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Research Article

Evaluation of Feed Value of Barley Fodder as an Alternative Feed Ingredient

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ABSTRACT

Barley is an important cereal gain which is traditionally used in some nations of Asia and North Africa, and there has been growing interest in using barley as an ingredient in food due to their nutritional value and high content of phyto-constituents. However, no study report on comparative feed value between sprouted barley, cornflake and alfalfa hay. Therefore, in this study we aimed to evaluate the chemical composition, amino acid profile and mineral content of 6 day sprouted barley fodder (SBF) compared with cornflake and alfalfa hay using by AOAC method, as an alternative feed ingredient. Results showed that SBF had higher content of crude protein, acid detergent insoluble crude proteins and neutral detergent insoluble crude protein than alfalfa hay and cornflake; cornflake had higher crude fiber, neutral detergent fiber content than SBF and alfalfa hay; alfalfa hay had higher crude fiber, crude ash, acid detergent fiber, neutral detergent fiber and lignin level than SBF and cornflake. Also, significant differences were found on amino acid content among them (p<0.01). The most abundant amino acid in SBF was glutamate (123 g/kg DM), which is higher than in alfalfa hay (1.27%) or cornflake (1.58%). However, methionine (1.33%) and cysteine (1.53%) were the least abundant amino acids in SBF compared with cornflake or alfalfa hay. Furthermore, our study results exhibited that SBE comprise a good sources of minerals including ferrous (90.01 mg/kg) followed by zinc (20.50 mg/kg), magnesium (0.20 mg/kg) and sodium (0.03 mg/kg) as compared to cornflake and alfalfa hay. The present research findings, confirmed that the nutritional values of SBF are comparable to those of cornflake and alfalfa hay. Hence, SBF can be a better alternative feed ingredient for cornflake or alfalfa hay. However, feeding trials will be required to determine acceptability of SBF for ruminant production.

(**Key words**: Barley fodder, Cornflake, Alfalfa, Amino Acids, Minerals)

Ⅰ. INTRODUCTION

With the rapidly increasing global population, there are increasing demands on animal protein. This resulted in revolutionary developments in livestock production enterprises such as commercial dairy, meat or poultry farms in the world. The dairy industries and small holder dairy farms need optimization of profit with limited investment on feeding cost as it is the major production cost in livestock production. It has been estimated that the costs of feeding contribute 60-80% of the variable costs of livestock production (Webster, 1993; Gallenti, 1997; Rose, 1997). Reducing feed cost is essential to make more income in livestock production. Adjusting total mixed ration with low input cost feed ingredients will reduce animal protein production cost. Sprouted grain was proposed as a useful alternative to produce forage in areas where rainfall is limited for consistent forage production (Rodríguez-Muela et al., 2005; Rodríguez, 2012).

Sprouted barley (SB) is barley grain that has been soaked in water, placed in trays, permitted to germinate and sprout for 6 to 8 days (Peer and Leeson, 1985; Dung et al., 2010; Fazaeli et al., 2012). The resulting intertwined mat of roots and green shoots then fed to ruminants. During the sprouting duration, barley seed increasing their fresh weight, as germination converts carbohydrates, protein, and lipids to their primary forms (Dung et al., 2010; Fazaeli et al., 2012). Earlier study reported that

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hydroponically produced barley sprout accumulated greater DM yields than other cereal grain such as wheat (Al-Karaki and Al-Hashimi, 2012). However, increasing corn price, a demand on grain supplements switched among dairy farmers to alternative solutions producing high-quality fresh forage using sprout grain throughout a year.

Utilization of sprouted fodder is not a new concept. Since 1600s, sprouting small grains have been used for fodder preparation. However, researchers have more attention on the preparation of feeding option with economically competitive. Specially, light, moisture and rational heat are critical measures for sprouted fodder to performance. Sprouted barley fodder is a live feed that increase the digestibility than other feeds which have been used in total ration, due to the enzymes present in their root. Virtually 30% of concentrated feed can be replaced with the same in dairy ewes and ruminants productivity (Pedretti, 2013). Therefore, in this experiment we aimed to evaluate the nutrient composition, amino acids and mineral profile of SBF that can be an alternative substitute to make good quality food for ruminant.

Ⅱ. MATERIALS AND METHODS

1. Samples and preparation

Six days sprouted barley fodder developed by Gffa, Inc., Seoul, Korea (culture condition: humidity 40-80%, ambient temperature 16 – 23 °C, water temperature 16 – 23 °C, constant air movement using Oscillating pedestal fan), cornflake and alfalfa hay was purchased from WOOSUNGFEED, Co., Ltd, Daejeon, Korea and used for their chemical compositions analysis. Therefore, the collected samples were dried at 63 °C for 72 hr and ground using a cyclone mill (Foss Tecator Cyclotec 1093, Foss, Hillerød, Denmark) fitted with a 1 mm screen, prior to chemical composition investigation.

2. Chemical composition analysis

Chemical composition of the sample was analysed based on the Cornell net carbohydrate and protein system (CNCPS) fractionation scheme (Fox et al., 2004). The content of DM, crude protein (CP), crude fat (CF), crude fiber, crude ash, acid detergent fiber (ADF), neutral detergent fiber (NDF), acid detergent insoluble crude protein (ADICP) and neutral detergent insoluble crude protein (NDICP) were determined as described by AOAC International (2005). Non-fiber carbohydrate (NFC) was calculated by 100–CP–EE–ash–(NDF–NDICP) of the samples was estimated based on the equations in National Research Council (2001).

3. Amino acid profile analysis

For amino acid profile analysis was done by the following method of Mansouri et al. (2018) with slight modification. Briefly, 500 mg of dried sample was dissolved in 10 ml of 6 N HCl containing 0.1% of phenol. The sample was then hydrolyzed under nitrogen at 110 °C for 24 hr. Followed by cooling and adjusting pH to 2.2 using NaOH, 0.5 ml of norleucine (Sigma-Aldrich, St. Louis, MO, USA) at 50 mM ml^{-1} was added as an internal standard. Then the sample was filtered through a 0.2 mm filter, and 20 ml of the filtrate were analyzed by high-performance liquid chromatography (HPLC Biochrom Plus amino acid analyzer, Pharmacia, Cambridge, UK) equipped with sodium oxidized column, cation exchange resin, followed by post-column derivatisation of the amino acids to ninhydrin and spectrophotometric detection at 570 nm, except for proline, which was detected at 440 nm.

4. Mineral content analysis

The level of Ca, P, Mg, Fe, Na and Zn from each sample was analysed by using a Varian VISTA-MPX CCD simultaneous ICP-OES (Varian Inc., Melbourne, Australia). The samples and the standard solutions for mineral analysis were prepared according to the method described by Chaudhry and Jabeen (2011) and Ramdani et al. (2013).

5. Statistical analysis

Data was statistically analysed with using triplicates by using the SAS System for Windows (release 9.2; SAS Institute, Cary, NC, USA). The results were stated as means and standard error of the mean on the basis by t-test (SAS Institute, 2007). The significant differences between the mean was declared at $p<0.05$ level.

Ⅲ. RESULTS AND DISCUSSION

1. Chemical composition

The results from the estimated chemical composition of 6 days SBF, corn flake and alfalfa hay are shown in Table 1. Results revealed that the moisture content varies in SBF, cornflake and alfalfa hay with a range from 6.28 to 13.46 and 85.84%, respectively; the protein content varies in SBF, cornflake and alfalfa hay with a range of 14.37, 8.47 and 17.09% respectively; the fat content varies in SBF, cornflake and alfalfa hay with a range of 1.78, 3.81 and 3.74% respectively; the fiber content varies in SBF, cornflake and alfalfa hay with a range of 26.50, 1.84 and 15.79% respectively; the ash content varies in SBF, cornflake and alfalfa hay with a range of 7.65, 1.32 and 3.62% respectively; the ADF content varies in SBF, cornflake and alfalfa hay with a range from 7.90% to 35.80% respectively, NDF content in SBF, cornflake and alfalfa hay with range from 13.90 to 49.04% respectively; NFC content in SBF, cornflake and alfalfa hay with a range from 27.16% to 72.50% respectively; ADICP content in SBF, cornflake and alfalfa hay with a range from 0.35 to 0.77% respectively; and NDICP content in SBF, cornflake and alfalfa hay with a ranged from 1.53% to 1.91% respectively based on dry matter. Fiber content in SBF was lower than in cornflake and alfalfa hay, it may be due to hemicellulose and lignin content and also this fiber content may be related with their genotypes (Norman et al., 2013; Di Marco et al., 2009).

The CP level in SBF was higher than that of cornflake and alfalfa hay. Chemical content of the SBF used in the study was considered moderate to good quality, with high CP (17%) and balanced NDF concentration (13.90%). The chemical composition

Table 1. Chemical composition of SBF, cornflake meal and alfalfa roughage

Items (%)	SBF	Corn flake	Alfalfa hay
Moisture content	85.84 ± 0.02[a]	13.46 ± 0.19[b]	6.28 ± 0.03[c]
CP	17.09 ± 0.07[a]	8.47 ± 0.73[c]	14.37 ± 0.05[b]
CF	3.74 ± 0.07[a]	3.81 ± 0.36[a]	1.78 ± 0.12[b]
Crude fiber	15.79 ± 0.10[b]	1.84 ± 0.04[c]	26.50 ± 0.34[a]
Crude ash	3.62 ± 0.07[b]	1.32 ± 0.24[c]	7.65 ± 0.13[a]
ADF	11.21 ± 0.02[b]	7.90 ± 0.12[c]	35.80 ± 0.47[a]
NDF	25.27 ± 0.33[b]	13.90 ± 0.17[c]	49.04 ± 1.49[a]
NFC	50.28 ± 0.64[b]	72.50 ± 0.24[a]	27.16 ± 0.11[c]
ADICP	0.77 ± 0.04[a]	0.35 ± 0.01[c]	0.64 ± 0.04[b]
NDICP	1.91 ± 0.02[a]	1.61 ± 0.01[b]	1.53 ± 0.03[b]

Values are expressed as mean ± SEM.
[a, b] and [c] denote comparisons made between column (p <0.05).
CP, crude protein; CF, crude fat; ADF, acid detergent fiber; NDF, neutral detergent fiber; TDN, total digestible nutrient; NFC, non-fiber carbohydrates; VFA, volatile fatty acid; NDICP, neutral detergent insoluble crude protein; ADICP, acid detergent insoluble crude protein.

level of the fodder used in this study was within expectation for conserved forage originating from a mostly alfalfa/grass mix (Kung et al., 2010). A numeric increase in CP, ADICP, and NDICP level from 17.09, 0.77 and 1.91 % for SBF than that of cornflake and alfalfa hay. The present study result was agreed with Inoue (2001) study results. Furthermore, in this study, SBF, cornflake and alfalfa hay had higher CP than who previously reported on the crude protein level in forage maize, forage sorghum and high sugar forage sorghum (Sujiang et al., 2016).

2. Composition of amino acids

The amino acid composition in the original feed and the soluble fraction of many feedstuffs have been reported previously, but no comparative study on the amino acid profile in the SBF, cornflake and alfalfa hay. Therefore we analysed the amino acid composition present in SBF, corn flake and alfalfa hay, and their results are presented in Table 2. From the study results, the most abundant amino acid in SBF is glutamate in a range of 12.28% of dry matter when compared with alfalfa hay (1.27%) and cornflake (1.58%), while methionine (1.33%) and cysteine (1.53%) are the least abundant in SBF when compared to others. This varies content of amino acids in SBF than that of cornflake and alfalfa hay may be due to higher content of crude protein in SBF. The results of the current study was agreed with Kim et al. (2012b) who earlier reported that the amino acid content varies in corn with a range from 3.6% to 5.4% mg/100g. The amino acid compositions in barley and other concentrated feedstuff may vary due to the crude protein content (Kim et al., 2012a; Chiang et al., 1972). Therefore, this amino acid content variation in the present study is considered depending on the variety, cultivation management and climatic conditions.

3. Mineral content

The higher ash content in alfalfa hay and SBF is most likely due to the higher concentrations of Fe and Mn in alfalfa hay than in cornflake. Variation in mineral and ash content may also be due to the change in proportion of leaf to stem ratio. Previous study results shown that ash content in leaf was almost double that of stem in six major energy crops (Monti *et al.* 2008). Also, Kung *et al.* (2015) found that the ash concentration was positively correlated to Fe and Mn. The ash contents in SBF presented in Table 1 are higher than those reported by Singh

Table 2. Amino acid composition of SBF, cornflake meal and alfalfa roughage

Items (%)	SBF	Corn flake	Alfalfa hay
Cysteine	1.53 ± 0.02[a]	0.18 ± 0.01[b]	0.18 ± 0.00[b]
Methionine	1.33 ± 0.02[a]	0.15 ± 0.00[b]	0.17 ± 0.00[b]
Aspartate	9.38 ± 0.01[a]	0.56 ± 0.04[c]	1.41 ± 0.03[b]
Threonine	3.82 ± 0.00[a]	0.32 ± 0.02[c]	0.61 ± 0.01[b]
Serine	3.83 ± 0.01[a]	0.43 ± 0.03[c]	0.62 ± 0.01[b]
Glutamate	12.28 ± 0.26[a]	1.58 ± 0.13[b]	1.27 ± 0.03[b]
Glycine	4.03 ± 0.02[a]	0.32 ± 0.02[c]	0.61 ± 0.02[b]
Alanine	5.22 ± 0.02[a]	0.62 ± 0.05[c]	0.72 ± 0.02[b]
Valine	4.82 ± 0.02[a]	0.37 ± 0.03[c]	0.64 ± 0.02[b]
Isoleucine	3.42 ± 0.02[a]	0.27 ± 0.02[c]	0.53 ± 0.01[b]
Leucine	6.47 ± 0.02[a]	1.08 ± 0.08[b]	0.99 ± 0.03[b]
Tyrosine	2.91 ± 0.01[a]	0.35 ± 0.03[b]	0.38 ± 0.01[b]
Phenylalanine	4.03 ± 0.02[a]	0.44 ± 0.03[c]	0.61 ± 0.01[b]
Lysine	4.20 ± 0.09[a]	0.22 ± 0.01[c]	0.78 ± 0.02[b]
Histidine	1.90 ± 0.02[a]	0.21 ± 0.02[b]	0.23 ± 0.00[b]
Arginine	4.02 ± 0.04[a]	0.33 ± 0.03[c]	0.57 ± 0.02[b]
Proline	5.18 ± 0.04[a]	0.76 ± 0.06[b]	0.63 ± 0.00[c]

Values are expressed as mean ± SEM.
[a, b] and [c] denote comparisons made between column ($p<0.05$).

et al. (2012), but in agreement with the reported values by Monti *et al.* (2008). The mineral contents of the SBF, cornflake and alfalfa hay used in this study are within the range reported by Singh *et al.* (2012).

Detailed analysis of mineral content of each sample is presented in Table 3. Ca content varies in SBF, cornflake and alfalfa hay with a range of 1.19, 0.00 and 0.15% respectively. This Ca requirement in animals is based on the animal type and production level, age and weight of animal (McDowell, 1985). The suggested level of Ca for the growth and lactation of sheep is 1.2-2.6 g/kg (Reuter and Robinson, 1997). Furthermore, Ca content as found in SBF in the present study have similar to those were reported by Pastrana et al., (1991). The phosphorous content varies in a range of 0.16, 0.26 and 0.53% respectively on dry weight. The adequate required level of Fe for grazing animals was above 50 mg/kg (McDowell, 1985; Khan et al., 2005). This variation in the level of Fe observed between samples could partly be explained by forage sample differences and the changes in Fe level of the sources. SBF, cornflake and alfalfa hay had a higher level of Fe than in animal tissues reference values (30-50 mg kg^{-1} DM). Among the study results, we suggest that the Fe levels present in the SBF can be sufficient for the optimal growth performance of the ruminants. The levels of Fe in the current study may support the findings of some earlier study result (Tejada et al., 1987). Also, the high level of forage Fe found in this study is in agreement with Khan (2003) who reported earlier study report.

Table 3. Mineral content, energy and lignin level in SBF, cornflake meal and alfalfa roughage

Items (%)	SBF	Corn flake	Alfalfa hay
Ca	0.15 ± 0.01[b]	0.00 ± 0.00[c]	1.19 ± 0.10[a]
P	0.53 ± 0.01[a]	0.26 ± 0.01[b]	0.16 ± 0.01[c]
Fe	90.01 ± 2.92[b]	15.47 ± 1.13[c]	272.42 ± 37.11[a]
Mg	0.20 ± 0.01[b]	0.12 ± 0.00[c]	0.24 ± 0.02[a]
Na	0.03 ± 0.00[b]	0.00 ± 0.00[c]	0.14 ± 0.01[a]
Zn	20.50 ± 1.20[a]	2.29 ± 0.58[c]	14.00 ± 1.06[b]
Energy (cal/g)	4881.10 ± 50.03[a]	4888.92 ± 416.48[a]	4547.55 ± 22.30[a]
Lignin	2.02 ± 0.50[b]	0.35 ± 0.14[c]	6.48 ± 0.09[a]

Values are expressed as mean ± SEM.
[a, b] and [c] denote comparisons made between column ($p<0.05$).
Ca, calcium; P, phosphorous; Fe, ferrous; Mg, magnesium; Na, sodium; Zn, zinc

Mg level varies in SBF, cornflake and alfalfa hay with a range of 0.12, 0.20 and 0.24 % respectively. Form the study results, the alfalfa hay had higher level of Mg than that of SBF followed by cornflake. These forages would therefore meet the theoretical requirement of Mg level for the production of ruminant (Khan et al., 2007). These forages have also higher levels of Mg than the recommended requirements for the growth performance of lambs, lactating ewes and goats (Meschy, 2000). Zn is a vital mineral that is essential for the growth performance of the ruminant. Results showed that SBF had a higher level of Zn than that of cornflake and alfalfa hay. It has been suggested that 30 mg/kg Zn is a critical dietary level, although it has been recommended that concentrations of 12-20 mg/kg are adequate for growing ruminants (Anonymous, 1980). Our study results are in agreement with Anon, 1980 who early reported the recommended Zn level in the forage.

Ⅳ. CONCLUSIONS

SBF in this study had higher protein, ADICP and NDICP level than cornflake and alfalfa hay. Cornflake had higher fat and NFC level than alfalfa hay and SBF. SBF and cornflake had lower fiber, ash, ADF and NDF concentration than alfalfa hay. The analysis of amino acid composition reveals that SBF had higher concentration of all amino acid than that of cornflake and alfalfa hay. Moreover, this study demonstrates that germination is a promising process for developing novel nutritive and functional flours from barley with improved quality features. Hence, our study result suggests that the SBF can be suitable replacements for cornflake in beneficial diets for animals in future. However, further research is needed to investigate the effect of silage made with SBF on palatability, intake and growth performance of ruminants.

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