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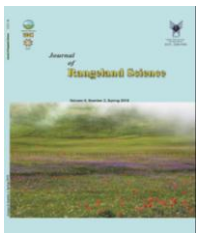

Research and Full Length Article:

Nutritive Value and Digestibility of *Rumex obtusifolius* in Three Phenological Stages by Chemical, Nylon Bag and Gas Production Methods

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Abstract. The present study was conducted to identify nutritional value of *Rumex obtusifolius* in three phenological stages (vegetative growth, flowering, and maturity). Samples were randomly taken in pastures of Saravan in Rasht, Iran in 2015. After drying and grinding, the chemical compositions of Crude Protein (CP), Crude Fiber (CF), Ether Extract (EE), Total Ash (ASH), Neutral Detergent Fiber (NDF), and Acid Detergent Fiber (ADF) were measured based on standard methods. Gas production (*in vitro*) and Dry Matter (DM) degradability (*in sacco*) were determined. Phenological stage effects were studied using a completely randomized design in three replications and data were analyzed using SAS software. In phenological stages of the plant with the progress of maturity, the amounts of CP, ASH, Nitrogen Free Extract (NFE), and Non Fibrous Carbohydrates (NFC) decreased while the CF, NDF, and ADF contents increased. CP had the highest value (23.92%) in the vegetative growth and lowest value (6.11%) in maturity stage. The gas production in 96 hours of vegetative growth, flowering, and maturity stages was 37.68, 40.76, and 26.69 ml/0.2g of dry matter. The DM degradability in 96 hours for vegetative growth, flowering, and maturity stages was 80.25, 70.42, and 40.43%, respectively. The correlation coefficient between gas production method and DM degradability methods were 0.99, 0.98, and 0.97 for vegetative growth, flowering, and maturity stages, respectively. Therefore, the gas production method due to its lower cost was suggested for measuring nutritive value of this plant. The results showed that considering higher or equal protein content of this plant during the vegetative growth and flowering stages as compared to alfalfa, it can be used for ruminant animal diet. Using this wild source is possible to significantly decrease the expenses involved in animal nourishment.

Key words: Degradability, Gas production, Nylon bags, Phenology, *Rumex obtusifolius*

Introduction

In Iran, rangelands are the cheapest sources of feedstuffs for the domesticated ruminants. There are 86.1 million hectares of rangelands in Iran (Hajipuor *et al.,* 2017) with 245,000 hectares distributed in Guilan province and over 700,000 grazing animals in Guilan rangelands (Forests and Rangeland Organization of Guilan province, 2009). One of the rangeland plants in this province that feeds the animals is *Rumex obtusifolius*. This plant is a common species in temperate grasslands of Asia, Europe, and Africa (Honěk and Martinkova, 2002). It is reported that the plant is distributed in North and West of Iran where ruminants graze (Akbarzadeh *et al.,* 2010). Identification of nutritive value of range plants (Ghanbari and Sahraei, 2012) used by ruminants help us to meet their nutrient requirements. The chemical composition and digestibility of forage can be determined based on herbage maturity stage, forage mix samples and application of fertilizer (Adesogan, 2002). Data on nutrient content, digestibility and nutritive value of *R. obtusifolius* are still quite scarce. Hejduk and Dolezal (2004) showed that *R. obtusifolius* exhibits low DM content, CP and fiber content as compared to red clover; yet, its Net Energy for Lactation (NE_L) concentration is low. They demonstrated that the quality of silages made of *R. obtusifolius* at DM content over 300 g/kg is good but the silages show significantly lower contents of lactic acid (35.9%), acetic acid (70.0%), and higher pH values (4.69 versus 4.35) as compared with the grass silage. Different factors affect the nutritional quality of plants. In this case, stage of plant vegetative growth in harvesting time (grazing time) has a higher effect on forage quality than others (Arzani *et al.,* 2004). There are some *in vitro* methods available to estimate the nutritive value of feedstuffs at low cost. The use of *in vitro* gas technique to estimate the degradability of feed is based on the measured relationships between the *in vivo* digestibility of feeds and *in vitro* gas production in combination with the feed's chemical composition (Menke and Steingass, 1988). The *in vitro* gas production technique developed by Menke *et al.* (1979) is a highly useful tool for the quick screening of feedstuffs to assess their potential as energy sources for ruminants (Blummel and Becker, 1997) assuming that the volume of produced gas reflects the end result of the substrate fermentation to (Short Chain Fatty Acids) SCFA, microbial biomass, and the SCFA neutralization. The gas produced from incubating 200 mg of feed dry matter during 24 hours can be used with the concentration of CP and ash to estimate the ME and OMD (Menke *et al.*,1979). It is a cheap method for evaluating forage plant nutritive value. Blummel and Orskov (1993) reported a high positive correlation between *in vitro* gas production data and dry matter digestibility at various incubation times (r=0.95 to 0.97) as well as the results of other researchers (Kamalak *et al.,* 2005; Vahdani *et al.,* 2014; Saravani *et al.,* 2013). On the other hand, there are good correlation between gas production (*in vitro*) and nylon bag (*in situ*) methods with animal performance (Orskov, 1989), feed intake (Blummel Orskov, 1993), and microbial protein synthesis and digestibility in the rumen (*in vivo*) (Khazaal *et al.,* 1993). However, no research has been conducted on determining the nutritional value of different phenological stages (vegetative growth, flowering, and maturity) of *R. obtusifolius*. Therefore, this research was conducted to identify nutritive value and digestibility of range plant *R. obtusifolius* in three phenological stages by chemical, nylon bag (*in sacco*), and gas production (*in vitro*) methods.

Materials and Methods

Sampling area

Rumex obtusifolius samples in three phenological stages were taken from Saravan rangelands in Rasht, Iran (latitude: 37° 12' N longitude: 49° 33' E altitude: 57 m) in 2015. The plant samples were harvested at their vegetative, full flowering and maturity stages from five specified locations. In each location, three 500 g samples from five different places were collected using the random-systematic method. Fresh samples after weighing were transfered to the Animal Sciences Institute (Hesarak, Karaj, IRAN). Plant samples were dried at room temperature for 72 h and then were milled with a mill having a sieve mesh size of 2 mm.

Chemical ccomposition analysis

Organic Matter (OM), Crude Protein (CP), Ether Extract (EE), and ash content of the samples were determined by the proposed standard method AOAC (2000). Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were measured by the method of Van Soest *et al.* (1991).

Gas production method

Samples of rumen fluid were taken from three rumen fistulated Taleshi steers (450±23 kg) fed twice daily with a diet containing hay of each phenological stage of *R. obtusifolius* (60%) and concentrate (40%) based on NRC (2001), 10% above maintenance requirements. The forage samples (200 mg dry weight) were incubated in triplicate in rumen fluid in calibrated glass syringes following the procedures of Menke *et al. (*1979) using 100 ml calibrated glass syringes. The rate and extent of gas production were tested by reading gas volumes before incubation (0) and 2, 4, 6, 8, 12, 24, 48, 72, and 96 hours after the incubation. Cumulative gas production data were fitted to the exponential equation of Orskov and McDonald (1979) (Equation 1):

$$y= a+b\,(1-e^{-ct}) \quad (1)$$

Where

y is the gas produced at time t

a is the gas production from the immediately soluble fraction (ml)

b *is* gas production from the insoluble fraction (ml)

c is the gas production rate constant for the insoluble fraction (b)

$a+b$ *is* the potential gas production (ml), and

t is the incubation time (h).

The ME (MJ kg^{-1} DM) content of forage, OMD, and NE_L were calculated using the equations of Menke and Steingass (1988) and Getachew *et al.* (1998) as follows (Equations 2 & 3 & 4 & 5):

$$OMD = 14.88 + 0.889\,Gas + 0.45\,CP + 0.0651\,Ash$$

$$ME = 2.2 + 0.136\,Gas + 0.0057\,CP + 0.000286\,CF^2$$

$$NEL = 0.54 + 0.096\,Gas + 0.0038\,CP + 0.000173\,CF^2$$

$$SCFA = 0.0601 + 0.239\,Gas$$

(Equations 2 & 3 & 4 & 5)

Where:

OMD is Organic Matter Digestibility (%DM);

Gas is net gas production in 24 hours (ml 200 mg^{-1});

CP is Crude Protein (g 100 g^{-1} DM);

ME is Metabolizable Energy (MJ Kg^{-1} DM);

CF is Crude Fat (g 100 g^{-1} DM);

NE_L is Net Energy for Lactation (MJ Kg^{-1} DM), and

SCFA is Short Chain Fatty Acids (mmol).

In situ disappearance

Dry matter degradability of samples was determined through nylon bag technique using the same animals used in gas production test with the method mentioned by Vanzant *et al. (*1998). Throughout the experimental period, Dacron bags of 40-45 µm pore size were filled with 3 g of sample in triplicate and incubated for 4, 8, 12, 24, 48, 72, and 96 hours in the rumen of each fistulated Taleshi steers. Following incubation, bags were removed from the rumen and rinsed with tap water until the rinsing water became clear. DM degradation data were fitted to the exponential model of

Orskov and McDonald (1979) (Equation 6): $P= a+b\,(1-e^{-ct})$ (6)

Where

p is rumen disappearance at time *t*

a is the rapidly soluble fraction

b is the potentially degradable (fermentable) fraction and

c is the constant rate of degradation of the *b* (percentage per hour).

Applying for the NEWAY program from Rowett Research Institute, Aberdeen, UK, parameters' kinetic were estimated. The effective degradability (P) of DM samples was calculated using the equation of Orskov and McDonald (1979) (Eq. 7): $P= a+[(b\times c)/(c+k)]$ (7)

Where:

k is the rate of particulate outflow from the rumen of 0.02, 0.05, and 0.08 h^{-1}.

Statistical analysis

Data were analyzed using analysis of variance (ANOVA) based on a completely randomized design. When significant effects were detected by ANOVA, treatment means were compared using Duncan's multiple range tests. All statistical analyses were performed with SAS (SAS, 2003).

Results and Discussion

Chemical composition

Table 1 presents chemical composition of *R. obtusifolius* in three phenological stages. Results of the chemical analysis indicated that there was a significant difference among vegetative growth, flowering and maturity stages for CP, CF, NDF, ADF, and ASH ($P<0.05$). In all phenological stages of the plant, with the progress of growth the CP, ASH, NFE, and NFC contents decreased while CF, NDF, and ADF increased. CP was the highest (23.92%) in the vegetative growth stage and the lowest (6.11%) in the maturity stage. Among phenological stages, the vegetative growth had higher quality than other stages. Thus, it can be inferred that higher values of CP, DMD and ME than other nutrients in range plants are common and introduced as the most important characteristics of forage quality (Arzani *et al.*, 2006; Rhodes and Sharrow, 1990). Van Soest *et al.* (1991) showed that ADF is the best index for determination of plant nutritive value. There is a high positive correlation between CP and DMD and a negative correlation between ADF and DMD. Therefore, measuring CP in animal feed formulation for preserving digestion condition of a ruminant is important (Arzani *et al.*, 2006). In our research, CP content was decreased with plant aging that is similar to the results reported by Arzani *et al. (*2006) and Turgut *et al. (*2008). Holchek *et al.* (1986) reported that decreasing CP content with plant aging is due to transmission of nutrients from leaves and stems to roots. CP content of *R. obtusifolius* in vegetative, flowering and maturity stages were 23.62, 19.07 and 6.11%, respectively. In contrast, Foster *et al. (*2007) and Kleinschmit *et al. (*2007) reported 19.8 and 18.2% CP for alfalfa forage, respectively. Then, it can replace alfalfa with *R. obtusifolius* either completely or partially. Kleinschmit *et al. (*2007) indicated that the ADF content of alfalfa is 32.6% that is consistent with our result of *R. obtusifolius* ADF content in growth stage (32.79%). With the aging of *R. obtusifolius*, the ash, NFE, and NFC contents were reduced and NDF was increased that is in accordance with the results of Arzani *et al.* (2006), Heady and Dennis-Child (1994) and Saravani *et al.* (2013). Based on the chemical composition of *R. obtusifolius* in our experiment, it seems that this plant had an important role in supplying the nutrients of ruminants in Guilan rangelands.

Table 1. Chemical composition of *R. obtusifolius* in three phenological stages

Growth Stages	CP	CF	EE	Ash	NFE	NFC	NDF	ADF	OM
Vegetative	23.92[a]	11.43[c]	0.36[c]	10.13[a]	54.16[a]	23.76[a]	41.83[c]	32.79[c]	89.77[c]
Flowering	19.07[b]	18.94[b]	0.40[b]	7.73[b]	53.85[ab]	17.56[b]	55.24[b]	39.22[b]	92.27[b]
Maturity	6.11[c]	36.4[a]	0.83[a]	5.90[c]	50.75[b]	16.00[b]	71.16[a]	56.44[a]	94.10[a]
SEM	0.31	0.67	0.07	0.34	0.93	1.29	1.18	1.25	0.63

Mean of column followed by similar letters are not significant based on Duncan method (P<0.05)
CP = Crude Protein; CF = Crud Fiber; EE = Ether Extract; NFE = Nitrogen Free Extract; NFC = Non fiber Carbohydrates; NDF = Neutral Detergent Fiber; ADF =Acid Detergent Fiber; OM =Organic Mater

Gas production and estimated parameters

The amount of gas production (Table 2) from different phenological stages of *R. obtusifolius* at different incubation times (except 2 h^{-1}) showed significant differences (P<0.05). However, there was no difference between vegetative and flowering stages for gas production. By increasing incubation time, the quantity of gas production increased in treatments. Total gas production at 96 h^{-1} was 37.68, 40.76, and 26.69 ml 200 mg^{-1} DM for different phenological stages, respectively. Also, there was a significant difference (P<0.05) among gas production parameters (*a*, *b*, *c*). Parameters of vegetative and flowering stages had significantly higher differences with maturity stage. In this regard, there were no data for gas production of *R. obtusifolius* phenological stages in literature. Songsak *et al.* (2007) reported gas production rate (*c*) is related to the easily digestible carbohydrates which are readily available for microorganisms. The reasons for higher gas production of vegetative and flowering stages are these stages that had more non-structural carbohydrates, and more leaves than stem tissues as compared to the maturity stages (Canbolat *et al.*, 2006). Kone and Van Geldor (1999), Ndlovu and Nherera (1997), and Kamalak *et al. (*2005) found a positive relationship between CP content of plant and *in vitro* gas production. De Boever *et al.* (2005) and Saravani *et al.* (2013) reported that gas production has a negative relationship with the cell wall. These discussions are in agreement with the findings of our experiment.

Organic Matter Degradability (OMD) of maturity stage was significantly (P<0.05) lower than that of flowering stage and OMD in the flowering stage; in turn, it was lower (P<0.05) than that of vegetative stage (Table 3). OMD is one of the basic indices for estimating the nutritional value of the forages. The lower OMD of maturity stage may be due to rougher content and some mineral contents of maturity stage like Si than two other phenological stages (Saravani *et al.*, 2013; Rezaeian *et al.*, 2006). SCFA, ME and NE_L of flowering and vegetative growth stages were higher (P<0.05) than that of maturity. Flowering and vegetative growth stages had higher Non Structural Carbohydrate (NSC) and soluble carbohydrate than maturity that produces greater Metabolizable Energy (ME). Menk and Steingass (1998) identified that there was a high correlation among ME, gas production, and chemical composition of feedstuffs. The difference in ME content is a result of different quantities of fermentable carbohydrates and available nitrogen (Saravani *et al.*, 2013; Khanum *et al.*, 2007), which is in agreement with the results of our test. Also, Lee *et al. (*2000) stated that the observed reduction of gas production in the rumen is the result of decreased dry matter digestibility and organic matter.

Table 2. Gas production (ml 200 mg^{-1} DM) and estimated parameters of *R. obtusifolius* in three phenological stages

Growth	Incubation time (h)								Estimated parameters		
Stages	2	4	8	12	24	48	72	96	*a+b*	*c*	*b*
Vegetative	2.98^{ab}	7.85^{a}	14.29^{a}	20.49^{a}	27.78^{a}	33.44^{a}	37.21^{a}	37.68^{a}	37.02^{a}	0.06^{a}	37.34^{a}
Flowering	3.76^{a}	8.62^{a}	15.68^{a}	21.56^{a}	29.32^{a}	36.22^{a}	39.66^{a}	40.76^{a}	39.89^{a}	0.05^{a}	39.79^{a}
Maturity	2.35^{b}	5.33^{b}	9.27^{b}	11.54^{b}	16.33^{b}	22.46^{b}	24.81^{b}	26.69^{b}	26.37^{b}	0.04^{b}	25.55^{b}
SEM	0.30	0.52	0.85	0.94	1.46	1.54	1.62	1.35	1.31	0.003	1.35

Mean of column followed by similar letters are not significant based on Duncan method (P<0.05)
a the gas production from the immediately soluble fraction (ml); *b* gas production from the insoluble fraction (ml); *c* the gas production rate constant for the insoluble fraction (*b*); *a+b* the potential gas production (ml)

Table 3. Estimated OMD, ME, NE_L and SCFA of *R. obtusifolius* in three phenological stages

Stages	OMD (% DM)	ME (MJ Kg^{-1} DM)	NE_L (MJ Kg^{-1} DM)	SCFA (mmol)
Vegetative growth	51.00^{a}	6.12^{a}	3.30^{a}	6.70^{a}
Flowering	44.07^{b}	6.22^{a}	3.38^{a}	7.06^{a}
Maturity	38.49^{c}	4.53^{b}	2.18^{b}	3.96^{b}
SEM	1.38	0.20	0.14	0.34

Mean of column followed by similar letters are not significant based on Duncan method (P<0.05)
OMD; organic matter digestibility (%DM); ME: Metbolizable Energy (MJ Kg^{-1} DM); NE_L=Net Energy for Lactation (MJ Kg^{-1} DM) and SCFA: Short Chain Fatty Acids (mmol)

In situ degradability of DM

Average DM degradability in three phenological stages of *R. obtusifolius* in different times was significantly (P<0.05) different (Table 4). Mean DM disappearance at time 0 for vegetative growth stage was the highest (21.51%) and for maturity, it was the lowest (17.32%). In flowering stage, DM disappearance at time 0 was 19.46%. After 96 h^{-1} of incubation, DM degradability of vegetative growth, flowering and maturity stages was 80.25, 70.42, and 40.43%, respectively. In this regard, there were no data for the disappearance of the nutrient in *R. obtusifolius* phenological stages in literature. In our investigation, degradability of DM was decreased with aging of *R. obtusifolius* which is in agreement with the results of Arzani *et al.* (2006), Arzani *et al.* (2004), Crowder (1985), Saravani *et al.* (2013), Pinkerton (1996) and Vahdani *et al.* (2014). Pinkerton (1996) stated that forage digestibility had a positive relationship with cell wall characteristics and as plants become mature, fiber content increases and digestibility decreases.

Significant (P<0.05) differences were observed among three phenological stages of *R. obtusifolius* with respect to the parameter *b*, the slow fraction of degradation, the parameter *a+b*, the potential degradability, and Effective Degradability (ED). Vegetative and flowering stages were similar in parameter *a*, fast fraction of degradation and parameter *c*, and degradability rate but differ with maturity stage. Higher degradability for fraction *a* was the vegetative growth stage (18.07% DM) and the lowest was the maturity stage (14.93% DM) which might be due to the result of higher CP in vegetative stage that is in agreement with the results of Mahala *et al. (*2007) and Saravani *et al. (*2013). They indicated that forage plants with higher protein also had a higher percentage of fraction *a*. The potential degradability values (*a+b*) of three phenological stages of *R. obtusifolius* were 80.23, 68.95 and 41.03% DM for vegetative, flowering, and maturity, respectively. Saravani *et al. (*2013) and Riasi *et al. (*2008) reported that the reason for the decrease in DM degradability rate of the feed is the low content of Ash and high composition of the cell wall, which is in agreement with our study. Parameter *c* was higher (P<0.05) in vegetative and flowering stages than maturity (0.06, 0.05 versus0.04% DM). Van Soest (1994) reported that this parameter depends on whether the microorganisms have enough time to adjoin with the cell wall and the nature of cell wall itself. There were

significant (P<0.05) differences among treatments in the effective degradability (ED). Vegetative stage had the highest ED and maturity had the lowest one in *k* (Rumen outflow rate (h^{-1})). Ramirez *et al.* (2009) indicated that CP has a positive effect on feed disappearance in the rumen but when the lignin increases, dry matter ED decreases; these results are also in agreement with our experiment.

There was a high correlation (Table 5) between gas production (*in vitro*) and DM disappearance (*in sacco*) in three phenological stages of *R. obtusifolius* (0.986, 0.984, and 0.970, respectively). These results are similar to the data of Taghizadeh *et al. (*2008) and Kamalak *et al.* (2005). Because of expensive cost of *in sacco* (*in vivo*) method and with attention to strong relationship between gas production and dry matter disappearance, gas production technique can be used to determine *R. obtusifolius* nutritive value.

Table 4. *In situ* estimated DM degradability parameters and effective DM degradability of *R. obtusifolius* in three phenological stages

Growth	Estimated parameters of DM Degradability (%DM)				Effective degradability of DM (%DM)		
Stages	*a*	*b*	*a+b*	*c*	*K=0.02*	*K=0.05*	*K=0.08*
Vegetative	18.07[a]	62.16[a]	80.23[a]	0.06[a]	64.16[a]	51.33[a]	44.10[a]
Flowering	17.37[a]	51.58[b]	68.95[b]	0.05[a]	55.43[b]	46.76[b]	38.80[b]
Maturity	14.93[b]	26.10[c]	41.03[c]	0.04[b]	32.70[c]	27.06[c]	24.26[c]
SEM	0.40	1.98	2.12	0.003	1.17	0.78	0.61

Mean of column followed by similar letters are not significant based on Duncan method (P<0.05)
a: The dry matter soluble nutrient fraction which is rapidly washed out of the bags and is assumed to be completely degradable
b: The portion of insoluble nutrient which is potentially degradable by micro-organisms
c: The degradation rate of fraction *b* per hour, *k*= Rumen outflow rate (h^{-1})

Table 5. Relationship between Gas production (Y) as dependent variables and Dry matter disappearance (X) as independent variables of *R. obtusifolius* in three phenological stages and their correlation coefficients

Growth Stage	R^2	r	Regression Equation
Vegetative	0.973	0.986	Y= 0.5512X - 7.8183
Flowering	0.969	0.984	Y= 0.7186X- 10.83
Maturity	0.941	0.970	Y= 0.8591X- 9.9355

Conclusion

In conclusion, *R. obtusifolius* forage can be considered as an effective replacement or alternative for alfalfa as a rich protein plant, especially in phenological stages of vegetative growth and flowering in temperate regions like Guilan province in north of Iran. With attention to strong relationship between gas production and dry matter disappearance and because of cheaper cost, the gas production method can be used for measuring nutritive value of this plant. However, it is necessary to carry out more research concerning the effects of *R. obtusifolius* forage on the performance of ruminants.

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تعیین ارزش غذایی و قابلیت هضم گیاه مرتعی *Rumex obtusifolius* در سه مرحله‌ی فنولوژیکی با روش‌های شیمیایی، کیسه نایلونی و تولید گاز

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چکیده. این پژوهش به منظور تعیین ارزش غذایی در سه مرحله فنولوژیکی (رشد رویشی، گلدهی و بلوغ) گونه مرتعی *Rumex obtusifolius* با روش‌های شیمیایی، تولید گاز و کیسه‌های نایلونی انجام شد. در این تحقیق از گونه مرتعی یادشده در سه مرحله رشد، گلدهی و بلوغ به صورت تصادفی از مراتع سراوان رشت در سال ۱۳۹۳ نمونه‌برداری به عمل آمد، که پس از خشک و آسیاب کردن در آزمایشگاه، ترکیبات شیمیایی پروتئین خام (CP)، فیبرخام (CF)، چربی خام (EE)، خاکسترخام (Ash)، دیواره‌ی سلولی (NDF)، دیواره‌ی سلولی منهای همی سلولز (ADF) با روش‌های استاندارد تعیین گردید. تولیدگاز (*in vitro*) و تجزیه‌پذیری ماده خشک (*in sacco*) تعیین شدند. آزمایش در قالب طرح کاملاً تصادفی انجام و داده‌ها با نرم‌افزار SAS مورد آنالیز قرار گرفت. در مراحل فنولوژی گیاه با پیشرفت بلوغ از میزان CP، Ash، عصاره عاری از نیتروژن (NFE) و کربوهیدرات غیر الیافی (NFC) کاسته و بر میزان CF، NDF و ADF افزوده گردید. از لحاظ درصد CP مرحله رشد رویشی به میزان ۲۳/۹۲ درصد بالاترین مقدار و مرحله زایشی به میزان ۶/۱۱ درصد کم‌ترین مقدار را داشت. هم‌چنین نتایج نشان داد که بیشترین و کم‌ترین مقدار ADF به ترتیب مربوط به مرحله بلوغ کامل و رشد رویشی بود. تولید گاز در ساعت ۹۶ برای مراحل رشد رویشی و گلدهی و بلوغ به ترتیب به مقدار ۳۷/۶۸، ۴۰/۷۶ و ۲۶/۶۹ میلی لیتر به ازای ۰/۲ گرم ماده خشک نمونه بود. میزان تجزیه‌پذیری ماده خشک (DM) از طریق تولید گاز در ۹۶ساعت برای مراحل رشد و گلدهی و بلوغ به ترتیب به مقدار ۸۰/۲۵، ۷۰/۴۲ و ۴۰/۴۳ درصد بود. ضریب همبستگی بدست آمده بین گاز تولیدی با تجزیه‌پذیری ماده خشک برای مراحل رشد رویشی، گلدهی و بلوغ به ترتیب ۰/۹۹، ۰/۹۸ و ۰/۹۷ بود. بنابراین، بخاطر هزینه کمتر، روش تولید گاز می‌تواند بعنوان جایگزینی جهت اندازه‌گیری ارزش غذایی این گیاه مورد استفاده قرار گیرد. نتایج نشان داد که در مراحل رشد رویشی و گلدهی با توجه به میزان پروتئین بالاتر از یونجه یا در حد یونجه، قابلیت استفاده در جیره‌های دام نشخوارکننده را دارا می‌باشد و با استفاده از این منبع خودرو امکان کاهش هزینه‌های مربوط به تغذیه دام‌ها را در پی خواهد داشت.

کلمات کلیدی: تجزیه‌پذیری، تولیدگاز، کیسه‌های نایلونی، فنولوژی، *Rumex obtusifolius*