* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$ ; ns = not significant; SEM = standard error of mean; SL = significance level; SW = slaughter weight; TEOC = total edible offal components

**Table 2:** Edible offal components of Tigray Highland sheep fed grass hay and supplemented with air dried leaves of African wild olive, Red thorn and their mixtures at different proportions.

percentage on empty body weight basis might be due to the exclusion of the contribution of gut fill, which was significantly heavier in non-supplemented animals (Table 2). In line with the present study, previous studies revealed that dressing percentage calculated on empty body weight basis did not differ significantly between supplemented and non-supplemented individuals. For instance, values of dressing percentage calculated on empty body weight basis obtained by Bruh [5], Emebet [6] and Hirut [7] did not show significant difference between supplemented and non-supplemented animals.

### Rib eye muscle area

Rib- eye (*longissimus dorsi*) muscle area, which is an indirect estimate of body musculature, or lean meat of the body, indicates the musculature development of the animal [4]. In the present study, supplemented sheep had significantly ( $P < 0.001$ ) higher rib-eye muscle area as compared to the non-supplemented sheep, indicating the development of more lean flesh in the supplemented groups. However, there was no statistically significant ( $P > 0.05$ ) difference among the supplemented groups. This is consistent with previous findings of Alemu et al. [8].

### Edible and non-edible offal components

Data on edible and non-edible offal components are presented in Tables 2 and 3. The results of the present study indicated that supplementation has a positive effect on most of the edible offal components (Table 3). This is in agreement with the findings of Tesfaye [9] and Bruh [5]. Among the edible offal components namely: tongue ( $P < 0.001$ ), liver with gall bladder and tail ( $P < 0.01$ ), total fat (omental and kidney) and omaso-abomasum ( $P < 0.05$ ) were significantly heavier in the supplemented sheep as compared to the non-supplemented sheep. However, heart was heavier ( $P < 0.5$ ) in T3 and T4 whereas heavier omaso-abomasum was recorded in T3. The remaining edible offal components such as blood, head, kidney, esophagus, reticulo-rumen, small and large intestines were not affected by supplementation.

The non-edible offal components, such as feet, lung with trachea, spleen and penis did not differ significantly ( $P > 0.05$ ) between the control and supplemented sheep. But, statistically ( $P < 0.01$ ) heavier

| Parameters         | Treatments         |                     |                    |                    |                     | SEM  | SL  |
|--------------------|--------------------|---------------------|--------------------|--------------------|---------------------|------|-----|
|                    | T1                 | T2                  | T3                 | T4                 | T5                  |      |     |
| Skin (kg)          | 1.5 <sup>b</sup>   | 1.9 <sup>ab</sup>   | 2.0 <sup>a</sup>   | 2.2 <sup>a</sup>   | 1.9 <sup>ab</sup>   | 0.06 | **  |
| Feet (g)           | 413                | 420                 | 460                | 483                | 417                 | 10.1 | ns  |
| Lung + trachea (g) | 180                | 200                 | 215                | 203                | 195                 | 3.93 | ns  |
| Spleen (g)         | 20                 | 25                  | 25                 | 25                 | 25                  | 0.7  | ns  |
| Penis (g)          | 55                 | 55                  | 60                 | 60                 | 55                  | 1.12 | ns  |
| Testicles (g)      | 135.0 <sup>b</sup> | 150.0 <sup>ab</sup> | 175.0 <sup>a</sup> | 175.0 <sup>a</sup> | 150.0 <sup>ab</sup> | 4.95 | **  |
| Gut fill (kg)      | 4.6 <sup>a</sup>   | 3.8 <sup>b</sup>    | 3.8 <sup>b</sup>   | 3.9 <sup>b</sup>   | 3.6 <sup>b</sup>    | 0.12 | **  |
| TNEOC (kg)         | 6.9                | 6.6                 | 6.8                | 6.9                | 6.7                 | 0.1  | ns  |
| TUP (kg)           | 10.8 <sup>b</sup>  | 14.0 <sup>a</sup>   | 14.7 <sup>a</sup>  | 15.1 <sup>a</sup>  | 14.1 <sup>a</sup>   | 0.36 | *** |
| TUP (%SW)          | 62.1 <sup>b</sup>  | 73.3 <sup>a</sup>   | 73.6 <sup>a</sup>  | 74.2 <sup>a</sup>  | 73.6 <sup>a</sup>   | 1.13 | *   |

<sup>a,b</sup>means within a row not bearing a common superscript letter significantly different; \*significant at P<0.05; \*\*significant at P<0.01; \*\*\*significant at P<0.001; ns = not significant; SEM = standard error of mean; SL = significance level; TEOC = total edible offal components; TUP = total usable products; SW = slaughter weight

**Table 3:** Non- edible offal components of Tigray Highland sheep fed grass hay and supplemented with air dried leaves of African wild olive, Red thorn and their mixtures at different proportions.

| Variables                                 | Treatments |       |       |       |       |
|---|------------|-------|-------|-------|-------|
|   | T1         | T2    | T3    | T4    | T5    |
| Number of animals                         | 5          | 5     | 5     | 5     | 5     |
| Purchasing price (ETB/sheep)              | 230        | 230   | 230   | 230   | 230   |
| Total hay consumption (kg/sheep)          | 48.56      | 33.65 | 33.57 | 34.95 | 32.61 |
| Total NSC consumption (kg/sheep)          | 5.4        | 5.4   | 5.4   | 5.4   | 5.4   |
| Total OTL consumption (kg/sheep)          | 0          | 27    | 17.55 | 9.45  | 0     |
| Total AL consumption (kg/sheep)           | 0          | 0     | 9.45  | 17.55 | 27    |
| Total cost for hay (ETB/sheep)            | 36.42      | 25.24 | 25.18 | 26.21 | 24.46 |
| Total cost for NSC (ETB/sheep)            | 9.72       | 9.72  | 9.72  | 9.72  | 9.72  |
| Additional cost for feed collection (ETB) | 0          | 25    | 25    | 25    | 25    |
| Total variable cost (ETB/sheep)           | 46.14      | 59.96 | 59.9  | 60.93 | 59.18 |
| Gross income, sale of sheep (ETB/sheep)   | 265        | 325   | 330   | 332   | 326   |
| Total return (ETB/sheep)                  | 35         | 95    | 100   | 102   | 96    |
| Net income (ETB/sheep)                    | -11.14     | 35.04 | 40.1  | 41.07 | 36.82 |
| ΔNI (ETB)                                 | 0          | 46.18 | 51.24 | 52.21 | 47.96 |
| ΔTVC (ETB)                                | 0          | 13.82 | 13.76 | 14.79 | 13.04 |
| MRR (%)                                   | -          | 334.1 | 372.3 | 353   | 367.7 |

ETB = Ethiopian Birr; NSC = noug seed cake; OTL = olive tree leaves; AL = *acacia lahai*; NI = Net income; ΔNI = change in net income; ΔTVC = change in total variable cost; MRR = marginal rate of return

**Table 4:** Partial budget analysis of Tigray Highland sheep fed grass hay plus 60 g of NSC and supplemented with air dried leaves of African wild olive, Red thorn and their mixtures at different proportions.

skin and testicles were recorded for sheep in T3 and T4 than the non-supplemented group. Gut fill was heavier in un-supplemented sheep, but significant difference was not recorded among the supplemented groups. The significantly (P<0.01) heavier gut fill in the control group could be attributed to the higher consumption of roughage feed (grass hay), which is characterized by low digestibility and increased amount of digesta in the rumen. Van Soest [2] and Pond et al. [10] noted that non supplemented animals fill their gut with less digestible roughage which is retained in the gut for long time to be degraded by rumen microorganisms. Apart from this, supplemented sheep had statistically higher (P<0.01) total edible offal components (TEOC) and (P<0.001) total usable products (TUP), because of the positive effect of supplementation on the weight of most organs.

### Partial budget analysis

Partial budget analysis was done in order to determine the economic importance of supplementing Tigray Highland sheep with

air dried leaves of African wild olive, Red thorn and their mixtures at different proportions (Table 4). Partial budget analysis measures profit or loss, which is the net benefit obtained by difference between gains and losses for the proposed change. The result of partial budget analysis of the present study revealed that supplementing Tigray Highland sheep with air dried leaves of the multipurpose trees resulted relatively to higher profit margin as compared to the un-supplemented sheep. The gross financial margin or total return obtained by calculating differences between gross income and purchasing price of sheep in the present study was 35, 95, 100, 102 and 96 ETB per animal for sheep fed T1, T2, T3, T4 and T5, respectively. The net income of supplemented sheep (T2, T3, T4 and T5), obtained by subtracting the total feed cost from the gross financial margin or total return, was 35.04, 40.10, 41.07 and 36.82 ETB per head, respectively (Table 4). However, sheep fed basal diet (grass hay on *ad libitum* basis plus 60 g NSC) had a loss of net income (11.14 ETB/head), and it was the lowest compared to the other groups. Sheep supplemented with T4 had higher net income (41.07ETB) as compared to the other supplemented sheep groups (T2, T3 and T5).

The change in net income (ΔNI) obtained from sheep fed T2, T3, T4 and T5 were 46.18, 51.24, 52.21 and 47.96 ETB, respectively with the corresponding marginal rate of return (MRR) of 334.1, 372.3, 353.0 and 367.7%. This showed that per unit of ETB increment to prepare supplement feed in order to attain the required gain by supplement feed could afford profit of 3.34, 3.72, 3.53 and 3.67 ETB per animal for T2, T3, T4 and T5, respectively. As a result, supplementation with leaves of the locally available browse species as sole or mixture is economical to use and this is very important particularly in arid and semi-arid areas, where these tree species are available on open grazing lands and enclosures [11-13].

From the economic analysis point of view, supplementing T4 mixed air dried leaves was found to be more profitable with its high net income. Foliages of the multipurpose trees can be acquired by farmers by using family labor, thus capital is not a problem. Therefore, T4 that is treatment with relatively better net income is recommended (Table 4) for pastoralists and agro-pastoralists as a supplementary feed to small ruminants.

### Summary and Conclusion

Results of the present study revealed that supplementation of sole or mixture of the browse leaves can help sheep keepers to attain better sheep productivity mainly during dry season with inexpensive cost. Therefore, supplementation effect of leaves from African wild olive and Red thorn need to be studied on another livestock species.

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