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Dry Matter Degradation Kinetics and Metabolizable Energy of Chickpea *(Cicer arietinum)* Straw in Ruminants

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Abstract: Chickpea straw is the main by-product which is produced in large amounts after chickpea grain threshing. There is a little information about its nutritive value. This experiment was carried out to determine the fiber and non-fibre component, ruminal dry matter degradability and Metabolizable Energy (ME) of chickpea straws using nylon bags (*in situ*) technique. Replicated samples were incubated at 0, 2, 4, 8, 12, 24, 48 and 72 h in 3 rumen canulated male Ghezel rams with 50±3 kg body weight. Dry Matter (DM), Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and Non-Fibrous Carbohydrates (NFC) content of chickpea straws were 92.18, 57.80, 37.40 and 22.65%, respectively. The dry matter soluble fraction (a), non-soluble but potentially degradable fraction (b) and potential degradability (a+b) of chickpea straws were 19.50, 38.60 and 58.10%, respectively. Effective degradability at different passage rates (2, 5 and 8% h^{-1}) were 53.70, 48.60 and 44.80%, respectively. Estimated metabolizable energy of chickpea straw was 8.55 MJ kg^{-1} DM. Based on the DM degradation kinetics and energy content, beseems chickpea straw could be used as a valuable feedstuff in ruminants diet.

Key words: Chickpea straw, fibre, dry matter degradability, metabolizable energy, nylon bag, Iran

INTRODUCTION

Legume grains are widely grown crops in the world for human and animal nutrition purposes. Chickpea grain (*Cicer arietinum*) is the most important legume crop and ranking first between grain legumes cultivation area (0.75 million ha) with 0.3 million ton in Iran (Parsa and Bagheri, 2007). Chickpea straw is the main by-product produced after chickpea grain threshing which is usually equal to or more than the seed yield. Chickpea straw generally is used by smallholder farmers around the production area. This by-product contains more nutritive value and palatability than cereal straws (Lardy and Anderson, 2009; El-Bordeny *et al*., 2010; Kafilzadeh and Maleki, 2011). Although, chickpea straw is an animal feed that high in fiber and low in nitrogen, it can be used as a ruminant feed especially in small ruminant's nutrition because of moderate nutritive value (Abreu and Bruno-Soares, 1998; Kishore and Sagar, 2006; Soha *et al*., 2008; Bampidis and Christodoulou, 2011).

Chickpea straw generally contains more protein and metabolizable energy concentrations and lower Neutral Detergent Fibre (NDF) contents than cereal straws. Dry Matter (DM) digestibility and rumen degradability of chickpea straw were about 10 and 42% higher than those of the cereal straws, respectively (Kafilzadeh and Maleki, 2011). Bampidis and Christodoulou (2011) reviewed that digestible energy and metabolizable energy content of chickpea straw were 8.3 and 7.7 MJ kg^{-1} DM, respectively.

Bruno-Soares *et al*. (2000) reported that Crude Protein (CP), NDF, ADF and Acid Detergent Lignin (ADL) content in chickpea are 6.1, 76.5, 59.6 and 14.2%, respectively. They are suggested that degradation characteristics of straws in the rumen will provide useful tools for the evaluation of their nutritive value. Based on their findings, DM and NDF potential degradability of legumes straws was in range of 45.4-63.2 and 36.6-57.1%, respectively. Dry matter degradability of chickpea straw was lower than that of other legume straws due to higher NDF, ADF and ADL content in this by-product.

In spite of wide use of chickpea straw in small ruminant nutrition in the site of grains threshing, there is scarce information (Bruno-Soares *et al*., 2000) on *in situ* rumen degradability of this by-product. The aim of this study was to determine the fibre and non-fibre component, ruminal dry matter degradability and Metabolizable Energy (ME) of chickpea straws using nylon bags (*in situ*) technique.

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MATERIALS AND METHODS

Sample collection and chemical analysis: Chickpea straw samples were collected from four local farms in Shabestar, East Azerbaijan province, Iran. Dry matter was determined by drying the samples at 105°C overnight and ash by igniting the samples in muffle furnace at 525°C for 8 h. Nitrogen (N) content was measured by the Kjeldahl Method (AOAC, 1990). Crude Protein (CP) was calculated as N*6.25. Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were determined by procedures outlined by Van Soest *et al.* (1991). Non-Fibrous Carbohydrates extract (NFC) was calculated using the equation proposed by NRC:

$$NFC\% = 100 - (NDF\% + CP\% + EE\% + Ash\%)$$

Metabolizable Energy (ME) was calculated by the equation of ME (MJ/kg DM) = 0.1073* DM deg 48 h + 2.27563 (Bhargava and Orskov, 1987).

***In situ* degradation procedures:** Three ruminally cannulated Gezel rams (about 55 kg BW) were used to determine *in situ* degradation characteristics. Rams were housed in individual tie stalls bedded with sawdust. Rams fed diets containing alfalfa hay (70%) and concentrate mixture (30%) at the maintenance levels. Dacron bags (18*9 cm; 40-45 μ pore size) were filled with 5 g dried and ground samples then incubated in the rumen of rams for the periods of 0, 2, 4, 8, 12, 24, 48 and 72 h. After the removal of bags from the rumen, bags were washed in cold water until rinse were clear and dried at 60°C for 48 h (Maheri-Sis *et al.*, 2011).

Rumen degradation kinetics of DM was fitted by the non-linear model proposed by Orskov and McDonald (1979) using FITCURVE software Version 6 (Chen, 1995):

$$P = a + b(1 - e^{-ct})$$

Where:

P = Percentage of degradability for response variables at t
t = Time relative to incubation (h)
a = Highly soluble and readily degradable fraction (%)
b = Insoluble and slowly degradable fraction (%)
c = Rate constant for degradation (/h)
e = 2.7182 (Natural logarithm base)

Following determination of those parameters, the effective degradability of DM in samples was calculated using and equation described by Orskov and McDonald (1979):

$$ED = \frac{a + (b*c)}{(c+k)}$$

Where:

ED = Effective degradability for response variables (%)
a = Highly soluble and readily degradable fraction (%)
b = Insoluble and slowly degradable fraction (%)
c = Rate constant for degradation (/h)
k = Rate constant of passage (/h)

RESULTS AND DISCUSSION

Chemical composition and fibre components of chickpea straw are shown in Table 1. Neutral detergent fibre of chickpea straw in current study (57.80%) was in range of previous findings (55.1-86.2%) while ADF content (37.40%) was lower than range of 40.5-59.6% which is reported by other researchers (Abreu and Bruno-Soares, 1998; Bruno-Soares *et al.*, 2000; Lopez *et al.*, 2005; Lardy and Anderson, 2009; Fekadu *et al.*, 2010; Bampidis and Christodoulou, 2011; Kafilzadeh and Maleki., 2011). Differences in chemical composition and fibre components of chickpea by-products (e.g., straws) in various investigations can be due to different chickpea varieties, growing conditions (geographic, seasonal variations, climatic conditions and soil characteristics), harvesting time of chickpea, leaves to stem ratio, amount of foreign materials and impurities such as soil contamination and different measuring methods (Lopez *et al.*, 2005; Maheri-Sis *et al.*, 2007; Fekadu *et al.*, 2010; Bampidis and Christodoulou, 2011; Kafilzadeh and Maleki, 2011). Non-fibrous carbohydrates which is the important determinative component in degradability of feedstuffs is 22.65% for chickpea straw in current study. Ruminal DM degradation of chickpea straw at different incubation times is shown in Table 2. Dry matter degradation at initial (washing loss; 0 h) and final (72 h) incubation times were 18.14 and 60.09%, respectively. Bruno-Soares *et al.* (2000) reported that dry matter washing loss of chickpea straw was in range of 6.2-10.5% which is lower than that of present study. This variation can be due to higher fibre content of chickpea straw in their study.

Table 1: Chemical composition of chickpea straw (%)

Chemical composition	Percentage
DM	92.18
CP	6.05
EE	5.50
Ash	8.00
NDF	57.80
ADF	37.40
NFC	22.65

DM: Dry Matter, CP: Crude Protein, EE: Ether Extract, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, NFC: Non-Fibrous Carbohydrates

Table 2: Ruminal dry matter degradation (%) of chickpea straw at different incubation times (h)

Time (h)	Ruminal dry matter degradation (%)
0	18.14
2	31.20
4	38.43
8	45.90
12	50.82
24	55.28
48	58.47
72	60.09

Table 3: Ruminal dry matter degradation parameters, effective degradability and metabolizable energy of chickpea straw

Parameters	Percentage
a	19.500
b	38.600
a+b	58.100
c	0.152
ED_2 (%)	53.700
ED_5 (%)	48.600
ED_8 (%)	44.800
ME	8.550

a: Washout fraction as measured by washing loss from nylon bags (%); b: Potentially degradable fraction (%); c: Rate of degradation of fraction b (/h); ED_2: Effective degradability at out flow rate 0.02 h^{-1}; ED_5: Effective degradability at out flow rate 0.05 h^{-1}; ED_8: Effective degradability at out flow rate 0.08 h^{-1}; ME: Metabolizable Energy (MJ kg^{-1} DM)

Ruminal DM degradation characteristics, effective degradability and ME content of chickpea straw were shown in Table 3. The soluble fraction (a), non-soluble but potentially degradable fraction (b) potential degradability (a+b) and degradation rate (c) of DM were 19.50, 38.60, 58.10 and 0.152 h^{-1}, respectively. Effective degradability at different passage rates (2, 5 and 8% h^{-1}) were 53.70, 48.60 and 44.80 %, respectively. *In situ* soluble fraction (a), potential degradability (a+b) and degradation rate (c) of chickpea straw in current study were higher than those of reported by Orskov *et al.* (1992) and Bruno-Soares *et al.* (2000). *In vivo* and *in vitro* dry matter digestibility of chickpea straw in different surveys was in range of 46.08-61% (Lopez *et al.*, 2005; Kishore and Sagar, 2006; Nsahlai and Apaloo, 2007; Kafilzadeh and Maleki, 2011). Wide range of DM degradability and digestibility in various studies can be due to different chemical composition, leaves to stems proportion, methods of feedstuffs evaluation (*in vivo*, *in vitro* and *in situ*), chickpea varieties, maturity and impurities as well as technical variation such as bag pore size, sample size, washing procedures, grinding size, diet of experimental animals, species of animal, sample preparation, incubation time and washing method (Orskov *et al.*, 1992; Chumpawadee, 2009; Bampidis and Christodoulou, 2011; Kafilzadeh and Maleki, 2011; Maheri-Sis *et al.*, 2011). Estimated metabolizable energy of chickpea straw in current study (8.55 MJ kg^{-1} DM) was higher than that of findings of other researchers which is in range of 5.59-8.3 MJ kg^{-1} DM (Lander and Dharmani, 1936; Melo and Ribeiro, 1990; Abreu and Bruno-Soares, 1998; Lopez *et al.*, 2005; Bampidis and Christodoulou, 2011; Kafilzadeh and Maleki, 2011) and in line with the range of 6.39-9.76 MJ kg^{-1} DM reported by Gungor *et al.* (2008). It seems that different chemical composition as well as measuring methods are the main reasons for different ME content in various studies. Kafilzadeh and Maleki (2011) cited that other factors which can be affect the nutritive value of straw are variety and cultivar, environmental and seasonal effects and proportion of different morphological fractions of straw.

CONCLUSION

In the study based on chemical composition, dry matter degradability and metabolizable energy content, chickpea straw can be used as good roughage in ruminant's nutrition.

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