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# Using Soybean Straw at Different Levels in Barki Sheep Rations and its Effects on Their Productive Performance, Water Intake and Economic Efficiency

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**Abstract:** Fifteen growing male Barki lambs aged 5-6 months with average weights (26.400±0.538 kg). Lambs randomly allotted into three equal groups an housed in semi-open pens as group feeding for 74 days to investigate the impact of incorporation soybean straw (SBS) at 30, 40 and 50%. On their productive performance, water consumption and economic evaluation. Concentrate: roughage (C: R) ratio were (70: 30), (60: 40) and (50: 50) for $R_1$, $R_2$ and $R_3$, respectively. Results showed that crude fibe ash, neutral detergent fiber, acid detergent fiber, acid detergent lignin and cellulose contents were higer in SBS comparing to concentrate feed mixture (CFM). Rations were differed in their contents of CP where CP varied from 10.70 to 13.22%. But, it seem to be iso-caloric. Gross energy ranged from 4138 to 4181 kcal/ kg DM. Inclusion SBS insignificantly ($P>0.05$) increased final weight, total body weight gain and average daily gain. CFM intake were significantly ($P<0.05$) decreased, meanwhile, SBS were significantly ($P<0.05$) increased. Dry matter, NFC, TDN intakes expressed as (g/h/day, g/kg$W^{0.75}$ or kg/ 100 kg live body weight) or feed intakes of gross and digestible energy expressed as (kcal/h/day, kcal/kg$W^{0.75}$ or Mcal/ 100 kg live body weight) were not affected. Furthermore, $R_2$ that composed 60% CFM plus 40% SBS recorded the highest values of different of feed intakes mentioned above. Feed conversion improved; furthermore, $R_3$ recorded the best feed conversion followed by $R_2$ comparing to $R_1$. Average daily water intake ranged from 3100 to 4000 ml/h/day. With increasing SBS, values of daily water intake decreased. Daily profit above feeding cost and relative economical efficiency were improved. Feed cost (LE/ kg gain) decreased by 20.56% and 37.56% for $R_2$ and $R_3$, respectively comparing to $R_1$. From the results obtained and under conditions available during field work, it can be mentioned that SBS can be used up to 50% with 50% of CFM that cover the nutrient requirements for growing sheep without occurring any adverse effect on their productive performance. Also it occurs decreasing in daily feeding cost with improving their relative economic efficiency. So this will be encourage the farmers to use SBS at high level to obtaining high profitability or net revenue through out decreasing feed cost/ kg gain.

**Key words:** Soybean straw · Sheep · Performance · Water intake · Economic efficiency

## INTRODUCTION

High prices of cereal grain and protein sources, combined with inadequate supplies of conventional roughages have enhanced the potential for using crop residues in ruminant rations. However, cereal straws are characterized by low crude protein, high lignin and low available energy content resulting in low intakes and utilization [1, 2].

Soybean crop is rich in carbohydrate, protein, fat, minerals and vitamins. Soybean is equally important as fodder as well as seed crop having better feeding value as alfa alfa, cow peas. Being leguminous crop, straw is superior over other cereal straws. It is preferred as rotational crop because it improves soil fertility [3].

Soybean straw is limited in animal diet as it is lignified crop residue [4, 5]. Because of its coarseness, the animals palatability is poor. Some chemical treatments have been

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tried in past to improve the palatability and digestibility of soybean straw [6, 7]. Also, many of farmers are not utilizing soybean straw as a feed for livestock due to lack of knowledge, about the cost of soybean straw in combination with Berseem (hay or straw) over sole feeding of Berseem (hay or straw) or soybean straw. Therefore to improve utilization of soybean straw by simple physical mixing it with another conventional straw (i.e. jowar straw has been tried by [3, 8].

Sruamsiri [9] noted that the nutritive value of soybean straw is relatively poor with a protein content ranging from 4 to 12% DM and very high fiber contents (NDF about 80% DM). However, like other legume straws, it is a better roughage than most cereal straws. In addition to, soybean straw is considered as a roughage but with a better nutritional value than rice straw. It is suitable for cattle both as fresh and ensiled material. The most practical ways of utilizing soybean straw in dairy cattle feeding systems are as a roughage source supplemented with protein sources or concentrate feeds, or as supplemental roughage. The palatability of untreated soybean straw is low because of its relatively hard stem To improve the nutritive value of soybean straw and pods, treating it chemically with urea and spraying it with a urea/molasses solution.

In Mediterranean areas, cereal straw and other fibrous feeds make up the major part of the daily ration for native ruminants during the dry season. However, the intake of digestible energy from straw is low owing to its high content of cell wall carbohydrates and lignin [10].

Kammlade and Mackey [11] made a comparison among lambs fed supplemented soybean (*Glycine max* (L.) Merrill) straw with that of lambs fed similarly supplemented oat (*Avena sativa* L.) straw on their productive performance. They observed a greater weight gains were realized with lambs received soybean straw containing ration than that lams fed oat straw containing ration and the finish was also better. A greater quantity of soybean straw was required, however, because much of it was refused because of its coarseness. Subsequently, Hamilton *et al*. [12] found that digestibility coefficients for all components of soybean straw except N-free extract were lower than for those of oat straw.

Wang *et al*. [13] evaluated 35 varieties of soybean [*Glycine max* (L.) *Merr.*] straw (SBS) as roughage, they noted that The contents of crude protein, crude fiber, crude ash, nitrogen-free extract (NFE), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) of SBS were ranged from 31.8 to 63.6 g $kg^{-1}$; 447.5 to 566.9 g $kg^{-1}$, 45.7 to 67.8 g $kg^{-1}$, 284.3 to 427.1 g $kg^{-1}$, 722.1 to 808.5 g $kg^{-1}$, 491.2 to 572.2 g $kg^{-1}$ and 128.3 to 195.8 g $kg^{-1}$, respectively. *In vitro* dry matter digestibility (IVDMD) and relative feed value (RFV) were ranged from 31.68 to 43.86% and 52.14 to 65.38%, respectively. The straw composition, excluding crude ash, hemicelluloses and cellulose was significantly different among varieties ($P<0.05$). The plant height and contents of NDF, ADF and ADL had negative correlations with *IVDMD* ($P<0.01$)

There is an increasing tendency, although technological problems still need to be solved, for feeding livestock (particularly ruminant animals) with crop residue [14, 15]

The soybean [*Glycine max* (L.) Merr.], as grain feed, is a high protein component of animal diets. In 2011, soybean production was about 15.1 million tons and the straw (SBS) yield was about 1.6-fold that of grain in China [16]. However, almost 75% of soybean consumption still relied on imported soybean [17]. Few efforts have been devoted to developing soybean for dual-purpose use as grain and straw, although there have been some studies on SBS as feed [18, 19, 20].

The nutritive value of soybean straw is higher than rice straw but lower than pod husk [4, 21, 22].

The blood biochemical profiles are considered important in evaluating the health status of animals. The estimates of biochemical constituents are the prerequisites to diagnose several pathophysiological and metabolic disorders in cattle [23, 24].

Soybean straw, the residual part, has the potential to serve an inexpensive feedstock for the production of fermentable sugars, instead of food sources, such as corn, sugar cane and other food stocks, for the production of bioethanol or other biorefinery products [25, 26]. Among various biomass sources, crop residues such as rice, wheat, barley straw and corn stover have gained considerable interest and several studies have already been reported based on these feed stocks [27, 28, 29]. However, soybean straw, like other lignocellulosic biomaterials, consists of a rigid cellulose structure of strongly cross-linked amorphous hemicellulose and lignin. Also, soybean straw contains a relatively low level of hemicellulose and lignin per gram biomass, compared with other lignocellulosic biomasses. Thus, pretreatment is needed to increase the cellulose content and to decrease the hemicellulose and lignin contents in the biomass [30, 31, 32, 33, 34].

Ibrahim1 and El-Naggar [35] fed growing Ossimi lambs on soybean straw as a main source of roughage that offered *ad lib*, they reported that no significant differences in feed intakes of soybean straw were found among different groups.

So, this study aimed to incorporate soybean straw at different levels with decreasing the percentages of concentrate feed mixture in sheep ration to decrease the feed costing and to study its effects on their productive performance, water intake and economic efficiency.

## MATERIALS AND METHODS

This study was carried out in co-operation work among Animal Production Department, National Research Centre, 33 El-Bohouth Street, P.O: 12622, Dokki, Cairo, Egypt and Field Crops Research Department, National Research Centre, 33 El-Bohouth Street, P.O: 12622, Dokki, Cairo, Egypt.

The field work was carried out at El-Nubaria Experimental and Production Station, Sheep Research Unit, El-Imam Malik Village, Behira Governorate.

The present work aimed to investigate the impact of incorporate soybean straw at different levels with decreasing the percentages of concentrate feed mixture in sheep ration to decrease their feed costing and to study its influence on their productive performance, water intake and economic efficiency.

**Animals and Feeds:** Fifteen of growing male Barki lambs aged 5-6 months with an average weights (26.400 ± 0.358 kg) were randomly distributed into three equal groups each contain 5 animals to investigate the impact of incorporation soybean straw (SBS) at different levels 30, 40 and 50%, meanwhile concentrate feed mixture were incorporated at 70, 60 and 50%. That considered as concentrate: roughage ratio as (70: 30), (60: 40) and (50: 50) for $R_1$, $R_2$ and $R_3$, respectively on live weight, average daily gain (ADG), feed conversion, feed and water intakes and economic evaluation.

Experimental animals were housed in semi-open pens and fed as group feeding for 74 days and the experimental rations were offered as 4% of live body weight that cover the requirements of total digestible nutrients and protein for growing sheep.

Lambs were received one of the three experimental rations that assigned as follows:

$R_1$: first 1$^{st}$ experimental ration that composed of 70% concentrate feed mixture (CFM) plus 30% soy bean straw (SBS) and assigned as control.
$R_2$: second 2$^{nd}$ experimental ration that composed of 60% CFM plus 40 % SBS
$R_3$: third 3$^{rd}$ experimental ration that composed of 50% CFM plus 50 % SBS.

Daily amounts of three different experimental rations were adjusted every 2 weeks according to body weight changes and it were offered twice daily in two equal portions at 800 and 1400 hours, while feed residues were daily collected, sun dried and weekly weighed.

Fresh water was always freely available in plastic containers. Individual body weight change was recorded weekly before receiving the morning ration. chemical analysis (%) of the ingredients are illustrated in (Table 1). Meanwhile, composition and chemical analysis (%) of experimental rations are presented in (Table 2).

**Analytical Procedures:** Chemical analysis of tested ration samples were analyzed according to AOAC [67] methods. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Goering and Van Soest [36] and Van Soest *et al*. [37]. Meanwhile, hemicellulose and cellulose content were calculated by difference using the following equations:

Hemicellulose = NDF - ADF. Meanwhile, Cellulose =ADF - ADL.

**Calculations:** Non-fibrous carbohydrates (NFC) were calculated according to Calsamiglia *et al*. [38] using the following equation: NFC = 100 - {CP + EE + Ash + NDF}.

Gross energy (kcal/ kg DM) was calculated according to Blaxter [39]. Each g CP = 5.65 Kcal, g EE = 9.40 kcal and g CF and NFE = 4.15 Kcal.

Digestible energy (DE) was calculated according to NRC [40] by applying the following equation: DE (kcal/ kg DM) = GE × 0.76.

Total digestible nutrient (TDN) was calculated according to NRC [40] by applying the following equation: TDN % = DE / 44.3.

Digestible crude protein (DCP): calculated according to NRC [40] by applying the following equation:

Digestible crude protein (%) = 0.85 $X_1$ – 2.5.

where X1= Crude Protein % on DM basis.

**Economic Evaluation:** Economical efficiency for the tested rations used in this study depended on both local market price of ingredients and price of sheep live body weight.

Economic evaluation was calculated as follows:
The cost for 1-kg gain = total cost per Egyptian pound (LE) of feed intake/ total gain (kilogram).

**Statistical Analysis:** Data collected of live weight, average daily gain, feed intake, feed conversion and drinking water were subjected to statistical analysis as one-way analysis of variance according to SPSS [41]. Duncan's Multiple Range Test [42] was used to separate means when the dietary treatment effect was significant according to the following model:

$Y_{ij} = \mu + T_i + e_{ij}$

where: $Y_{ij}$ = observation. ì = overall mean.

$T_i$ = effect of different experimental rations for i = 1-3, 1 = $R_1$: first 1st experimental ration that composed of 70% concentrate feed mixture (CFM) plus 30% soy bean straw (SBS) and assigned as control., 2 = $R_2$: 2nd experimental ration that composed of 60% CFM plus 40 % SBS and 3 = $R_3$: third 3rd experimental ration that composed of 50% CFM plus 50 % SBS.
$e_{ij}$ = the experimental error.

## Results and Discussion

**Chemical Analysis, Cell Wall Constituent and Nutritive Values of Feed Ingredients and Concentrate Feed Mixture (CFM):** Data of (Table 1) cleared that concentrate feed mixture (CFM) contents higher values of organic matter (OM), crude protein (CP), ether extract (EE), nitrogen free extrct (NFE), hemicellulose, cell soluble-NDF, gross energy (GE), digestible energy (DE) total digestible nutrient (TDN) and digestible crude protein (DCP) comparing to soybean straw (SBS). Meanwhile, values of crude fiber (CF), ash, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and cellulose were higer in SBS in comparison with the CFM. These results of chemical analysis for soybean straw (SBS) in agreement with those noted by [4, 43, 6, 44, 45, 46, 47, 48, 49, 50, 8, 51, 19, 13]; Ibrahim and, El Naggar [35] who noted that values recorded for chemical analysis of SBS were ranged from 85.1 to 96.0 % for DM; ranged from 3.0 to 12.6% for CP; ranged from 38.1 to 51.4% for CF; ranged from 76.2 to 83.2% for NDF; ranged from 40.2 to 68.8% for ADF ; ranged from 7.5 to 16.4% for ADL (lignin); ranged from 0.80 to 1.7% for EE; ranged from 3.1 to 13.8 % for ash contents, respectively. Also, Soybean straw contains about 25 to 44.2% of cellulose; 5.9 to 22.6 of hemicellulose; 5 to 21.7% of lignin and; 2 to 10.6% of ash as described by [30, 31, 32, 33, 34, 52].

**Composition and Chemical Analysis of the Concentrate Feed Mixture and Different Experimental Rations:** Data illustrated in (Table 2) showed that the experimental rations were different in their contents of CP (not iso-nitrogenous) where CP varied from 10.70 to 13.22% among three experimental ration. But, it seem to be iso-caloric where GE contents ranged from 4138 to 4181 kcal/ kg DM. Also, it was noticed that with increasing the percentages of soybean straw (SBS) with decreasing the percentages of concentrate feed mixture (CFM) caused gradually decreasing in CP, EE, NFE, ash, hemicellulose, cell soluble-NDF and DCP% contents of experimental ratios. Meanwhile, values of CF, NDF, ADF, ADL and cellulose were increased. Moreover, values of NFC, GE DE and TDN were near in the three testes rations. The corresponding values of CP, CF and EE were (13.22, 15.95 and 2.45%); (11.95, 19.70 and 2.27%) and (10.70, 23.45 and 2.11%) for $R_1$, $R_2$ and R3, respectively. This variation in chemical analysis of the experimental ration related to the different percentage levels of both CFM and SBS that used in formulation the experimental rations.

**Productive Performance of the Experimental Groups:** Results of productive performance includes live weights, feed intake and feed conversion that presented in (Table 3) mentioned that incorporation SBS at different levels in significantly (P>0.05) increased final weight (FW), total body weight gain (TBWG), Average daily gain (ADG), average body weight and Metabolic body weight ($kgW^{0.75}$).

Values of CFM intake were significantly (P<0.05) decreased, meanwhile, values SBS were significantly (P<0.05) increased. In addition to, feed intakes values of DM, NFC, TDN that expressed as (g/h/day, g/kgW 0.75 or kg/ 100 kg live body weight) or feed intakes values of GE and DE that expressed as (kcal/h/day, kcal/kgW 0.75 or Mcal/ 100 kg live body weight) were not affected by inclusion SBS at different levels with noticed that $R_2$ that contained 60% CFM plus 40% SBS recorded the highest values of different of feed intakes that mentioned above. On the other hand, crude protein intake (CPI) and digestible crude protein intake (DCPI) that expressed as (g/h/day, g/kgW 0.75 or kg/ 100 kg live body weight) in significantly (P<0.05) decreased with $R_2$ comparing to $R_1$, meanwhile it significantly (P<0.05) decreased with $R_3$ comparing to $R_1$ and $R_2$.

Values of feed conversion expressed as (g. intake / g. gain) of dry matter, crude protein, digestible crude protein, non fiber carbohydrates, total digestible nutrients or Values of feed conversion expressed as (kcal intake / g. gain) of gross energy and digestible energy were improved with $R_3$ that contained (50% CFM plus 50% SBS) in comparison with $R_1$ that contained (70% CFM plus 30% SBS), Furthermore $R_3$ recorded the best feed conversion followed by $R_2$ comparing to $R_1$.

Table 1: Chemical analysis, cell wall constituent and nutritive values of feed ingredients and concentrate feed mixture (CFM)

| Item | Feed ingredients | | | | |
|---|---|---|---|---|---|
| | SBS | SBM | YC | WB | CFM |
| Moisture | 9.54 | 6.95 | 8.35 | 8.33 | 8.01 |
| *Chemical analysis on DM basis (%)* | | | | | |
| Organic matter (OM) | 91.30 | 94.89 | 98.35 | 89.68 | 95.06 |
| Crude protein (CP) | 4.44 | 43.94 | 9.12 | 14.33 | 16.99 |
| Crude fiber (CF) | 42.17 | 4.23 | 3.52 | 9.22 | 4.71 |
| Ether extract (EE) | 1.29 | 0.77 | 3.35 | 3.95 | 2.91 |
| Nitrogen free extrct (NFE) | 43.40 | 45.95 | 82.36 | 62.18 | 70.45 |
| Ash | 8.70 | 5.11 | 1.65 | 10.32 | 4.94 |
| *Cell wall constituents (%)* | | | | | |
| Neutral detergent fiber (NDF) | 56.63 | 31.70 | 31.24 | 34.98 | 32.02 |
| Acid detergent fiber (ADF) | 47.89 | 13.29 | 12.64 | 17.84 | 13.73 |
| Acid detergent lignin (ADL) | 8.67 | 2.24 | 2.12 | 3.08 | 2.32 |
| Hemicellulose[1] | 8.74 | 18.41 | 18.60 | 17.14 | 18.29 |
| Cellulose[2] | 39.22 | 11.05 | 10.52 | 14.76 | 11.41 |
| Cell soluble-NDF[3] | 43.37 | 68.30 | 68.76 | 65.02 | 67.98 |
| Non fiber carbohydrates (NFC)[4] | 28.94 | 18.45 | 54.64 | 36.42 | 43.13 |
| Nutritive values | | | | | |
| Gross energy (GE), kcal/ kg DM | 3923 | 4637 | 4394 | 4144 | 4353 |
| Digestible energy (DE) kcal/ kg DM | 29.81 | 3524 | 3339 | 3149 | 3308 |
| Total digestible nutrient (TDN) | 67.29 | 79.55 | 75.37 | 71.08 | 74.67 |
| Digestible crude protein (DCP) | 1.27 | 34.85 | 5.25 | 9.68 | 11.94 |

SBS: Soybean straw. SBM: soybean meal. YC: yellow corn. WB: wheat bran. CFM: Concentrate feed mixture.
[1]Hemicellulos = NDF – ADF. [2]Cellulose = ADF – ADL. [3]Cell soluble-NDF = 100 – NDF. [4]NFC = 100 – {CP + EE + Ash + NDF}.

Table 2: Composition and chemical analysis of the concentrate feed mixture and different experimental rations

| Item | CFM | SBS | Experimental rations | | | Price of one kg (LE) |
|---|---|---|---|---|---|---|
| | | | $R_1$ | $R_2$ | $R_3$ | |
| *Composition (kg/ ton)* | | | | | | |
| Yellow corn | 600 | - | 70 % CFM | 60 % CFM | 50 % CFM | 3.750 |
| Soybean meal | 200 | | + | + | + | 7.500 |
| Wheat bran | 190 | | 30% SBS | 40% SBS | 50 % SBS | 3.500 |
| Lime stone | 2 | | | | | 0.250 |
| Sodium chloride | 3 | | | | | 1.000 |
| Anti toxic | 2 | | | | | 5.000 |
| Vitamin and mineral mixture[1] | 3 | | | | | 15.000 |
| Price of Ton (LE) | 4444 | 900 | | | | |
| *Calculated of chemical analysis (%)* | | | | | | |
| Moisture | 8.01 | 9.54 | 8.47 | 8.63 | 8.78 | |
| *Chemical analysis on DM basis (%)* | | | | | | |
| Organic matter (OM) | 95.06 | 91.30 | 92.43 | 93.56 | 93.18 | |
| Crude protein (CP) | 16.99 | 4.44 | 13.22 | 11.95 | 10.70 | |
| Crude fiber (CF) | 4.71 | 42.17 | 15.95 | 19.70 | 23.45 | |
| Ether extract (EE) | 2.91 | 1.29 | 2.45 | 2.27 | 2.11 | |
| Nitrogen free extrct (NFE) | 70.45 | 43.40 | 60.81 | 59.64 | 56.92 | |
| Ash | 4.94 | 8.70 | 7.57 | 6.44 | 6.82 | |
| *Cell wall constituents (%)* | | | | | | |
| Neutral detergent fiber (NDF) | 32.02 | 56.63 | 39.40 | 41.87 | 44.33 | |
| Acid detergent fiber (ADF) | 13.73 | 47.89 | 23.98 | 27.40 | 30.82 | |
| Acid detergent lignin (ADL) | 2.32 | 8.67 | 4.22 | 4.86 | 5.49 | |
| Hemicellulose[2] | 18.29 | 8.74 | 15.42 | 14.47 | 13.51 | |
| Cellulose[3] | 11.41 | 39.22 | 19.76 | 22.54 | 25.33 | |
| Cell soluble-NDF[4] | 67.98 | 43.37 | 60.60 | 58.13 | 55.67 | |
| Non fiber carbohydrates (NFC) | 43.13 | 28.94 | 37.36 | 37.47 | 36.04 | |
| Gross energy (GE), kcal/ kg DM | 4353 | 3923 | 4163 | 4181 | 4138 | |
| Digestible energy (DE) kcal/ kg DM | 3308 | 29.81 | 3164 | 3178 | 3145 | |
| Total digestible nutrient (TDN) | 74.67 | 67.29 | 71.42 | 71.74 | 70.99 | |
| Digestible crude protein (DCP) | 11.94 | 1.27 | 8.74 | 7.66 | 6.60 | |

[1]Vitamin & Mineral mixture: Each kilogram of Vit. & Min. mixture contains: 2000.000 IU Vit. A, 150.000 IU Vita. D, 8.33 g Vit. E, 0.33 g Vit. K, 0.33 g Vit. $B_1$, 1.0 g Vit. $B_2$, 0.33g Vit. $B_6$, 8.33 g Vit.$B_5$, 1.7 mg Vit. $B1_2$, 3.33 g Pantothenic acid, 33 mg Biotin, 0.83g Folic acid, 200 g Choline chloride, 11.7 g Zn, 12.5 g Fe, 16.6 mg Se, 16.6 mg Co, 66.7 g Mg and 5 g Mn. [2]Hemicellulos = NDF – ADF. [3]Cellulose = ADF – ADL. [4]Cell soluble-NDF = 100 – NDF. CFM: concentrate feed mixture. SBS: Soybean straw.
$R_1$: 1$^{st}$ experimental ration assigned as control and it contained 70% CFM plus 30% SBS.
$R_2$: 2$^{nd}$ experimental contained 60% CFM plus 40% SBS. $R_3$: 3$^{rd}$ experimental ration contained 50% CFM plus 50% SBS.

Table 3: Productive performance of the experimental groups

| Item | Experimental rations $R_1$ | $R_2$ | $R_3$ | SEM |
|---|---|---|---|---|
| Lambs number | 5 | 5 | 5 | - |
| Initial weight (kg) | 26.300 | 26.200 | 26.400 | 0.358 |
| Final weight ( FW, kg) | 38.000 | 40.000 | 41.000 | 0.739 |
| Total body weight gain (TBWG, kg) | 11.700 | 13.800 | 14.600 | 0.629 |
| Experimental duration period | 74 days | | | |
| Average daily gain (ADG, g/day) | 158.11 | 186.49 | 197.30 | 8.467 |
| Average body weight, kg* | 32.150 | 33.100 | 33.700 | 0.489 |
| Metabolic body weight ($kgW^{0.75}$) | 13.502 | 13.800 | 13.987 | 0.152 |
| *Feed intake* | | | | |
| Concentrate feed mixture (CFM), g | $781^{a}$ | $689^{b}$ | $597^{c}$ | 26.983 |
| Soy bean straw (SBS), g | $217^{b}$ | $407^{a}$ | $470^{a}$ | 41.744 |
| *Dry matter intake (DMI) as* | | | | |
| g/h/day | 998 | 1096 | 1067 | 22.554 |
| $g/kgW^{0.75}$ | 73.91 | 79.42 | 76.29 | 1.48 |
| kg/ 100 kg live body weight (LBW) | 3104 | 3311 | 3166 | 60.331 |
| *Crude protein intake (CPI) as* | | | | |
| g/h/day | $131.94^{a}$ | $130.97^{a}$ | $114.17^{b}$ | 3.524 |
| $g/kgW^{0.75}$ | $9.77^{a}$ | $9.49^{a}$ | $8.16^{b}$ | 0.284 |
| g/ 100 kg live body weight (LBW) | $410^{a}$ | $396^{a}$ | $339^{b}$ | 12.441 |
| *Digestible crude protein intake (DCPI) as* | | | | |
| g/h/day | $87.23^{a}$ | $83.95^{a}$ | $70.42^{b}$ | 2.878 |
| $g/kgW^{0.75}$ | $6.46^{a}$ | $6.08^{a}$ | $5.03^{b}$ | 0.233 |
| g/ 100 kg live body weight (LBW) | $271^{a}$ | $254^{a}$ | $209^{b}$ | 10.03 |
| *Non fiber carbohydrates (NFC) as* | | | | |
| g/h/day | 373 | 411 | 385 | 8.429 |
| $g/kgW^{0.75}$ | 27.63 | 29.78 | 27.53 | 0.584 |
| g/ 100 kg live body weight (LBW) | 1160 | 1242 | 1142 | 24.389 |
| *Total digestible nutrients intake (TDNI) as* | | | | |
| g/h/day | 713 | 786 | 757 | 16.429 |
| $g/kgW^{0.75}$ | 52.81 | 56.96 | 54.12 | 1.094 |
| g/ 100 kg live body weight (LBW) | 2218 | 2375 | 2246 | 44.848 |
| *Gross energy intake (GEI) as* | | | | |
| kcal/h/day | 4155 | 4582 | 4415 | 95.021 |
| $kcal/kgW^{0.75}$ | 308 | 332 | 316 | 6.316 |
| Mcal / 100 kg live body weight (LBW) | 12.924 | 13.843 | 13.101 | 0.258 |
| Digestible energy intake (DEI) as | | | | |
| kcal/h/day | 3158 | 3483 | 3356 | 72.27 |
| $kcal/kgW^{0.75}$ | 234 | 252 | 240 | 4.752 |
| Mcal / 100 kg live body weight (LBW) | 9.823 | 10.523 | 9.958 | 0.196 |
| *Feed conversion expressed as g. intake / g. gain of* | | | | |
| Dry matter | $6.312^{b}$ | $5.877^{ab}$ | $5.408^{a}$ | 0.160 |
| Crude protein | $0.834^{c}$ | $0.702^{b}$ | $0.579^{a}$ | 0.038 |
| Digestible crude protein | $0.552^{c}$ | $0.450^{b}$ | $0.357^{a}$ | 0.029 |
| Non fiber carbohydrates | $2.359^{b}$ | $2.204^{a}$ | $1.951^{a}$ | 0.068 |
| Total digestible nutrients | $4.510^{b}$ | $4.215^{ab}$ | $3.837^{a}$ | 0.118 |
| *Feed conversion expressed as kcal intake / g. gain of* | | | | |
| Gross energy | $26.279^{b}$ | $24.570^{ab}$ | $22.377^{a}$ | 0.682 |
| Digestible energy | $19.976^{b}$ | $18.677^{ab}$ | $17.010^{a}$ | 0.518 |

a, b and c: Means in the same row having different superscripts differ significantly ($P<0.05$).

SEM: Standard error of mean. *Average body weight, kg = (Initial weight + final weight) / 2

The present results were in harmony with those recorded by Adangale *et al*. [3] who noted that when soybean straw incorporated in H.F. X Deoni cross bred interse calves at 50 or 100% of roughage caused insignificantly (P>0.05) increasing in their final weight, total body weight gain and average daily gain, meanwhile, feed intake was increased with increasing the level of SBS but concentrate was decreased.

Dry matter intake of soybean straw fed alone to sheep ranged from 55.76 g/kg $W^{0.75}$ [53] to 62.84 g/kg $W^{0.75}$ [51]. Soybean straw offered as sole feed to growing sheep 5[1] or supplemented with 8.5% soybean meal for mature ewes (United States, Gupta *et al*., [4]) met the maintenance requirements in both cases. Soybean straw offered as sole feed to growing goats met the maintenance requirements [51]. DM intake of soybean straw fed alone ranged from 35.60 g/kg $W^{0.75}$ [53] to 53.21 g/kg $W^{0.75}$ [51]. In India, soybean straw fed *ad libitum* with a concentrate to growing kids led to a higher forage intake and lower concentrate intake compared to sorghum stover [54]. In Nigeria, soybean straw included at up to 30% of the DM, replacing maize mill waste, in the diets of growing goats significantly increased DM intake (516 *vs*. 465 g/d) and daily weight gain (57.8 *vs*. 34.7 g/d) [68]. In the USA, soybean straw given without a supplement to weaned beef cattle heifers did not maintain their weight, but when supplemented with maize grain there was a small weight gain of 110 g/d [55]. In India, Murrah buffaloes heifers fed soybean straw *ad libitum* as the sole diet had a daily weight gain of 316 g/d, but supplementation was recommended for better performance [44]. Soybean straw fed to growing calves replaced 50% or 100% of sorghum straw in diets with concentrates, supporting the same growth performance [8]. In India, a complete diet comprised of 60% soybean straw and 40% concentrate maintained the body weight of 26 kg adult goats [56]. The same diet allowed a daily weight gain of 48.6 g/d in growing kids [45]. Fresh or dried soybean forage may be used to -feed growing rabbits if included in a balanced diet, with a special attention to phosphorus and to the amino acid content of the diet. In Cuba, soybean forage harvested at the milk stage was used as only feed for growing rabbits [57]. In Nigeria, soybean forage offered with Rhodes grass (*Chloris gayana*) and a concentrate resulted in significantly lower growth rate (-54%) than groundnut haulms or sweet potato vines [58]. This poor performance may reflect the low lysine content of soybean forage protein (3.5%, *i.e.* 70% of the requirements) and sulphur-containing amino acids (2.6%, *i.e.* 69% of the requirements) as noted by [57, 59].

**Drinking Water by the Experimental Groups:** Data of (Table 4 ) cleared that average daily water intake ranged from 3100 to 4000 ml/h/day. With increasing the level of SBS incorporation the values of daily water intake were decreased. The corresponding values were 4000, 3600 and 3100 ml/h/d for $R_1$, $R_2$ and $R_3$, respectively. Generally, experimental sheep fed ration contained 50% CFM plus 50% SBS recorded the lowest values of water intake that expressed as (ml/h/day, ml/ $kgw^{0.75,}$ liter/ kg dry matter intake, liter/ kg non fibrous carbohydrate intake, liter/ kg total digestible nutrients intake, liter/ M cal gross energy intake and liter/ M cal digestible energy intake and it was significantly (P<0.05) decreased in comparison with that fed ration composed of 70% CFM plus 30% SBS ($R_1$). Meanwhile ($R_3$) in significantly (P<0.05) decreased of water intake that expressed as (liter/ kg crude protein intake and liter/ kg digestible crude protein intake). Sonone *et al*. [60] fed crossbred calves in four groups for 90 days on different sources of roughage that includes Jowar Kadbi, Soybean straw, green fodder (Hy. Napier) with concentrate to study its effect on their feed and water intake. They designed the groups as ($T_1$) composed of Jowar Kadbi, green fodder (Hy. Napier) and concentrate; ($T_2$) composed of Soybean straw, green fodder (Hy. Napier) and concentrate; ($T_3$) composed of Soybean straw and concentrate and ($T_4$) composed of Soybean straw only. They noted that incorporation of soybean straw in the ration of the calves did not influence on the feed intake. However, the incorporation of soybean straw in the ration increased the feed intake in $T_2$ as comparing to $T_1$, $T_3$ and $T_4$ groups. Also, they noticed that the daily water intake of the calves was differ significantly between the feeding group, the calves from $T_2$ group drunk more (12.88) than that $T_1$ (12.50), $T_3$ (12.13) and $T_4$ (11.84). This trend indicated that the water in treatment $T_1$, $T_2$, $T_3$, $T_4$ were significant, indicating, that level of soybean straw had effect on the water consumption of calves. Also, they mentioned that feeding trial was conducted during early months of summer therefore the water intake seems to be higher. In addition to, similar trend was observation when the water intake was converted to unit body size. The average water intake per 100 kg body weight was 13.84, 13.52, 13.82 and 14.38 liter per calves per day in $T_1$, $T_2$, $T_3$ and $T_4$ respectively. On the other hand, as a result of this solution dry matter to water intake ratio was more or less similar in all the groups and it was 1: 5.4, 1: 5.3, 1. 5.4 and 1: 5.7 for $T_1$, $T_2$, $T_3$ and $T_4$ groups respectively. Also, the present results in agreement with those found by [61] who noted that values of water consumption were 2833, 3000 and

Table 4: Drinking water by the experimental groups

| Item | Experimental rations R$_1$ | R$_2$ | R$_3$ | SEM |
|---|---|---|---|---|
| *Drinking water calculated as:* | | | | |
| Metabolic body weight size (kgW$^{0.75}$) | 13.502 | 13.800 | 13.987 | 0.152 |
| ml/h/day | 4000$^{a}$ | 3600$^{ab}$ | 3100$^{b}$ | 152.75 |
| ml/ kgw$^{0.75}$ | 296$^{a}$ | 261$^{ab}$ | 222$^{b}$ | 12.14 |
| Liter/ kg dry matter intake | 4.008$^{a}$ | 3.285$^{b}$ | 2.905$^{b}$ | 0.18 |
| Liter/ kg crude protein intake | 30.317 | 27.487 | 27.152 | 0.79 |
| Liter/ kg digestible crude protein intake | 45.856 | 42.883 | 44.022 | 1.05 |
| Liter/ kg non fibrous carbohydrate intake | 10.724$^{a}$ | 8.759$^{b}$ | 8.052$^{b}$ | 0.45 |
| Liter/ kg total digestible nutrients intake | 5.610$^{a}$ | 4.580$^{b}$ | 4.95$^{b}$ | 0.25 |
| Liter/ M cal gross energy intake | 0.963$^{a}$ | 0.786$^{b}$ | 0.702$^{b}$ | 0.04 |
| Liter/ M cal digestible energy intake | 1.267$^{a}$ | 1.034$^{b}$ | 0.924$^{b}$ | 0.06 |

a and b: Means in the same row having different superscripts differ significantly (P<0.05).

SEM: Standard error of mean

R$_1$: 1$^{st}$ experimental ration assigned as control and it contained 70% CFM plus 30% SBS.

R$_2$: 2$^{nd}$ experimental contained 60% CFM plus 40% SBS.

R$_3$: 3$^{rd}$ experimental ration contained 50% CFM plus 50% SBS.

Table 5: Economic evaluation of the experimental groups

| Item | Experimental rations R$_1$ | R$_2$ | R$_3$ |
|---|---|---|---|
| *Daily feed intake (fresh, kg)* | | | |
| Concentrate feed mixture (CFM), kg | 0.850 | 0.750 | 0.650 |
| Value of 1-kg CFM (LE) | 4.444 | | |
| Soybean straw (SBS), kg | 0.240 | 0.450 | 0.520 |
| Value of 1-kg SBS (LE) | 0.900 | | |
| Daily feeding cost (LE)$^{a}$ | 3.99 | 3.74 | 3.11 |
| Average daily gain (kg) | 0.15811 | 0.18649 | 0.19730 |
| Value of daily gain (LE)$^{b}$ | 11.07 | 13.05 | 13.81 |
| Daily profit above feeding cost (LE) | 7.08 | 9.31 | 10.70 |
| Relative economical efficiency $^{c}$ | 100 | 131 | 151 |
| Feed cost (LE/ kg gain) | 25.24 | 20.05 | 15.76 |

LE = Egyptian pound equals 0.06 American dollars ($) approximately.

$^{a}$: based on price of 2020.

$^{b}$: Value of 1-kg live body weight equals 70 LE (2020).

$^{C}$: Assuming that the relative economic efficiency of control ration (R$_1$) equals 100.

R$_1$: 1$^{st}$ experimental ration assigned as control and it contained 70% CFM plus 30% SBS.

R$_2$: 2$^{nd}$ experimental contained 60% CFM plus 40% SBS.

R$_3$: 3$^{rd}$ experimental ration contained 50% CFM plus 50% SBS.

3250 ml/h/day when growing male Barki lambs fed complete feed mixture (CFM) replaced sesame meal (SM) 50 or 100% of soy bean meal (SBM). These values less than that recorded in the present study (4000, 3600 and 3100 ml/h/day). These may be related to differences in live body weight of the experimental sheep, the ingredient used in ration formulation and chemical analysis contents especially ash and CF in two comparison studies. DMI and water intake are positively associated [62], so ash is not the only constituent of dry matter in the feed, therefore, the ash contents could not be the sole cause of the changes in the water consumption. Also, Omer *et al*. [63] noted that Ossimi sheep received rations composed of 50% concentrate feed mixture plus 50% of peanut vein hay, beans straw, kidney beans straw, or linseed straw increased (P<0.05) drinking water compared to control group that offered ration composed of (50% concentrate feed mixture plus 50% berseem hay) Also, they recorded that the corresponding values of drinking water were 3088, 3742, 4650, 3660 and 3038 ml/h/day for control and the other four experiment groups mentioned above. On the other hand, Ahmed and Abdalla [64] showed that replacing 50% of cotton seed cake (CSC) by sesame seed cake (SSC) in yearling sheep had no effect on water intake (3.04 vs. 3.00 l/kg DM intake) for CSC and SSC, respectively. They also, think that ash content in the two sources in the same range had not caused any adverse effect on quantity water consumption.

**Economic Evaluation of the Experimental Groups:** Data of economic evaluation presented in (Table 5) showed that gradually incorporation of SBS from 30 to 40 and 50% realized decreasing in their daily feeding cost from 3.99 to 3.74 and 3.11 LE for $R_1$, $R_2$ and $R_3$, respectively. Resulting for decreasing the quantity of CFM that highly cost (4.444 LE/ kg) comparing to low price of SBS (0.90 LE/ kg) that replaced from CFM, in addition to improving their daily gain occurred an improving in daily profit above feeding cost that recorded 7.08, 9.31 and 10.70 LE for $R_1$, $R_2$ and $R_3$, respectively. Also, relative economical efficiency was improved by 131 and 151% for ($R_2$ and $R_3$), respectively when assuming that the relative economic efficiency of $R_1$ (control ration) equals 100. Values of feed cost (LE/ kg gain) was decreased from 25.24 to 20.05 and 15.76 LE for $R_1$, $R_2$ and $R_3$, respectively. These decreasing in feed cost (LE/ kg gain) equals 20.56% and 37.56% for $R_2$ and $R_3$, respectively comparing to $R_1$. These results in harmony with this obtained by Adangale *et al*. [3] who made a comparison among jowar straw and soybean straw through out designed an experiment using Nine H.F. X Deoni cross bred interse calves their age varied from 6 to 12 months. Calves distributed into three groups. First 1[st] composed of jowar straw ad lib plus concentrate and considered as control ($T_0$); meanwhile the ($T_1$) received jowar straw 50 % and soybean straw 50 % + concentrate, but ($T_2$) received 100% soybean straw + concentrate as per requirement. They noted that The feeding cost per kg body weight gain was decreased with increasing the level of soybean straw incorporated in calve rations, the corresponding values were 48.99, 43.09 and 39.11 for $T_0$, $T_1$ and $T_2$ respectively. Also, the similar trend was recorded by Talokar [65] on feeding of Soybean straw and Jowar straw with concentrate in buffalo heifers.

## CONCLUSION

Under conditions as this available during carried out of this work it can be mentioned that soybean straw (SBS) can be used up to 50% with concentrate feed mixture at the same percentage (50%) of nutrient requirements for growing sheep without occurring any adverse effect on their productive performance, in addition to, incorporation SBS up to 50% caused decreasing in their daily feed costing with improving their relative economic efficiency, so this will be encourage the farmers to use SBS at high level in sheep rations to obtained an improvements in profitability or net revenue and decrease feed cost/ kg gain.

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