World Applied Sciences Journal 16 (4): 531-539, 2012
ISSN 1818-4952

Productivity and Nutritive Value of Barley Green Fodder Yield in Hydroponic System

[1]H. Fazaeli, [2]H.A. Golmohammadi, [3]S.N. Tabatabayee and [4]M. Asghari-Tabrizi

[1]Animal Science Research Institute, Karaj, Iran
[2]Agricultural Research Station, Golpayegan, Iran
[3]Department of Animal Science, Khorasgan-Branch, Islamic Azad University, Isfahan, Iran
[4]Khorasgan-Branch, Islamic Azad University, Isfahan, Iran

Abstract: Barley grain was sprouted in a still hydroponic growing chamber for 6, 7 and 8 day periods and sampled for chemical analyses, protein fractions, *in vitro* digestion and metabolisable energy (ME) determination. Productivity measured on the basis of the input-output balance of barley grain and GF yield. Results showed that CP, Ash, EE, NDF, ADF and water soluble carbohydrate (WSC) were increased whereas OM and non fiber carbohydrate (NFC) decreased ($p<0.05$) in the GF when compared with the original grain. As the growing period extended from day 6 to day 8, the CP, Ash, EE, NDF and ADF were increased but NFC and WSC reduced ($p<0.05$). The non protein nitrogen was increased but true protein decreased ($p<0.05$) in GF in comparison to barley grain, however no differences was shown among the growing periods for protein fractions. The potential (b) and rate (c) of *in vitro* gas production shown a decreasing trend ($p<0.05$) by sprouting the barley grain up to 8 days. The amount of OM and ME of GF, obtained per kg of cultivated barley grain, were lower than those of the original grain.

Key words: Barley sprout · Hydroponic · Feed value · Performance

INTRODUCTION

Sprouting grains for human consumption has been used for centuries in Asian countries to improve food value [1]. A desirable nutritional changes may be occurred during sprouting that were mainly due to the breakdown of complex compounds into a more simple form, transformation into essential constituents and breakdown of nutritionally undesirable constituents [2]. Sprouting of grains affected the enzyme activity, increased total protein and changes in amino acid profile, increased sugars, crude fibre, certain vitamins and minerals, but decreased starch and loss of total dry matter [3]. There were some arguments about the sprouting grains for convenience of green forage production in hydroponics system to compensate the feed resources for animals [4, 5]. The hydroponic GF is produced from forage grains that are germinated and grown for short period of time inside special growing rooms, provided with the appropriate growing conditions [6].

The concept of putting one kilogram of grain into a hydroponic system and producing 6 to 10 kilograms of fresh green sprouts, independent of weather and at any time of year, is of interest [7]. Development of this planting system has enabled the production of fresh forage from oats, barley, wheat and other grains [8]. Depending to the type of grain, the forage mat reaches between 15 to 30 cm high where the production rate ranged about 7 to 9 Kg of fresh forage corresponding to 0.9 to 1.1 Kg of dry matter [9, 10]. However, the efficient use of water through the production of hydroponic fodder of barley and wheat for goats in semi-desert conditions has been recommended [11]. Moreover, the period between starting the production and green forage harvesting was about one week where a carpet is obtained made up with germinated seeds, their interweaved white roots and the green shoots [12]. During this time, nutrient proportions of sprouted barley changed by the growing cycle [13]. Chung *et al.* [14] found that the fibre content increased from 3.75% in un-sprouted barley seed to 6% in 5-day sprouts. Peer and Leeson [15] found significant losses in dry matter digestibility, which declined progressively during 7 to 8-day growing period nevertheless the digestibility of 4-day old sprouts barley

Corresponding author: H. Fazaeli, Animal Science Research Institute, Karaj, Iran.

was superior to original grain. However, according to Mansbridge and Gooch [16] *in vitro* digestibility of sprouts grown at 6 or 8 days ranged 72-74 percent that were not significantly different. Other report shown that the *in vivo* digestibility of 8-day barely sprouts ranged 73-76 percent and ME to be around 12.2 MJ/kgDM [13]. Comparing of green sprouted with no-sprouted barley shown that the total amount of protein remained similar, though the percentage of protein increased in green fodder because of the decrease in other components [15, 17].

However, the biological and economical performance of hydroponic green forage production and utilization depends on the local conditions where it is need to be identified. Due to the limitation of forage and drought disaster that is a common problem in many part of Iran, this experiment was conducted to assess the nutrient profile, digestibility and conversion ratio of barley fodder production in hydroponic system.

MATERIALS AND METHODS

Hydroponic System and Grain Sprouting: A growing plan was conducted using a steel hydroponic chamber, size of 4.0×3.0×2.6 m equipped with automatic sprayer irrigation and ventilation apparatus with capacity of 100 polyethylene trays sized 70×30 cm each. Temperature inside the chamber was controlled to get a range of working temperature from 18°C to 21°C and the relative humidity adjusted about 70% using an air circulation. Fluorescent lighting tubes with watertight appliances were arranged on the walls in vertical position to growing leaves when it provides 1000 to 1500 microwatts/cm^2 during 12 to 14 h of daily light. Clean seeds of barley (*Hordeum vulgare* L.) were washed and soaked in tap water for 20 h then were spread in the trays, where the density obtained was equivalent to seed rate of 4.5 kg/m^2.

Three growth periods: 6, 7 and 8 days were considered, thus the trays contained green fodder were removed from the chamber and the fresh fodder batches were weighed and sampled to measure the fresh yield and estimate the conversion ratio. Representative samples (250g each), in four replication, were oven-dried at 60 °C, ground to pass a 1-mm mesh screen sieve and stored for chemical analysis and *in vitro* studies. Four samples of barley grain were prepared to serve as control treatment. Production performance was determined based on the balance of dry mater and nutrients obtained in green fodder from the initial grain.

Analytical procedures: Samples of GF and barley grain were chemically analyzed in duplicate according to the AOAC [18]. DM was determined by drying the samples at 60 °C in a forced-air oven for 48 h. Crude protein (CP) was calculated by multiplying N×6.25. Ash content was measured by ingestion of the dried material in a muffle furnace at 600 °C for 4 h. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Van Soest *et al.* [19]. The water soluble carbohydrate (WSC) was determined by the anthrone method, using freeze dried samples where the WSC was extracted with water [20]. The non fiber carbohydrate (NFC) was estimated as: [100-(CP+Ash+EE+NDF)]. Samples for the determination of macro and microelements were prepared according to the wet method where the samples digested in mixture of sulfuric acid, salicylic acid and selenium [21]. Phosphorus was determined using spectrophotometer (Genway 630), Ca, K, Mg, Fe, Mn, Zn and Cu by Atomic Adsorption Spectrometer (GBC 902 double BEAM), using AOAC [18].

The total protein in samples was partitioned into 5 fractions as proposed by the cornel net carbohydrate, net protein system (CNCPS) [22, 23]. These have been described as: fraction A, contains non protein nitrogen (NPN) that is calculated as the difference between the total nitrogen and the value of the true protein nitrogen precipitated with 100 g/l (w/v) tangstic acid; unavailable fraction C, which is the acid detergent-insoluble nitrogen (ADIN); the B fraction contains the true protein and is further subdivided into rapidly (B1), intermediate (B2) and slowly (B3) degradable fractions based on rates of protein degradation in the rumen into using the equations of Sniffen *et al.* [23]. True protein nitrogen, buffer-insoluble protein nitrogen, neutral detergent-insoluble nitrogen (NDIN) and ADIN of samples were analysed as described by Licitra *et al*. [24].

***In vitro* Study:** Samples were incubated *in vitro* with rumen fluid in calibrated glass syringes following the procedure of Menke *et al.* [25]. Rumen fluid was collected, before the morning feeding, from three ruminally fistulated male cows, strained through four layers of cheese cloth and mixed in a pre-warmed CO_2-filled thermos flask that was maintained at 39 °C before use. The inoculum was consisted of the rumen liquor mixed with artificial saliva (1:2 v/v) as described by Menke and Steingass [26]. A 200 mg of dried and ground (1mm) samples were weighted into each calibrated glass syringes of 100 ml and recorded actual weight. The syringes were pre-warmed at 39 °C, before the addition of rumen-buffer mixture and their

pistons lubricated with Vaseline to ease movement and to prevent gas from escaping. The syringes were inoculated with 30 ml inoculums under continuous CO_2 reflux and incubated in an incubator equipped with rotary at 39°C for 96 h. Blanks syringes were included at the beginning, in the middle and end of the set. The net gas production (GP) were then related to a sample weight of exactly 200 mg DM. Cumulative gas production data were fitted to the exponential equation $P = b(1-e^{-ct})$.

Where *b* is the gas production from the fermentable fraction (ml), *c* the gas production rate constant for *b*, *t* the incubation time (h) and *p* is the gas produced at time *t*.

The ME content and organic matter digestibility (OMD) was estimated from the equations of Menke and Stingass [27], as:

$$ME\ (Mj/kgDM) = 2.2 + 0.136\,GP + 0.057\,CP + 0.0029\,CP^2$$

$$OMD\ (\%) = 14.88 + 0.889\,GP + 0.448\,CP + 0.0651\,XA$$

Where CP is crude protein in g/100gDM, GP is the gas production (ml) from 200 mg sample after 24 h of incubation and XA is Ash in g/100gDM.

Statistical Analysis: Data were statistically analyzed by the general linear model (GLM) procedure of SAS [28] according to a completely randomized model with four treatments and four replications as:

$$Yijk = \mu + T_j + \varepsilon_{ijk};$$

where Yijk is the observation, μ is the overall mean, T_j is the effect of treatment and ε_{ijk} is the residual error. Significance was defined as $P \leq 0.05$ and $0.05 < P \leq 0.10$ was considered a trend. Three single degree-of-freedom orthogonal contrasts were constructed to infer the linear and quadratic effects of sprouting barley compared with barley grain. Treatment means were compared by Dunkan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Chemical Composition: There was a significantly difference ($p<0.05$) between the original barley grain and GF for DM, where it was less than 20 percent in case of GF but more than 90 percent in initial grain(Table 1). The DM content of GF was significantly ($p<0.05$) reduced by increasing the growing periods from 6 to 7 days. The amount of fresh Gf obtained per kg of planted barley grain was several times but this increase was due to the large uptake of water during germination of the seeds, resulted in a sharply reducing of DM percentage in GF. These results were in accordance with those of Bautista [29] and Morgan *et al*. [17] who reported a significant differences in wet weight (WW) and dry weight (DW) of the hydroponic fodder. According to Peer and Leeson [30]

Table 1: Chemical composition of the barley grain before and after sprouting

	Treatments				
		GF[b]			
Parameters	Bg[a]	Day 6	Day 7	Day 8	SEM
dry matter (%)	91.4[a]	19.27[b]	14.35[c]	13.3[c]	2.36
Ash	2.81[c]	3.65[b]	3.72[b]	4.11[b]	0.26
organic matter	97.19[a]	96.35[b]	96.28[b]	95.89[b]	0.26
ether extract	1.9[c]	2.55[b]	3.04[ab]	3.86[a]	0.24
crude protein	11.73[b]	13.69[ab]	13.68[ab]	14.67[a]	1.21
neutral detergent fibre	20.2[c]	31.25[b]	31.80[ab]	35.40[a]	2.03
Acid detergent fibre	7.2[c]	14.35[b]	15.50[ab]	17.15[a]	1.01
water soluble carbohydrate	3.76[c]	7.18[a]	6.26[ab]	6.73[b]	0.59
non fibre carbohydrate	64.65[a]	49.04[b]	45.76[bc]	43.00[c]	2.7
Macro minerals (%)					
Ca	0.26[b]	0.32[a]	0.39[a]	0.36[a]	0.04
P	0.42	0.41	0.44	0.43	0.5
K	0.39	0.29	0.34	0.36	0.25
Mg	0.17	0.17	0.26	0.23	0.25
Micro minerals (mg/kg)					
Fe	96.1[c]	150[b]	147[b]	171[a]	4.6
Mn	25.2[a]	20.3[b]	17.5[b]	17.8[b]	1.88
Zn	17.5[b]	19.6[ab]	22.4[a]	21.4[a]	1.98
Cu	8.0	5.35	7.80	7.23	0.85

a: barley grain; *b*: green fodder; SEM: standard error of means

In a row, means followed by a common letter are not significantly different at the 5% level by DMRT

fresh weight increased from 1.72 times of the original seed weight, after sprouting for 1 day, to 5.7 folds after 7 days but a negative relation was found in DM content with fresh weight yield. Such a low DM content would have a limitation effect on intake of GF when fed to animals.

The Ash, EE, NDF, ADF and WSC were increased but OM and NFC decreased ($p<0.05$) in GF compared to the initial barley grain. The CP content was significantly ($p<0.05$) increased only at day 8. By extending the growing period from day 6 to day 8, the CP, Ash, EE, NDF and ADF were increased but NFC and WSC reduced. The CP obtained in this study was comparable with those reported by Al-Ajmi *et al*. [9] who found about 14 percent of CP in hydroponically barley green fodder. Morgan *et al.* [17] reported that CP content was increased from 10.8 at day 4 to 14.9 percent at day 8 in hydroponically barley fodder that were in accordance with our findings.

But, Snow *et al.* [31] reported a higher (16.13%) CP content, in hydroponically barley fodder. The CP contents could be affected by the cultivation conditions in hydroponic systems. Sneath and McIntosh [6] evaluated the composition of sprouted barley and reported that the CP ranged from 11.38 to 24 percent. However, protein content may be influenced as a result of the nitrogen supplementation and other nutrients changes in sprouting grains.

By enhancing the time of sprouting, the higher organic matter, particularly starch consumed to support the metabolism and energy requirement of the growing [2], therefore resulted in a lower OM and higher Ash in sprouted grain. According to Kent and Amos [32], after 6 days of growing, starch accounted for 53-67% of the dry weight of barley seed, so any decrease in the amount of starch would cause a corresponding decrease in OM, NFC and DM as well.

The increase in EE could be due to the production of chlorophyll associated with plant growth that are recovered in ether extract measurement [33]. Such changes in nutrients profile and recovery are misleading, since they only described the alterations in the proportion of nutrients during growth and sprouting of seeds [17]. A change in weight of any one of the nutrient leaded to proportional changes in other compositions. During the germination and early stage of plant growing, starch was catabolized to soluble sugars for use in respiration and cell-wall synthesis [34].

Morgan *et al.* [17] found that Ash content of sprouts increased from day 4 corresponding with the extension of the root, which allowed mineral uptake. They reported that Ash content changed from 2.1 in original seed (barley) to 3.1 and 5.3 at day 6 and 8 respectively that were relatively similar to our findings. The macro minerals including phosphorous (P), potassium (K) and magnesium (Mg) were not affected by sprouting the grain or growing period but the calcium (Ca) content was increased ($p<0.05$) in green forage than that of the original grain. The trace minerals concentration were significantly affected by the sprouting of barley grain with increasing of Fe and Zn but decreasing of Mn. Sneath and McIntosh [6] found that Ca, P, K and Mg respectively ranged 0.07-0.13, 0.30-0.31, 0.48-0.60 and 0.12 to 0.40 percent; Fe, Zn, Mn and Cu ranged 81-168, 21-34, 21-27 and 6-11mg/kg respectively in hydroponic barley fodder that were comparable with our finding. However, these findings were in contrast to those of Al-Ajmi *et al*. [9] who reported that Ca, K, P and Mg were 1.27, 4.43, 2.99 and 1.3 % in hydroponically barley fodder that could be due to the type of irrigated water and nutrients solutions [31].

Protein Fractions: The protein fractions which were determined according to the CNCPS are presented in Table 2. The percentage of soluble protein (SP) was significantly ($p<0.05$) increased in GF harvested at day 7 and 8 but no difference was found for the insoluble protein (IP). As a portion of total CP, the NPN content increased but the true protein decreased ($p<0.05$) in GF compared to the barley grain. However, there were no differences obtained between the growing periods. An increasingly tendency was shown for the NDICP and ADICP content by extending the sprouting period from 6 to 7 and 7 to 8 day. Contradictory to the B1, fractions B3 and C were increased when the grain transformed to green forage, meanwhile significant ($p<0.05$) differences were found between the growing periods. Complicated biochemical changes occur during hydration and subsequent sprouting seeds where stored chemical constituents, such as protein, starch and lipids, are broken down by enzymes into simple compounds. The period of greatest enzyme activity in sprouts was generally between germination and 7 days of age [2].

No report was found about the protein fractions in hydroponics green fodder. Meanwhile our finding may be comparable with fresh grasses and silages where a large quantity of CP is in the form of NPN in silage that resulted in a low N efficiency when fed to ruminants [35]. Volden *et al*. [36] reported that around 30% of soluble non ammonia nitrogen (NAN) in the silage was in the form of long chain true protein.

Table 2: Protein fractions of barley grain and barley sprouted fodder (dry matter basis)

	Treatments				
		GF[b]			
Components (%)	BG[a]	Day 6	Day 7	Day 8	SEM
Crude protien	11.73 [c]	13.69 [b]	13.69[ab]	14.67 [a]	1.21
Soluble protein	10.49 [b]	10.87 [b]	12.52 [a]	12.30 [a]	0.87
Insoluble protein	1.24	2.84	1.18	2.37	1.66
True protein	9.39 [a]	7.80 [b]	7.72 [b]	8.24 [b]	0.27
NDICP[c]	8.08 [c]	12.81 [b]	16.5 [ab]	18.0 [a]	2.3
ADICP[d]	2.75 [cb]	4.63 [b]	6.06 [a]	7.19 [a]	1.2
A[e] 2.34 [b]	5.90 [a]	5.96 [a]	6.48 [a]	0.93	
B_1[f] 8.15 [a]	4.96 [b]	6.53 [b]	5.84 [b]	1.16	
B_2[g] -.05	0.80	-1.46	0.29	1.89	
B_3[h] 0.85 [c]	1.31 [b]	1.60 [a]	1.73 [a]	0.10	
C[i] 0.44 [c]	0.30 [c]	0.67 [b]	0.87 [a]	0.084	

a: barley grain; *b*: green fodder; SEM: standard error of means

In a row, means followed by a common letter are not significantly different at the 5% level by DMRT

c: Neutral detergent-insoluble crude protein (percentage of total crude protein)

d: acid detergent-insoluble crude protein (percentage of total crude protein)

e: non protein nitrogen fraction, *f*: rapidly degradable protein fraction

g: intermediate degradable protein fraction, *h*: slowly degradable protein

i: non degradable and absorbable protein fraction

Table 3: Effect of sprouting on *in vitro* gas production and estimated parameters (ml/200mg dry matter)

	Treatments				
		GF[d]			
Parameters	BG[a]	Day 6	Day 7	Day 8	SEM
IVGP	86.20 [a]	75.45 [b]	72.7 [c]	71.33 [c]	0.82
b	106.7 [a]	85.49 [b]	80.2[c]	78.35 [d]	1.07
c	0.13 [a]	0.12 [ab]	0.10 [b]	0.11 [b]	0.004
OMD [e]	87.58 [a]	85.53 [a]	83.04[ab]	81.86 [b]	1.26
ME [f]	3.038 [a]	2.838 [b]	2.757 [c]	2.714 [c]	0.028

a: barley grain; *d*: green fodder; SEM: standard error of means;

IVGP: *in vitro* gas production for 24 h (ml/200mg); *b*: the gas production from the insoluble but fermentable fractions for 72 h (ml/200mg); *c*: rate constant of gas production during incubation (ml/h); *e*: Organic matter digestibility (%); *f*: metabolisable energy (Mcal/kg dry matter)

In a row, means followed by a common letter are not significantly different at the 5% level by DMRT

***In vitro* Findings:** *In vitro* fermentation of green fodder as well as the barley grain samples were evaluated by gas test adopting short (i.e. 2 h) to long (i.e. 72 h) incubation lengths to produce information about their immediate, or potentially available, fractions in the rumen. The gas production (GP), at different times of incubation, was significantly ($p<0.05$) different when compared between original barley grain and GF (Fig. 1). There was also significant ($p<0.05$) variation among the GF growing at different days (6, 7 and 8). At the early incubation time the gas yield was lower in barley grain whereas by increasing the incubation time for 12h and afterward, the amount of gas production increased in barley grain. A reducing trend of gas yield, particularly at 48 and 72h incubation, was observed by extending the growing cycle from 6 to 8 days.

The potential GP (b) was reduced ($p<0.05$) in GF comparing to the barley grain, meanwhile it was shown a decreasing trend with increasing the growing period in GF (Table 3). The rate of GP (c) in green forage, harvested at day 7 and 8, was reduced ($p<0.05$) when compared to the original grain. Gas production is the result of variations in chemical composition, particularly the water soluble carbohydrates and fibre fractions. These compounds were affected by the treatments in this study (Table 1) that could affect the GP at different incubation times and GP fractions [37].

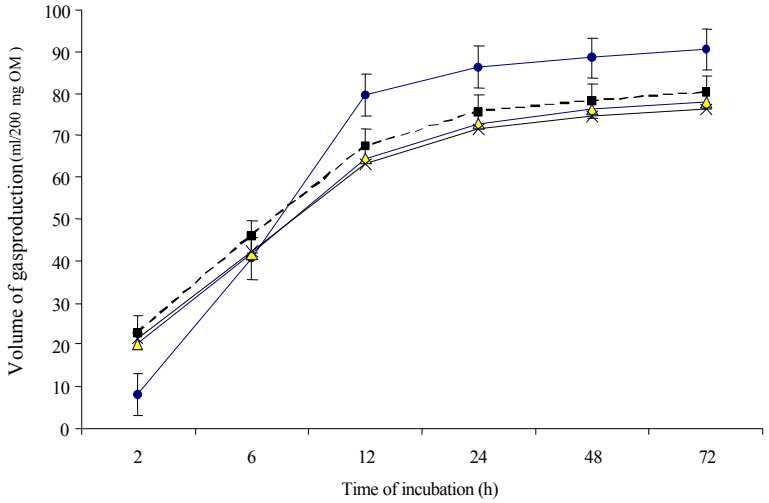

Fig. 1: Cumulative gas production curves for Barley grain (*), GF 6 day (■), GF 7 day (▲) and GF 8 day (×).

Table 4: Conversion ratio [a] of nutrients obtained in green fodder per kg of barley grain

	Days after seedling			
Item	6	7	8	Significance
Fresh weight	4.93	6.65	7.21	*
Dry matter	0.95	0.95	0.96	ns
Organic matter	0.94	0.95	0.95	ns
Ash	1.23	1.26	1.40	ns
Crude protein	1.19	1.20	1.36	*
True protein	0.68	0.67	0.67	ns
Non protein nitrogen	2.05	2.09	2.11	ns
Neutral detergent fibre	1.47	1.50	1.68	*
Acid detergent fibre	1.89	2.05	2.28	*
Non fibre carbohydrate	0.72	0.68	0.64	ns
Water soluble carbohydrate	1.81	1.59	1.72	ns
Digestible organic mater	0.92	0.94	0.91	ns
Metabolisable energy	0.92	0.94	0.91	ns

*: statistically significant (P< 0.05).

ns: statistically not significant (P> 0.05).

[a] The conversion ratio (CR) for each nutrient calculated as below:

$$CR = \frac{\text{Nutrients contents in green fodder obtained per kg of barley grain}}{\text{Nutrients contents per kg of barley grain}}$$

The OMD showed a reduction trend by the sprouting of barley grain (Table 3). Meanwhile, the differences in digestibility was significant ($p<0.05$) only for the GF harvested at 8 day growing period. Reduction in digestibility could be as a result of the higher fibre fractions and lower NFC in green forage comparing to the initial barley grain (Table 1). Such reduction in digestibility could be as a result of components changes in GF where the NFC was decreased but fibre fractions were increased. Other reports: Mansbridge and Gooch [16]; Grigor'ev *et al*. [38]; Cuddeford [13] shown that *in vitro* digestibility of hydroponically grown barley at 6 to 8 days growing periods ranged 72-76 that were comparable to our findings. The DM digestibility could be influenced by the proportion of germinated barley. Peer and Leeson [30] reported significant losses in DM digestibility of sprouting grains, which declined progressively during a 7 to 8-day growth cycle. The ME values shown a significantly ($p<0.05$) decreasing trend in GF sprouted at different days (Table 4). There were few reports about the ME value of hydroponic fodder, it was reported that the values for ME were around 2.77 Mcal/kgDM [16] and 2.92 Mcal/kg DM [13] that were in accordance with our results.

Conversion Factor: During the growing cycle of sprouting barley, the main visible change was the increase in root length and thickness. As it is shown in Table 4, the average green forage yield ranged from 4.93 kg per kg of barley grain at day 6 to 7.21 kg at day 8. The production conversion ratio, based on the amount of fresh fodder produced per unit of seed used, could be approximately 4 to 8 times [17, 30]. Nevertheless, lower amount of green forage to seed ratio was reported by Al-Ajmi *et al*. [9] and Al-Hashmi [39] who obtained a ratio of 2.76 to 3 kg green fodder per kg of barley seed. This ratio depended on the several factors such as management, type and quality of grain, amount and frequency of irrigation, nutritious solution, temperature, humidity, density and position of lights, bulk of seeds on each tray and number of days allowed to grow [40-42].

However, the recovery of DM and OM ranged 95-96 and 94-95 percent respectively that were lower than that of the initial seed grain used. An increase in fresh weight of forage was due to the large uptake of water during germination and vegetation that still some DM loss was found in green sprout comparing to that of the original grain [17, 29]. A reduction of OM recovery was also reported when grain barley converted to GF [30]. Morgan *et al.* [17] carried out a series of sprout production experiments and concluded that it was not possible to produce a gain in DM just 6 to 8 days. They recorded DM losses ranging 7-18% which is mostly non fibre carbohydrate. In the other hand, the structural carbohydrate increased in sprout green forage. These changes affected the proportion of the other nutrients such as protein that could be shown a higher percentage [17, 18].

Therefore, the most of the increases observed in the nutrients were not true; they simply reflected the loss of DM, mainly in the form of carbohydrates, due to respiration during sprouting. Such status could be understood where the amount of digestible organic matter obtained from green forage per unit of barley grain used were reduced. Additionally the recovery of ME and NE reduced when the barley grain changed to the sprouted or green form. These nutrient changes are happening because in order to germinate the seeds, the stored energy inside the grain is used and dissipated during the process [2, 13].

CONCLUSION

In is concluded that no increase in quantity and quality of DM and nutrients could be obtained by sprouting barley grain still some DM and DOM loss was found in green fodder, therefore economically it is not recommended for animal farming.

REFERENCES

1. Resh, H.M., 2001. Hydroponic Food Production, 6th ed., 567 pp., Woodbridge Press, Santa Barbara, CA.
2. Chavan, J. and S.S. Kadam, 1989. Nutritional improvement of cereals by sprouting. Critical Reviews in Food Science and Nutrition, 28(5): 401-437.
3. Lorenz, K., 1980. Cereal sprouts: composition, nutritive value, food applications. Critical Reviews in Food Science and Nutrition, 13(4): 353-385.
4. Rajendra, P., J.P. Seghal, B.C. Patnayak and R.K. Beniwal, 1998. Utilization of artificially grown barley fodder by sheep. Indian Journal of Small Ruminants, 4(2): 63-68.
5. Tudor, G., T. Darcy, P. Smith and F. Shallcross, 2003. The intake and live weight change of drought master steers fed hydroponically grown, young sprouted barley fodder, Department of Agriculture Western Australia.
6. Sneath, R. and F. McIntosh, 2003. Review of hydroponic fodder production for beef cattle. Department of Primary Industries: Queensland Australia 84. McKeehen, pp: 54.
7. Kruglyakov, Yu. A., 1989. Construction of equipment for growing green fodder by a hydroponic technique. Traktory-I Sel'skokhozyaistvennye Mashiny, 6: 24-27.
8. Rodriguez-Muela, C., H.E. Rodriguez, O. Ruiz, A. Flores, J.A. Grado and C. Arzola, 2004. Use of green fodder produced in hydroponic system as supplement for lactating cows during the dry season. In the Proceeding of the American Society of Animal Science, pp: 271-274.
9. Al-Ajmi, A., A. Salih, I. Kadhim and Y. Othman, 2009. Yield and water use efficiency of barley fodder produced under hydroponic system in GCC countries using tertiary treated sewage effluents. Journal of Phytology, 1(5): 342-348.
10. Mukhopad, Yu., 1994. Cultivating green forage and vegetables in the Buryat Republic. Mezhdunarodnyi Sel'skokhozyaistvennyi Zhurnal, 6: 51-52.
11. Buston, C.D.E., E.L. Gonzalez, B.A. Aguilera and G.J.A. Esptnoz, 2002. Forraje hidropónicouna alternativa para la suplementación caprina en el semidesierto Queretano pp: 383. XXXVIII Reunión Nacional de Investigación Pecuaria. (Puebla, México).

12. Pandey, H.N. and N.N. Pathak, 1991. Nutritional evaluation of artificially grown barley fodder in lactating crossbred cows. Indian Journal of Animal Nutrition, 8(1): 77-78.
13. Cuddeford, D., 1989. Hydroponic grass. In Practice, 11(5): 211-214.
14. Chung, T., E.N. Nwokolo and J.S. Sim, 1989. Compositional and digestibility changes in sprouted barley and canola seeds. Plant Foods for Human Nutrition, 39: 267-278.
15. Peer, D.J. and S. Leeson, 1985a. Nutrient content of hydroponically sprouted barley. Animal Feed Science and Technology, 13: 191-202.
16. Mansbridge, R.J. and B.J. Gooch, 1985. A nutritional assessment of hydroponically grown barley for ruminants. Animal Production, 40: 569-570.
17. Morgan, J., R.R. Hunter and R. O'Haire, 1992. Limiting factors in hydroponic barley grass production. In the proceeding of the 8th International congress on soil less culture, pp: 241-261.
18. AOAC, 1999. Official methods of analysis. Association of Official Analytical Chemists, Inc. Arlington, Virginia, USA.
19. Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science, 74: 3583-3597.
20. Thomas, T.A., 1977. An automated procedure for the determination of soluble carbohydrate in herbage. Journal of Science of Food and Agriculture, 28: 639-642.
21. Ryan, J., G. Estefan and A. Rashid, 2001. Soil and Plant Analysis Laboratory Manual (2nd edn.). International Center for Agricultural Research in the Dry Areas ICARDA: Aleppo, Syria.
22. Chalupa, W. and C.J. Sniffen, 1994. Carbohydrate, protein and amino acid nutrition of lactating dairy cattle. In: P.L. Garnsworthy and D.J.A. Cole (eds.) Recent Advances in Animal Nutrition. Nottingham University Press.
23. Sniffen, C.J., J.D. O'Connor, P.J. Van Soest, D.G. Fox and J.B. Russell, 1992. A net carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and protein availability. Journal of Animal Science, 70: 3562-3577.
24. Licitra, G., T.M. Hernandez and P.J. Van Soest, 1996. Standardization of procedures for nitrogen fractionation of ruminant feeds. Animal feed Science and Technology, 57: 347-358.
25. Peer, D.J. and S. Leeson, 1985b. Feeding value of hydroponically sprouted barley for poultry and pigs. Animal Feed Science and Technology, 13: 183-190.
26. Menke, K.H., L. Raab, A. Salewski, H. Steingass, D. Fritz and W. Schneider, 1979. The estimation of the digestibility and metabolisable energy content of ruminant feedstuffs from the gas production when they are incubated with rumen liquor. Journal of Agricultural Science, 93: 217-222.
27. Menke, K.H. and Y.H. Stingass, 1988. Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. Animal Research and Developments, 28: 7-55.
28. SAS, 2003. SAS/SAT Guide for Personal Computers, Version 9.13 (SAS Institute Inc: Cary NC, USA).
29. Bautista, S.H., 2002. Producción de forraje verde hidropónico de trigo Triticum aestivum L. para el mantenimiento de conejos criollos Oryctolagus cuniculus. MSc thesis, Universidad Autónoma de Guerrero (UAG) Chilpancingo, Guerrero, México.
30. Peer, D.J. and S. Leeson, 1985b. Feeding value of hydroponically sprouted barley for poultry and pigs. Animal Feed Science and Technology, 13: 183-190.
31. Snow, A.M., A.E. Ghaly and A. Snow, 2008. A Comparative Assessment of Hydroponically Grown Cereal Crops for the Purification of Aquaculture Wastewater and the Production of Fish Feed. American Journal of Agricultural and Biological Sciences, 3(1): 364-378.
32. Kent-Jones, D.W. and A.J. Amos, 1967. Modern Cereal Chemistry. 6th ed. Food Trade Press, London.
33. Mayer, A.M. and A. Poljakoff-Mayber, 1975. The Germination of Seeds, (2nd edn). Pergamon Press, Toronto.
34. Hillier, R.J. and T.W. Perry, 1969. Effect of Hydroponically Produced Oat Grass on Ration Digestibility of Cattle. Journal of Animal Science, 29: 783-785.
35. Bertilsson, J. and M. Murphy, 2003. Effects of feeding clover silages on feed intake, milk production and digestion in dairy cows. Grass Forage Science, 58: 309-322.
36. Volden, H., L.T. Mydland and V. Olaisen, 2002. Apparent ruminal degradation and rumen escape of soluble nitrogen fractions in grass and grass silage administered intraruminally to lactating dairy cows. Journal of Animal Science, 80: 2704-2716.
37. Spanghero, M., S. Boccalon, L. Gracco and L. Gruber, 2003. NDF degradability of hays measured in situ and *in vitro*. Animal Feed Science and Technology, 104: 201-208.

38. Grigor'ev, N.G., A.I. Fitsev and T.I. Lesnitskaya, 1986. Nutritive value of hydroponic feed and its use for feeding high-yielding cows. Sel'skokhozyaistvennaya Biologiya, 7: 47-50.
39. Al-Hashmi, M., 2008. Hydroponic green fodder production in the Arabian Gulf region. MSc thesis, Desert and arid zones programme, Arabian Gulf University, Bahrain.
40. Trubey, C.R. and Y. Otros, 1969. Effect of Light, Culture Solution and Growth Period on Growth and Chemical Composition of Hydroponically Produced Oat Seedlings. Agronomy Journal, 61: 663-665.
41. Hubballi, M., S. Nakkeeran and T. Raguchander, T. Anand and R. Samiyappan, 2010. Effect of environmental conditions on growth of *Alternaria alternata* causing leaf blight of Noni. World Journal of Agricultural Sciences, 6(2): 171-177.
42. Molla, A. and D. Birhan, 2010. Competition and resource utilization in mixed cropping of barley and durum wheat under different moisture stress levels. World Journal of Agricultural Sciences, 6(6): 713-719.