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# Incorporation of different roughage sources in growing sheep rations 2: Nutritional impact on growth performance, digestion coefficients, nutritive values, water metabolism, nitrogen balance and ruminal fermentation

**Hamed Abdel-Aziz Ali Omer[1] and Azza M.M. Badr [2]**

[1]Animal Production Department, National Research Centre, 33 El-Bohouth Street, P.O: 12622, Dokki, Cairo, **Egypt.**
[2]Regional Centre for Food and Feed, Agriculture Research Centre, Ministry of Agriculture, Cairo, **Egypt**·

***Correspondence:** azzabadr805@yahoo.com **Accepted: 0**1 May 2019 **Published online:** 04.June 2019

This work was carried out to investigate the impact of replacing Berseem hay (BH) that considered the main roughage source in sheep feeding by alternative sources of roughage (field crop residues) such as pea straw (PS), chick pea straw (CPS) or lentil straw (LS). Twenty eight growing Barki male lambs aged 6 months with an initial live body weight 24.05±0.25 kg approximately were randomly assigned to four experimental groups (seven lambs in each treatment) and used in group feeding trial continuous for 120 days and lambs were received one of the four tested experimental rations; first*1st* ration contained 30% BH and considered as control ($R_1$), second*2nd* ration contained 30% PS ($R_2$); third*3th* ration contained 30% CPS ($R_3$) and fourth*4th* ration contained 30% LS ($R_4$). The results showed that All tested ration seams to be almost iso-caloric and iso-nitrogenous (CP ranged from 16.00 to 16.17%) among the four experimental rations. Dietary treatments had no significant (P>0.05) effect on their total body weight gain (TBWG) and average daily gain (ADG). Moreover, sheep received ration contained 30% pea straw ($R_2$) insignificantly increased their BWG and ADG in comparison with the other groups that received BH or CPS or LS. Dry matter intake (DMI) significant (P<0.05) decreased. Incorporation PS or CPS significantly (P<0.05) decreased digestible crude protein intake (DCPI) in comparison with that received BH or LS containing rations. Sheep fed PS ($R_2$) recorded the highest value of total digestible nutrient intake, meanwhile, that received LS recorded the least value of TDNI. Feed conversion that expressed as g. intake / g. gain of dry matter or total digestible nutrient in significant improved. Meanwhile, that expressed as g. intake /g. gain of digestible crude protein for ration contained PS or LS were significantly (P<0.05) improved compared to that fed BH containing ration. Rations that contained PS or CPS significantly (P<0.05) increased both DM and CF digestibilities, meanwhile, OM, CP, EE and NFE digestibilities were not affected compared to that contained BH. Sheep received LS significantly (P<0.05) increased DM, EE and NFE digestibilities, meanwhile, CP digestibility significantly (P<0.05) decreased, but OM insignificantly (P>0.05) increased however, CF digestibility insignificantly decreased comparing to sheep received BH. Dietary treatments had no significant effect on nutritive values that includes (TDN and DCP). DCP% was significantly (P<0.050 decreased with sheep fed LS containing ration comparing to the other groups. Sheep received ration contained BH superior in their cell wall constituent digestibility comparing to other groups. Nitrogen retention was positive for all experimental groups. Total water intake, total water losses and insensible water losses were (P<0.05) decreased. Roughage source had no significantly effect on ruminal pH, $NH_3$-N and TVFA's concentration. Sampling time at 3hrs post feeding significantly (P<0.05) decreased ruminal pH, meanwhile it significantly (P<0.05) increased both values of $NH_3$-N and TVFA's concentrations in compared to before feeding (0hrs). There was no significant interaction between roughage source and sampling time on rumen fluid parameters. It could be concluded that, pea straw, chick pea straw and lentil straw considered good alternative for berseem hay in sheep ration occurred decreasing in ration costing without causing any adverse effect on their performance, digestion coefficients, nutritive values, water metabolism and ruminal fermentation.

**Keywords: Roughage sources, performance, digestibility coefficients, nutritive values, water metabolism, nitrogen balance, ruminal fermentation**

## INTRODUCTION

One of the important limiting factors for animal production in Egypt is the availability of feedstuffs. Locally produced feeds are not sufficient to cover the nutritional requirements of livestock (Abou-Akkada, 1988). In addition to in Egypt, the total area planted by clover hay reached about 2 million feddans (EMA, 2003). Recently, according to the national policy, the berseem area was decreased to increase the wheat area. Using non-traditional feed in animal feeding led to some advantages such as participates in solving the problem of feed shortage, decrease the cost of feeding and alleviate the pollution problems (Abdel-Magid et al., 2008).

In Egypt, shortage in animal feeds has been found to have a negative effect on the development of animal and poultry production. More attention was given to agricultural by-products (El-Ashry et al., 2002).

There are about 35 million tons of plants by-products annually produced that can be used in animal, rabbits and poultry diets (El-Manylawi et al., 2005).

Cereals and legumes are cultivated to obtain grain for human consumption or for animal feed (Lopez et al., 2005). Legume grains are important in meeting human dietary requirements in developing countries (Maheri-Sis et al., 2008; Aghajanzadeh-Golshani et al., 2012).

Crop residues after harvesting can produce substantial amount of biomass, often considered an agricultural waste. Straw is one of the main by-products from cereal and grain legume crops (Lopez et al., 2005). After chickpea grain threshing, large amounts of straw (about 400 kg per ha) usually equal to or more than the seed yield remain. Chickpea straw generally contains more protein, greater energy and lower cell wall contents than cereal straws (Aghajanzadeh-Golshani et al., 2012).

Lardy and Anderson (2009) reported that, chickpea straw is higher in nutritive value than cereal straws (44-46% TDN and 4.5-6.5% CP). Chickpea straw can be more palatable than wheat straw, but it is suggested that animals should be allowed to acclimate to the taste before offering large quantities.

Bampidis and Christodoulou (2011) concluded that chickpea straw has relatively high metabolizable energy content (7.7 MJ/Kg DM) and can be used as a ruminant feed.

Abreu and Bruno-Soares (1998) and Maheri-Sis et al., (2011) suggested that legume straws are usually used in sheep and goat nutrition. Kishore and Sagar (2006) reported that chickpea straw can be used as sole feedstuff for yearling sheep.

Several researches have shown that these straws such as chick pea straw, pea straw, peanut vein hay, beans straw, kidney beans straw, linseed straw, lentil straw and others had considerable amounts of nutrients that of suitable digestibility (Etman and Soliman 1999; Tawila 1999; Talha 2001; Talha et al., 2001; Mahmoud et al., 2003; Talha et al., 2005; Abdel-Magid 2005; Omer et al., 2012a and 2012b).

In addition to, Fekadu et al., (2010) noted that both *in vivo* and in vitro organic matter (OM) and crude protein (CP) digestibility of chickpea straw ranged between 47.1-62% and 40-64%, respectively. Meanwhile, Ørskov et al., (1992) determine the chemical composition and ruminal OM and CP degradability of chickpea straw using nylon bags (*in situ*) technique on in situ rumen degradability of chickpea straw.

So, this work aimed to investigate the impact of inclusion untraditional sources of roughages (field crop residues) such as (pea straw, chick pea straw or lentil straw) as alternative of berseem hay in sheep rations on their performance, water metabolism, digestion coefficients and ruminal fermentation.

## MATERIALS AND METHODS

This work was carried out in co-operation work between Animal Production Department, National

Research Centre, 33 El-Bohouth Street, P.O: 12622, Dokki, Giza, Egypt and Regional Center for Food and Feed, Agriculture Research Center, Ministry of Agriculture, Giza, Egypt.

The present work aimed to study the influence of inclusion different roughage sources (field crop residues) such as pea straw (PS), chick pea straw (CPS) and lentil straw (LS) as alternative source of Berseem hay (BH) in growing sheep rations on their growth performance, digestion coefficients, ruminal fermentation and water metabolism.

**Animals and feeds**

Twenty-eight growing Barki male lambs aged 6 months with an initial live body weight 24.05±0.25 kg approximately were used to establish the impact of replacing BH by alternative sources of roughage that mentioned above (PS, CPS and LS).

The animals were randomly allotted to four experimental groups (seven lambs each).

Experimental animals were housed in semi-open pens and fed as group feeding for 120 days, the experimental rations were offered in form of complete feed mixture that formulated to cover the requirements of growing sheep according to the NRC (1985).

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

- First*1st* experimental ration contained 30% BH and considered as control ($R_1$).
- Second*2nd* experimental ration contained 30% PS ($R_2$).
- Third*3th* experimental ration contained 30% CPS ($R_3$).
- Fourth*4th* experimental ration contained 30% LS ($R_4$).

Tested 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. Composition and chemical analysis (%) of the tested rations presented in Table (1).

**Apparent digestibility, nutritive values and nitrogen balance**

At the end of feeding trial, four animals in each treatment were housed in individual metabolic cages. Cages allowed catching feces separately from the urine which was collected in attached glass containers containing 50 ml sulphoric acid 10%. The digestibility trial consisted of 7 days as a preliminary period followed by 5 days for feces and urine collection.

Animals were received their tested rations and drinking water as mentioned before as described throughout the feeding period system.

During the collection period, feces and urine were quantitatively collected from each animal once a day at 7.00 a.m. before feeding. Actual quantity of feed intake and water consumption were recorded. A sample of 10% of the collected feces from each animal was sprayed with 10 % sulphoric acid and 10% formaldehyde solutions and dried at 60 °C for 24 hrs. Samples were mixed and stored for chemical analysis. Composite samples of feeds and feces were finely ground prior to analysis. Also 10% of the daily collected urine from each animal was preserved for nitrogen determination. The nutritive values expressed as the total digestible nutrient (TDN) and digestible crude protein (DCP) of the experimental rations was calculated by classical method that described by Abou-Raya (1967).

**Rumen fluid parameters**

Rumen fluid samples were collected from for animals at the end of the feeding trial before feeding (0 hrs) and 3 hrs post feeding via stomach tube and strained through four layers of cheesecloth. Samples were separated into two portions, the first portion was used for immediate determination of ruminal pH and ammonia nitrogen ($NH_3$-N) concentration, while the second portion was stored at-20 °C after adding a few drops of toluene and a thin layer of paraffin oil till analyzed for volatile fatty acid's (TVFA's).

**Analytical procedures**

Chemical analysis of tested ration samples, feces and urine were analyzed according to AOAC (2005) methods. Meanwhile, Cell wall constituents includes {neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL)} were evaluated according to Goering and Van Soest (1970) and Van Soest et al., (1991). In addition to, hemicellulose content was calculated as the difference between NDF and ADF, while, cellulose content was calculated as the difference between ADF and ADL.

Ruminal pH was immediately determined using digital pH meter. Ruminal ammonia nitrogen ($NH_3$-N) concentrations were determined applying $NH_3$ diffusion technique using Kjeldahle distillation method according to AOAC (2005). On the other hand, ruminal total volatile fatty acids (TVFA's) concentrations were determined by steam distillation according to Warner (1964).

**Statistical analysis**

Data collected of live weight, average daily gain, feed and water intake, feed conversion, nutrient digestibility, cell wall constituent digestibility and nutritive values were subjected to statistical analysis as one-way analysis of variance according to SPSS (2008). Duncan's Multiple Range Test Duncan, (1955) 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. $\mu$ = overall mean.

$T_i$ = effect of experimental rations for i = 1-4, 1 = ($R_1$ contained 30% berseem hay and considered as control), 2 = ($R_2$ contained 30% of pea straw), 3 = ($R_3$ contained 30% Chick pea straw) and 4 = ($R_4$ contained 30% lentil straw).

$e_{ij}$ = the experimental error.

Meanwhile, data of rumen fluid parameters (ruminal pH, $NH_3$-N and TVFA's) concentrations were statistically analyzed as two factors-factorial analysis of variance according to the following model:

$Y_{ijk} = \mu + T_i + S_j + (TS)_{ij} + e_{ijK}$

Where: $Y_{ij}$ = observation. $\mu$ = overall mean.

$T_i$ = effect of experimental rations for i = 1-4, 1 = ($R_1$ contained 30% berseem hay and considered as control), 2 = ($R_2$ contained 30% of pea straw), 3 = ($R_3$ contained 30% Chick pea straw) and 4 = ($R_4$ contained 30% lentil straw).

$S_j$ = the effect of sampling time for j =1-2, 1= before feeding (0 hrs) and 2= 3hrs post feeding.

$(TS)_{ij}$ = the interaction of roughage sources (T) and sampling time (S).

$e_{ij}$ = the experimental error.

## RESULTS AND DISCUSSION

**Composition and chemical analysis**

Data of composition and chemical analysis for the experimental rations are presented in Table (1) cleared that all tested rations were formulated to meet the requirements of growing sheep and it seams to be almost iso-caloric and iso-nitrogenous (CP ranged from 16.00 to 16.17%). On the other hand, crude fiber (CF) contents were slightly differing resulting change source roughage used in ration formulation that ranged from 13.85 to 15.52%. Ether extract (EE) contents ranged from (2.82 to 3.05%). On the other hand, values of cell wall constituents contents includes (NDF, ADF and ADL) were slightly increased, meanwhile both hemicellulose and cellulose contents were in the same trend among the different four experimental rations.

**Growth performance of the experimental groups**

As presented in Table (2) inclusion different untraditional sources of roughage such as (PS, SPS or LS) as alternative for BH had no significant (P>0.05) effect on their total body weight gain (TBWG) and average daily gain (ADG).Moreover, sheep received ration contained 30% pea straw ($R_2$) insignificantly increased their BWG and ADG comparing to the other groups that received BH or CPS or LS.

These results in agreement with those found by Abdel-Magid et al., (2008) who observed that during the growing period, sheep fed 35% pea straw containing diet group recorded the highest values of body weight gains (BWG) and average daily gain (ADG) followed by those of the control (35% Berseem hay (BH), while the lowest value was recorded for those fed 35% Chick pea straw (CPS) diet. On the other hand, Forster et al., (1988) noted that when lambs received 30% ground maize and 70% chopped forage of 0, 25, 50, 75 or 100% pea hay with Lucerne showed no significant differences in daily weight gains. In addition to, Mohamed (2007) noted that incorporation 15% bean straw plus 15% pea straw and 15% chick pea straw as a replacement for groundnut hay that incorporated at 40% in control ration fed to growing Maghraby camels caused significantly (P<0.05) increasing in their average daily gain.

Also, our results showed that replacing BH ($R_1$) by CPS ($R_3$) or LS ($R_4$) caused significant decreasing (P<0.05) in dry matter intake (DMI), meanwhile sheep received PS containing ration was not affected on their DMI in comparison with that received BH containing diet. Incorporation PS or CPS significantly (P<0.05) decreased digestible crude protein intake (DCPI) in comparison with that received BH or LS containing rations. On the other hand, sheep fed PS ($R_2$) recorded the highest value of total digestible nutrient intake (TDNI, 699 g), meanwhile, that received LS ($R_4$) recorded the least value of TDNI (667g).

**Table: 1. Composition and chemical analysis of the experimental rations.**

| Item | Experimental rations |
|---|---|

| | ($R_1$) | ($R_2$) | ($R_3$) | ($R_4$) |
|---|---|---|---|---|
| ***Composition (%)*** | | | | |
| **Yellow corn** | 30.00 | 30.00 | 30.00 | 30.00 |
| **Wheat bran** | 15.00 | 15.00 | 15.00 | 15.00 |
| **Soybean meal** | 10.00 | 10.00 | 10.00 | 10.00 |
| **UDCSM** | 12.00 | 12.00 | 12.00 | 12.00 |
| **Berseem hay (BH)** | 30.00 | - | - | - |
| **Pea straw (BS)** | - | 30.00 | - | - |
| **Chick pea straw (CPS)** | - | - | 30.00 | - |
| **Lentil straw (LS)** | - | - | - | 30.00 |
| **Limestone** | 1.20 | 1.20 | 1.20 | 1.20 |
| **Sodium chloride** | 1.00 | 1.00 | 1.00 | 1.00 |
| **Vitamin & mineral mixture[1]** | 0.80 | 0.80 | 0.80 | 0.80 |
| **Price of Ton (LE)** | 4093 | 3643 | 3613 | 3583 |
| ***chemical analysis*** | | | | |
| **Moisture** | 8.20 | 7.73 | 8.17 | 8.00 |
| ***Chemical analysis on DM basis*** | | | | |
| **Organic matter (OM)** | 92.35 | 91.68 | 92.57 | 91.65 |
| **Crude protein (CP)** | 16.17 | 16.08 | 16.00 | 16.00 |
| **Crude fiber (CE)** | 13.85 | 14.15 | 14.79 | 15.52 |
| **Ether extract (EE)** | 3.05 | 3.03 | 2.92 | 2.82 |
| **Nitrogen free extract (NFE)** | 59.28 | 58.42 | 58.86 | 57.31 |
| **Ash** | 7.65 | 8.32 | 7.43 | 8.35 |
| ***Cell wall constituents*** | | | | |
| **Neutral detergent fiber (NDF)** | 37.69 | 38.33 | 38.91 | 37.70 |
| **Acid detergent fiber (ADF)** | 29.16 | 30.07 | 30.40 | 29.88 |
| **Acid detergent lignin (ADL)** | 4.67 | 5.23 | 5.38 | 5.52 |
| **Hemicellulose*** | 8.53 | 8.26 | 8.51 | 7.82 |
| **Cellulose**** | 24.49 | 24.84 | 25.02 | 24.36 |

[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. UDCSM: Un-decorticated cotton seed meal.

$R_1$: first[1st] experimental ration contained 30% Berseem hay.

$R_2$: second[2nd] experimental ration contained 30% pea straw.

$R_3$: third[3th] experimental ration contained 30% chick pea straw.

$R_4$: fourth[4th] experimental ration contained 30% Lentil straw.

* Hemicellulose = NDF – ADF. ** Cellulose = ADF – ADL.

These results in agreement with those obtained by El-Basiony (1992) who observed that calves fed berseem hay consumed less (P<0.05) DM and also, with those found by Abdel-Magid et al., (2008) who observed that Rahmani lambs fed berseem hay consumed less (P<0.05) DM compared to pea straw. On the other hand, the present results disagreement with those found by Omer et al. (2012b) who noted that inclusion peanut vein hay (PVH); beans straw (BS); kidney beans straw (KBS) or linseed straw (LS) in sheep diet significantly increased (P<0.05) feed consumption as DM or CP intakes in comparison with the BH containing diet. Also, Pathirana and Ørskov (1995) recorded an increasing in nutrient intake as a result of increases of forage legumes as supplements to low quality basal diets. Bartle et al. (1994) fed alfalfa and cottonseed hulls at 10, 20, or 30% of the dietary DM to finishing beef cattle; they found that within each roughage level, DMI was decreased compared to control diet. Guthrie et al. (1996) fed heifers diets with alfalfa, cottonseed hulls, and sorghum Sudan grass hay at either 7.5 or 15% of DM in whole shelled corn-based diets. They noted that DMI was greater by heifers fed the cottonseed hulls and sorghum Sudan grass hay diets than by those fed alfalfa.

**Table: 2. Growth performance of the experimental groups.**

| Item | Experimental rations | | | | SEM |
|---|---|---|---|---|---|
| | ($R_1$) | ($R_2$) | ($R_3$) | ($R_4$) | |

| | | | | | |
|---|---|---|---|---|---|
| ***Live body weight, g*** | | | | | |
| **Lambs number** | 7 | 7 | 7 | 7 | - |
| **Initial weight (kg)** | 24.100 | 23.900 | 24.200 | 24.000 | 0.25 |
| **Final weight (FW, kg)** | 46.400 | 47.000 | 45.850 | 45.900 | 0.20 |
| **Total body weight gain (TBWG, kg)** | 22.300 | 23.100 | 21.650 | 21.900 | 0.26 |
| **Experimental duration period** | 120 days | | | | |
| **Average daily gain (ADG, g/day)** | 186 | 193 | 180 | 183 | 2.11 |
| **Dry matter intake, g** | 1058$^{a}$ | 1035$^{ab}$ | 1005$^{bc}$ | 989$^{c}$ | 7.39 |
| **Digestible crude protein intake, g** | 114$^{a}$ | 108$^{b}$ | 108$^{b}$ | 95$^{c}$ | 1.45 |
| **Total digestible nutrient intake, g** | 697$^{a}$ | 699$^{a}$ | 680$^{ab}$ | 667$^{b}$ | 4.42 |
| ***Feed conversion expressed as g. intake / g. gain of*** | | | | | |
| **Dry matter ((DM)** | 5.688 | 5.363 | 5.583 | 5.404 | 0.07 |
| **Digestible crude protein (DCP)** | 0.613$^{c}$ | 0.560$^{ab}$ | 0.600$^{bc}$ | 0.519$^{a}$ | 0.01 |
| **Total digestible nutrient (TDN)** | 3.747 | 3.622 | 3.778 | 3.465 | 0.05 |

a, b and c: Means in the same row having different superscripts differ significantly ($P<0.05$).
SEM: Standard error of mean.
$R_1$: first$^{1st}$ experimental ration contained 30% Berseem hay.
$R_2$: second$^{2nd}$ experimental ration contained 30% pea straw.
$R_3$: third$^{3th}$ experimental ration contained 30% chick pea straw.
$R_4$: fourth$^{4th}$ experimental ration contained 30% Lentil straw.

On the other hand, Gad Alla (1997); Mohamed (1999); El-Adawy and Borhami (2001); Tag El-Din et al. (2002); Abdel-Magid (2005); Omer et al. (2011) and Omer and Badr (2013) noted that, replacing berseem hay by carrot-tops, strawberry byproducts, peanut hay, kidney beans or pea straws significantly improved the growth performance of growing rabbits. Mohamed (2007) reported that inclusion 15% bean straw plus 15% pea straw and 15% chick pea straw as a replacement for groundnut hay that incorporated at 40% in control ration fed to growing Maghraby camels not affected on dry matter intake and it was in the same trend approximately.

Also, our results presented in Table (2) showed that feed conversion that expressed as g. intake / g. gain of dry matter or total digestible nutrient for rations contained 30% of PS ($R_2$) or CPS ($R_3$) or LS ($R_4$) in significant improved compared to BH ($R_1$). However, feed conversion that expressed as g. intake /g. gain of digestible crude protein for ration contained 30% PS ($R_2$) or LS ($R_4$) were significantly ($P<0.05$) improved in comparison with the BH ($R_1$) containing ration. These results in agreement with those obtained by Abdel-Magid et al. (2008) who reported that incorporation 35% of pea straw in sheep ration insignificantly improved their feed conversion that expressed as kg DM intake/ kg gain (4.69) comparing to sheep received ration containing 35% berseem hay (4.78). Also, results in agreement with those found by Gad Alla (1997) who stated that feed conversion was improved by incorporation of sun-dried crops and vegetable residues up to 50 or 75%. In addition to, the present results in agreement with those found by Abdel-Magid (2005) and El-Medany et al. (2008) and Omer et al. (2011) and Omer and Badr (2013) who replaced berseem hay with pea, chick pea or kidney beans straws; dried carrot processing waste or strawberry by-products, in growing rabbit diets. Mohamed (2007) noted that incorporation 15% bean straw plus 15% pea straw and 15% chick pea straw as a replacement for groundnut hay that incorporated at 40% in control ration fed to growing Maghraby camels in significantly improved their feed conversion.

### Digestibility coefficients and nutritive values of the experimental rations

Data of Table (3) cleared that sheep received 30% PS ($R_2$) or CPS ($R_3$) containing rations significantly ($P<0.05$) increased both DM and CF digestibilities, meanwhile, OM, CP, EE and NFE digestibilities were not affected in comparison with that received 35% BH ($R_1$). On the other hand, sheep received 30%

**Table: 3. Digestibility coefficients and nutritive values of the experimental rations.**

| Item | Experimental rations | | | | SEM |
|---|---|---|---|---|---|
| | **($R_1$)** | **($R_2$)** | **($R_3$)** | **($R_4$)** | |
| ***Nutrient digestibilities (%) of*** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Dry matter (DM)** | 60.19$^{b}$ | 63.54$^{a}$ | 62.65$^{a}$ | 64.32$^{a}$ | 2.04 |
| **Organic matter (OM)** | 67.79$^{ab}$ | 65.26$^{b}$ | 69.60$^{a}$ | 68.27$^{a}$ | 2.24 |
| **Crude protein (CP)** | 66.51$^{a}$ | 65.15$^{a}$ | 67.42$^{a}$ | 60.30$^{b}$ | 3.27 |
| **Crude fiber (CF)** | 63.61$^{b}$ | 68.55$^{a}$ | 66.58$^{a}$ | 61.70$^{b}$ | 3.06 |
| **Ether extract (EE)** | 65.85$^{b}$ | 66.34$^{b}$ | 64.20$^{b}$ | 70.34$^{a}$ | 2.81 |
| **Nitrogen-free extract (NFE)** | 70.55$^{b}$ | 73.29$^{b}$ | 72.70$^{b}$ | 76.38$^{a}$ | 2.68 |
| ***Nutritive values (%)*** | | | | | |
| **Total digestible nutrient (TDN)** | 65.90 | 67.53 | 67.64 | 67.49 | 1.56 |
| **Digestible crude protein (DCP)** | 10.75$^{a}$ | 10.48$^{a}$ | 10.79$^{a}$ | 9.65$^{b}$ | 0.54 |
| ***Cell wall constituents digestibility of*** | | | | | |
| **Neutral detergent fiber (NDF)** | 69.49$^{a}$ | 66.35$^{b}$ | 64.39$^{bc}$ | 63.44$^{c}$ | 2.77 |
| **Acid detergent fiber (ADF)** | 71.10$^{a}$ | 70.31$^{a}$ | 69.73$^{a}$ | 65.28$^{b}$ | 2.76 |
| **Hemicellulose*** | 60.01$^{a}$ | 62.49$^{a}$ | 51.59$^{b}$ | 53.23$^{b}$ | 4.97 |
| **Cellulose**** | 72.27$^{a}$ | 71.82$^{ab}$ | 69.53$^{bc}$ | 67.17$^{c}$ | 2.56 |

a, b and c: Means in the same row having different superscripts differ significantly ($P<0.05$).
SEM: Standard error of mean.
$R_1$: first$^{1st}$ experimental ration contained 30% Berseem hay.
$R_2$: second$^{2nd}$ experimental ration contained 30% pea straw.
$R_3$: third$^{3th}$ experimental ration contained 30% chick pea straw.
$R_4$: fourth$^{4th}$ experimental ration contained 30% Lentil straw.

LS containing ration significantly (P<0.05) increased DM, EE and NFE digestibilities, meanwhile, CP digestibility significantly (P<0.05) decreased, but OM insignificantly (P>0.05) increased however, CF digestibility insignificantly (P>0.05) decreased comparing to sheep received 35% BH.

On the other hand, sheep received 30% LS containing ration significantly (P<0.05) increased DM, EE and NFE digestibilities, meanwhile, CP digestibility significantly (P<0.05) decreased, but OM insignificantly (P>0.05) increased however, CF digestibility insignificantly (P>0.05) decreased comparing to sheep received 35% BH.

Also, our results showed that dietary treatments (PS, CPS and LS) had no significant effect on nutritive values that includes (TDN and DCP) in comparison with that fed on BH containing ration, however, DCP% was significantly (P<0.05) decreased with sheep fed LS containing ration comparing to the other groups. In addition to, sheep received BH containing diets superior in their cell wall constituent digestibility includes (NDF, ADF and cellulose digestibilities), meanwhile, hemicellulose digestibility of sheep fed ration contained PS recorded the best value (62.495%) comparing to other groups that ranged from (51.59 to 60.01%). These results in harmony with those obtained by Mohamed (2007) who noted that incorporation 15% bean straw plus 15% pea straw and 15% chick pea straw as a replacement for groundnut hay that incorporated at 40% in control ration fed to growing Maghraby camels insignificantly increased DM, OM, CP, EE and NFE digestibility and TDN and DCP. Also, our results in agreement with those found by Abdel-Magid et al. (2008) who reported that sheep fed PS containing diet and control containing (BH) had similar values of digestibilities of OM, CP, CF and NEF of experimental diets, being higher than those of PS containing diets. Differences reached significances (P<0.05) with OM digestibility and NFE digestibilities. Foster et al., (1988) noted that lambs received 30% ground maize and 70% chopped forage of 0, 25, 50, 75 or 100% pea hay with Lucerne showed linear decrease in DM digestibility of the diet from 59.7 to 53.3% with increasing proportion of pea hay. On the other hand, Abdel-Magid et al. (2008) recorded that no significant differences in DCP content was found among period were higher than those reported 40% roughage experimental diets. However, the CPS diet tended to be lower by Aly et al. (1982) on Rahmani lambs fed diets containing in DCP content than the control or PS diets, this was due to the lower CP digestibility. In addition to, Omer et al. (2012a) reported that nutrient digestibility coefficients and nutritive values significantly improved when sheep fed ration contained biologically treated corn stalks for all nutrient digestibility coefficients and cell wall constituent digestibilities compared to the control group that fed clover hay. Also, they showed that, with increasing the level of replacement of CH by BTCS the cell wall constituent digestibilities were increased. Meanwhile, Omer and Badr (2013) reported that incorporation PS in the rabbit diets significant (P<0.05) decreased

DM and CP digestibilities in comparison with that received BH (control), however, OM, CF, EE and NFE digestibilities were significantly (P<0.05) improved with replacement BH by PS in tested rations at different levels of replacement (25, 50, 75 and 100%). Also, they found that replacing BH by PS at different levels significantly (P<0.05) increasing TDN values, but it significantly (P<0.05) decreased their DCP content.

**Nitrogen utilization by sheep fed the experimental rations**

Data of Table (4) cleared that dietary treatments had no significant effect on nitrogen, intake, fecal nitrogen, digested nitrogen, urinary nitrogen, total nitrogen extraction and nitrogen retention. Also, nitrogen retention was positive for all experimental groups. These results in harmony with those reported by Omer and Badr (2013) who fed rabbits diets replaced 25, 50, 75 and 100% of BH by PS. Also, Abdel-Magid et al., (2008) showed that nitrogen balance of lambs fed CPS was significantly lower compared among the other two diets (BH and PS) which recorded no significant values. Also, Forster et al. (1988) noted that nitrogen retention was not affected by diet when lambs were fed 30% ground maize and 70% chopped forage of 0, 25, 50, 75 or 100% pea hay with Lucerne. In addition to, Mohamed (2007) reported that incorporation 15% bean straw plus 15% pea straw and 15% chick pea straw as a replacement for groundnut Hay that incorporated at 40% in control ration fed to growing Maghraby camels significantly (P<0.05) increased nitrogen retained. Also, he noted that both nitrogen retained/ nitrogen intake (%) and nitrogen retained/ digestible nitrogen (%) were in significantly increased.

**Water metabolism by the experimental groups**

As presented in Table (5) data showed that instead of BH by PS or CPS or LS caused significantly (P<0.05) decreasing in drinking water, feeds water and total water intake. Also, urinary water losses, feces water losses and total water losses were significantly (P<0.05) decreased, meanwhile, insensible water losses were insignificantly decreased. These results in agreement with those obtained by Mohamed (2007) who reported that inclusion 15% bean straw plus 15% pea straw and 15% chick pea straw as a replacing for groundnut hay that incorporated at 40% in control ration fed to growing Maghraby camels in significantly increased their drinking water meanwhile, it significantly (P<0.05) increased their insensible water loss. Also, our results in agreement with those reported by Omer et al. (2012b) who observed that feeding sheep on ration contained 50% linseed straw significantly decreased their drinking water compared to sheep fed ration contained 50% Berseem hay. Meanwhile, they noted that feeding sheep on ration contained 50% beans straw significantly (P<0.05) increased drinking water, however, feeding sheep on ration contained 50% peanut vein hay or kidney beans straw in significantly increased drinking water in comparison with that received 50% Berseem hay containing ration.

**Rumen fluid parameters of the experimental rations**

Data of Table (6) mentioned that roughage source had no significantly effect on ruminal pH, $NH_3$-N and TVFA's concentration. Values of ruminal fermentation includes (pH, $NH_3$-N and TVFA's) tended to slightly decrease. On the other hand, sampling time at 3hrs post feeding significantly (P<0.05) decreased ruminal pH, meanwhile it significantly (P<0.05) increased both values of $NH_3$-N and TVFA's concentrations in comparison with the before feeding (0hrs).

There was no significant interaction between roughage source and sampling time on rumen fluid parameters that mentioned above (Table 7).

These results in agreement with those obtained by Omer and Abdel-Magid (2015) who showed that ruminal pH value (P<0.05) decreased at 3hrs post feeding, while, total volatile fatty acids concentration significantly (P<0.05) increased at the same time when they fed their Ossimi lambs rations containing different levels (0, 5, 10 and 15%) of dried tomato pomace replaced from BH in control ration. In contrast, they noted that values of ammonia nitrogen concentration significantly (P<0.05) decreased at 3hrs post feeding.

Ruminal pH is one of the most important factors affecting the fermentation and influences its functions.

It varies in a regular manner depending on the nature of the diet and on the time, it is measured after feeding and reflects changes of organic acids quantities in the ingesta. The level of $NH_3$-N and TVFA's as end products of fermentation and breakdown of dietary protein, have been used a parameters of ruminal activity by Abou-Akkada and Osman (1967).

**Table: 4. Nitrogen utilization by sheep fed the experimental rations.**

| Item | Experimental rations | | | | SEM |
|---|---|---|---|---|---|
| | ($R_1$) | ($R_2$) | ($R_3$) | ($R_4$) | |
| **Nitrogen intake (NI)** | 28.78 | 28.58 | 29.15 | 30.06 | 0.56 |
| **Fecal nitrogen (FN)** | 9.62 | 9.86 | 10.25 | 10.76 | 0.22 |
| **Digested nitrogen (DN)** | 19.16 | 18.72 | 18.90 | 19.30 | 0.36 |
| **Urinary nitrogen (UN)** | 9.85 | 10.05 | 10.27 | 10.75 | 0.21 |
| **Total nitrogen extraction (TNE)** | 19.47 | 19.91 | 20.52 | 21.51 | 0.43 |
| **Nitrogen retention (NR)** | 9.31 | 8.67 | 8.63 | 8.55 | 0.18 |
| **NR, % of NI** | $32.35^{a}$ | $30.34^{ab}$ | $29.60^{b}$ | $28.44^{b}$ | 0.37 |
| **NR, % of DN** | $48.59^{a}$ | $46.31^{ab}$ | $45.66^{b}$ | $44.30^{b}$ | 0.40 |

a and b: Means in the same row having different superscripts differ significantly (P<0.05). SEM: Standard error of mean. $R_1$: first$_{1s}$$^{t}$ experimental ration contained 30% Berseem hay.
$R_2$: second$^{2nd}$ experimental ration contained 30% pea straw.
$R_3$: third$^{3th}$ experimental ration contained 30% chick pea straw.
$R_4$: fourth$^{4th}$ experimental ration contained 30% Lentil straw.

**Table: 5. Water metabolism by the experimental groups.**

| Item | Experimental rations | | | | SEM |
|---|---|---|---|---|---|
| | ($R_1$) | ($R_2$) | ($R_3$) | ($R_4$) | |
| ***Water intake, ml*** | | | | | |
| **Drinking water** | $3800^{a}$ | $3650^{b}$ | $3550^{b}$ | $3400^{c}$ | 41.03 |
| **Feeds water** | $95^{a}$ | $87^{b}$ | $89^{b}$ | $86^{b}$ | 1.20 |
| **Total water intake** | $3895^{a}$ | $3737^{b}$ | $3639^{b}$ | $3486^{c}$ | 41.80 |
| ***Water losses*** | | | | | |
| **Urinary water losses, ml** | $1246^{a}$ | $1158^{ab}$ | $1092^{bc}$ | $1011^{c}$ | 25.95 |
| **Feces water losses, ml** | $1091^{a}$ | $1009^{b}$ | $946^{b}$ | $872^{c}$ | 11.84 |
| **Total water losses, ml** | $2337^{a}$ | $2167^{b}$ | $2038^{c}$ | $1883^{d}$ | 45.86 |
| **Insensible water losses, ml** | 1558 | 1570 | 1601 | 1603 | 19.17 |

a, b c and d: Means in the same row having different superscripts differ significantly (P<0.05).
SEM: Standard error of mean. $R_1$: first$^{1st}$ experimental ration contained 30% Berseem hay.
$R_2$: second$^{2nd}$ experimental ration contained 30% pea straw.
$R_3$: third$^{3th}$ experimental ration contained 30% chick pea straw.
$R_4$: fourth$^{4th}$ experimental ration contained 30% Lentil straw.
Insensible water losses, ml = Total water intake -Total water losses.

The results of ruminal fermentations showed that increasing TVFA's might be related to the more utilization of dietary energy and positive fermentation in the rumen. Increasing TVFA's might be related to the more utilization of dietary energy and positive fermentation in the rumen. Addition of more fermentable carbohydrate to ruminant rations causes a decrease in rumen ammonia (Tagari et, 1964) probably due to a greater uptake of ammonia by rumen microorganisms in support of enhanced microbial growth. The rate of TVFA's production may in this situation exceed the rate of TVFA's absorption through the rumen epithelium and TVFA's concentration in the rumen juice is increased (Van'tKlooster, 1986). It should be mentioned that, TVFA's concentration in the rumen is governed by several factors such as dry matter digestibility, rate of absorption, rumen pH, transportation of the digesta from the rumen to the other parts of the digestive tract and the microbial population in the rumen and their activities (Allam et al., 1984). Increasing of ruminal TVFA's concentration is an indicator for better utilization of dietary carbohydrate as described by Fadel et al. (1987).

**Table: 6. Main Effect of roughage source or sampling time on rumen fluid parameters of the experimental rations.**

| Item | Roughage source | | | | SEM | P<0.05 | Sampling time | | SEM | P<0.05 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 30% BH | 30% PS | 30% CPS | 30% LS | | | Before feeding | 3 hrs post feeding | | |
| pH | 6.33 | 6.30 | 6.23 | 6.25 | 0.03 | NS | 6.40[a] | 6.15[b] | 0.03 | * |
| $NH_3$-N (mg/dl) | 20.26 | 19.98 | 19.75 | 20.04 | 0.46 | NS | 17.75[b] | 22.26[a] | 0.46 | * |
| TVFA's (meq/dl) | 8.86 | 8.85 | 8.92 | 8.95 | 0.23 | NS | 8.01[b] | 9.78[a] | 0.23 | * |

a and b: Means in the same row within each treatments having different superscripts differ significantly (P<0.05).
SEM: standard error of the mean. NS: not significant *: significant at (P<0.05).
BH: Berseem hay. PS: Pea straw. CPS: Chick pea straw. LS: Lentil straw. YC: Yellow corn. WB: wheat bran.
$NH_3$-N: Ammonia nitrogen concentration.
TVFA's: Total volatile fatty acids concentration.

**Table: 7. Effect of interaction between roughage source and sampling time on rumen fluid parameters of the experimental rations.**

| Item | Sampling time | | | | | | | | SEM | P<0.05 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Before feeding | | | | 3 hrs post feeding | | | | | |
| | 30% BH | 30% PS | 30% CPS | 30% LS | 30% BH | 30% PS | 30% CPS | 30% LS | | |
| pH | 6.46[a] | 6.43[a] | 6.34[ab] | 6.36[ab] | 6.21[bc] | 6.16[bc] | 6.11[c] | 6.14[bc] | 0.03 | NS |
| $NH_3$-N (mg/dl) | 17.86[b] | 17.57[b] | 17.59[b] | 17.97[b] | 22.65[a] | 22.39[a] | 21.91[a] | 22.11[a] | 0.46 | NS |
| TVFA's (meq/dl) | 7.99[b] | 7.83[b] | 8.01[b] | 8.22[ab] | 9.73[a] | 9.88[a] | 9.82[a] | 9.68[a] | 0.23 | NS |

a, b and c: Means in the same row having different superscripts differ significantly (P<0.05).
SEM: standard error of the mean.
NS: not significant
BH: Berseem hay. PS: Pea straw. CPS: Chick pea straw. LS: Lentil straw. YC: Yellow corn. WB: wheat bran.
$NH_3$-N: Ammonia nitrogen concentration.
TVFA's: Total volatile fatty acids concentration.

## CONCLUSION

Under the same conditions available during carrying out for this work and from the data obtained, it could be concluded that, pea straw, chick pea straw and lentil straw as unconventional source of roughage considered good alternative for berseem hay in sheep ration realized depressing in ration costing. Also, it could be successfully used as instead of Berseem hay without causing any adverse effect on their performance, digestibility coefficients, nutritive values, nitrogen balance, water metabolism and ruminal fermentation.

## CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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## AUTHOR CONTRIBUTIONS

Hamed A.A.Omer cooporation in designed and performleed the experiments, alculated the data, statistical analysis, wrote the manuscript and reveision the MS during the different steps of publication.

Azza M.M. Badr cooporation cooporation in designed, performleed the experiments and following the publication of the MS.

All authors read and approved the final version.



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