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Effects of Harvesting Time on Nutritional Value of Hydroponic Barley Production

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Abstract

In this study aimed that the effects of different harvesting times on the nutritional value of barley fodder producing in hydroponic system. Barley fodders were harvested on the 4th, 7th, 10th and 13th days following sowing date. Analysis performed for determining the chemical composition and organic matter digestibility (OMD) and ME content with *in vitro* gas production technique. It was determined that the DM content was decreased, the CP content was not changed significantly, cell wall contents (NDF, ADF, ADL) and ash content were increased by the maturation of the sprouts. In this study DM, ADF and ash contents were changed significantly ($P<0.05$). It was obtained that 96 hours cumulative gas production, OMD and ME contents were decreased by the increasing number of harvesting time but the variations were not significant ($P>0.05$). According to the results, suitable harvesting date was 7th day following the sowing in term of nutritional value of the fodder.

Keywords: barley, hydroponics, *in vitro* gas production, harvest time

Hidroponik Arpa Üretiminde Hasat Zamanının Besleme Değeri Üzerine Etkileri

Özet

Bu çalışma, hidroponik sistemde yetiştirilen arpa bitkisinin besleme değerliliği üzerine farklı hasat zamanlarının etkisinin araştırılması amacıyla yürütülmüştür. Bu amaçla arpa hasılı 4, 7, 10 ve 13. günlerde hasat edilmiş, bitki örnekleri üzerinde kimyasal bileşimin belirlenmesine yönelik analizler ve *in vitro* gaz üretim tekniği kullanılarak OMS ve ME içerikleri belirlenmiştir. Bitkide hasat gününün ilerlemesiyle KM içeriğinin düştüğü, HP içeriğinde düzenli bir değişim olmadığı, hücre duvarı bileşen miktarı (NDF, ADF, ADL) ve kül içeriğinin arttığı tespit edilmiştir. Çalışmada KM, ADF ve kül içeriklerinin önemli düzeyde değiştiği tespit edilmiştir ($P<0.05$). Yürütülen *in vitro* analizler sonucunda ise bitkide 96 saatlik kümülatif gaz üretimi, OMS ve ME içeriklerinin, hasat gününün ilerlemesiyle düştüğü fakat bu düşüşün istatistik açıdan önemli olmadığı tespit edilmiştir ($P>0.05$). Bu çalışmadan elde edilen bulgulara göre, besleme değerliliği açısından en uygun hasat zamanının 7. gün olduğu sonucuna ulaşılmıştır.

Anahtar kelimeler: arpa, hidroponik, *in vitro* gaz üretimi, hasat zamanı

Introduction

Agriculture is the most critical sector in term of the global climate change. Natural water resources are affected by global climate change so food production and sustainability are endangered (Falkenmark, 2007). It's expected that the global climate change cause negative impact on the grazing lands in arid and semi-arid regions (Hoffman and Vogel, 2008). The rain fall is reduced while environmental temperature is increased, so the grassland yields decrease and range and meadow deteriorated over the time.

Water use efficiency and developing strategies maximize the yield per unit area in the conditions of water deficiency. One of the modern techniques is hydroponic systems that minimize the use of water in fodder production. It's reported that the water consumption decreased to 2-3 % levels in hydroponic system related with traditionally field condition (Al -Karaki and Al- Monani, 2011). Al-Karaki (2010) was reported that 1.5-2 L water is necessary for germination of 1 kg grain in hydroponic system, contrasting 73 L water consumption suitable for 1 kg green fodder under conventional barley production.

It is reported that green fodder produced under hydroponic conditions has high metabolizable energy, crude protein and digestibility (El-Morsy et al., 2013). Hydroponic fodder production allows water use economy and early maturation. While conditions are not possible for agriculture such arid and semiarid climate, acclimatized and sterile hydroponic conditions provide an economic fodder production. The green fodders are harvested in approximately 7 days in hydroponic system (Naik and Singh, 2013). On the one hand many bio-chemical reactions occur in seeds, the other hand dry matter loss occurs during the germination (Lorenz, 1980). The animal consumption of fodder may be effects negatively because high moisture content of the fodder (Fazeli et al., 2011), it is suggested that adding some amount of hay will decrease moisture and raised dry matter contents (Tudor et al., 2003).

Although many different types of small grains such as wheat, oats, corn and legumes can be used in hydroponic systems, barley is the most common. Barley is an important raw material for feed industry and widely used for animal feeding as grain in livestock (whole grain, the form of cracked or pomace, particularly in the breeding season) also green fodder (Yılmaz, 2007).

This study was carried out to evaluate the effects of harvest time on nutritional value of barley fodder.

Material and Methods

Plant Material and Growing Condition

The germination process carried out in the Fodder Solutions T-12 model machine with a daily 40-50 kg green fodder production capacity. The germination trays are made from polyethylene material. The germination cabin internal temperature was 24 ^{0}C, light intensity 3000 lux and irrigation set was 4 times and approximately 50 liters for daily. Slodoran barley variety is used as study material. 0,416 kg seed were placed to trays and soaked for germination. Trails were conducted on 3 parallels.

The sprouts were harvested on 4th, 7th, 10th and 13th days following to soak. Fresh and dried weights were recorded with whole plant and separately root and shoot because preventing to mold or deterioration from high moisture content. Drying was conducted at 55 ^{0}C in the oven for 4 days. After drying the each part of the samples ground to 1 mm mesh. The different part (roots and shoots) of ground samples were then mixed after drying process.

Chemical Analysis

Chemical analysis was carried out in tree parallel. The Nitrogen (N) content was determined by Kjeldahl method. Crude protein (CP) was calculated by multiplying Nx6.25 (AOAC, 1990). Ash content was determined by igniting plant samples in a muffle furnace at 550 ^{0}C for 4 hour (Protherm, PFL 110/10 model). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest et al. (1991) with using sodium sulfide by ANKOM 200 Fiber Analyzer (ANKOM, 2005).

In vitro Analysis

In vitro analysis was carried out following to method of Menke and Steingass (1988). *In vitro* incubations were performed in three parallels and three replications. Rumen fluid was collected with rumen probe from three adult goats before the morning meal. The gas production was measured in the 4th, 8th, 12th, 24th, 48th, 72th and 96th hours of incubations.

Metabolizable energy (ME) and organic matter digestibility (OMD) of the plants was calculated from the gas production according to Menke et al., (1979).

ME (MJ/kg DM) = 2.20 + 0.136 GP + 0.057 CP

OMD (%) = 14.88 + 0.889 GP + 0.45 CP + 0.0651 A

Where GP is 24 h net gas production (ml/200 mg), CP crude protein content (%) and A ash content (%).

Statistical Analysis

Statistical analysis of chemical and *in vitro* gas production data was performed in SAS statistical (1999) programme. In the repeated variance analysis, harvest time was integrated as fixed effect and parallel as random effect. The *post hoc* analysis was performed with the Tukey test.

Results

Barley sprouts were harvested at four different periods, the nutritional composition of the samples was presented in table 1. As seen on table 1; the DM content were significantly decreased by harvest day along ($P<0.0001$). The CP changes were not significant and not related with harvesting days.

It is determined that the cell wall components increased progress of the harvest days in this investigation. The ash content of barley was increased by the advance of harvested day in the recent study (Table1).

Table 1. The change chemical composition of barley by harvested day least square means, standart errors (SE) and significance probability (P)

Parameters	Harvest days				SE	P
	4	7	10	13		
DM	202.32 a	136.14 b	103.04 c	102.28 c	6.058	<.0001
CP	177.19	171.05	182.50	175.93	6.714	0.6984
NDF	470.10	510.17	525.35	540.53	41.144	0.4585
ADF	166.53 c	214.61 b	236.34 ab	261.47 a	14.324	0.0088
ADL	30.73	39.24	59.49	51.48	10.650	0.3027
Ash	43.89 c	49.78 b	53,.90 ab	57.57 a	1.767	0.0033

DM: dry matter, g/kg;CP: crude protein, g/kg DM; NDF: neutral detergent fiber, g/kg DM; ADF: acid detergent fiber, g/kg DM; ADL: acid detergent lignin g/kg DM; ash, g/kg DM.
Different letter indicate significance (P<0.05)

In the study *in vitro* gas production (ml), OMD (%) and ME (MJ / kg DM) contents were determined for different harvested days of barley are presented in Table 2. The gas production has been increasing with the progress of incubation time (Table 2). During the first 12 hours of incubations gas productions were significantly changed by harvest day (P≤0.0352). The cumulative gas production of 96 hours incubation were 75.83 ml in day 4, 72.50 ml in day 7, 66.28 ml in day 10 and 66.39 ml in day 13. The higher gas production was determined on day 4, and the lowest gas production was determined on 10th and 13th days of harvested (Table 2). ME and OMD were not changed significantly between the harvest days (P>0.05). However, with enhancing the harvest period, ME and OMD value of barley were decreased numerically. In the current study ME content of barley fodder were 2.61 Mcal ME, 2.50 Mcal ME, 2.34 Mcal ME and 2.26 Mcal ME respectively according to harvested days.

Table 2. Least square means of *in vitro* gas production, organic matter digestibility and metabolizable energy for barley (ml), standart error (SE) and statistically probability (P)

Incubation hours	Harvest days					
	4	7	10	13	SE	P
4	19.67 a	16.06 a	12.28 b	11.89 b	1.731	0.0127
8	31.28 a	27.56 a	21.61 b	20.83 b	2.714	0.0352
12	40.77 a	37.06 a	30.11 b	26.61 b	2.553	0.0116
24	55.44	52.72	47.72	45.32	3.394	0.1106
48	69.28	65.94	59.11	59.33	3.284	0.0979
72	73.78	70.56	64.06	63.83	3.236	0.1010
96	75.83	72.50	66.28	66.39	3.145	0.1027
OMD	73.57	70.71	66.74	63.93	3.243	0.1240
ME	10.91	10.48	9.80	9.44	3.018	0.1426

OMD: organic matter diggestibility, %; ME: metabolizable energy, MJ/kg DM. Different letter indicate significance (P<0.05)

Discussion

During germination occur some biochemical changes such as DM and starch content decrease and CP, CF, ash contents increase. Also carbohydrates were assimilated for metabolic activity during germination. The metabolic energy is used for growth and development with this biochemical process. Because the dry matter could not be substituted by the photosynthesis, sprout weight is decreased by the time photosynthesis accelerate (Anonymous, 2011).

It is reported that DM content of the seeds are decreased while CP content increased during the sprouting (Tudor et al., 2004; Fazeli et al., 2012). Naik et al. (2012) indicated that the corn CP content raise following increasing harvest days. It is reported that the increasing amount of nutrients during germination were not actual changes, so these monitored increases depended on DM decreasing in proportionally (Lorenz, 1980).

Cell wall cellulose accumulation such NDF, ADF and ADL percentage was raised due to increasing growth stage (Hoffman et al., 2003). Fazeli et al. (2012) and Naik et al. (2012) reported that with the progress of harvest period, the plants

cell wall components are increased also in their study.

The ash content of barley was increased by the maturation. This result was in accordance with Naik et al. (2012). It is indicated that the ash content of the seeds increased during the sprouting. This relatively increases due to the decrease of DM, in other terms the alterations are based on changing of proportion of the nutrients (Chavan and Kadam, 1989). According to Lorenz (1980), during the sprouting, the situation of DM decrease are related with degradation of the large part of seed content is carbohydrate (such as starch) used for energy source.

The *in vitro* gas production is affected by the nutrient composition of the plant. There are some reports available that the gas production is correlated with cell wall components negatively (Nsahlai et al., 1994; Larbi et al., 1998).

Fazeli et al. (2012) reported that ME content of barley was decreased significantly related with increasing harvest days. The study reported ME contents of 2.84 Mcal ME, 2.76 Mcal ME and 2.71 Mcal ME respectively for 6. 7. and 8. days of sprouting.

Conclusion

Hydroponically germinated fodders chemical composition, OMD and ME levels are changed related with the harvest days. The fodder DM contents were decreased significantly by maturation of sprouts. Although there is no clear distinction about *in vitro* gas production, quantitative and nutritional values show 7th day is the best harvest day, in terms of green fodder production. In conclusion economic evaluation of animal nutrition regard to changing climate conditions, hydroponic systems are an alternative green forage source for animal production.

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