Potential Use of Brewers’ Grain as an Animal Feed in and around Population Centers in Mongolia

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Abstract: The potential use of brewers’ grain (BG) for animal feed was estimated, targeting Ulaanbaatar and Tuv Prefecture in Mongolia. Relative data such as numbers of animals in the country and areas under study, production, chemical composition, and costs of purchase and transportation of BG compared with wheat bran (WB) were used for analysis. Although BG was less widely available than WB, the costs of purchase and transportation of BG may be lower for areas near the central production sites, and the opportunities for BG use were increasing for herders further out of production. The results of this study indicate a good potential for BG to be utilized as animal feed in the target areas.

Key Words: Brewers’ grain, Dzud, Supplemental feed, TDN, Wheat bran.

1. Introduction

Current pastoral husbandry systems in Mongolia are extremely vulnerable with regard to three points. First, pasture productivity is strongly seasonal (Purev, 1990; Yamasaki et al., 2012). Second, there have been rapid increases in the numbers of herders and animals during the past two and a half decades (Mearns, 1993; Swift and Mearns, 1993; Cooper, 1995; Gelder, 1999; NSOM, 2015). Over-grazing of pastures in Mongolia has been repeatedly demonstrated (Enkhamgalan, 1995; Muller, 1995). Sternberg (2008) reported that 70% of pasture in Mongolia had some degree of erosion. Third, there had been drastic decrease in cereal and forage production in the fertile forest steppe in 1990s (Cullis et al., 1993; Jigidsuren, 1993; Suttie, 2000; Tuvshinbat and Niimura, 2008). Under the above situations, serious cold and snow disasters involving enormous animal losses, termed dzud in Mongolian, have occurred twice between 1999 and 2002 and in the winter/spring of 2010/2011 (NSOM, 2005, 2012). During the dzud, grazing is quite difficult because deep snow covers the pastures, and storage of forage is insufficient. Temporary evacuation is possible for some herders, but additional costs and labor forces are required to evacuate animals (Soyolikhram et al., 2010). To overcome these issues, the Mongolian government has been trying to increase the production of forage for cold months. The production has increased, but has not yet met with the growing demands of animals (Rasmussen and Dorlig, 2011).

The common forage in the country includes hay from natural pasture, and straw, screenings, and brans, particularly of wheat from cultivated land. The total amount of forage production in Mongolia in 2014 was 614,000 tons (t) in terms of Scandinavian fodder unit, and hay comprised more than 95% of the total production (NSOM, 2015). Wheat bran (WB) is the most prevalent concentrated supplemental feed for animals. Mongolia was an exporter of WB until the 1990s, but has been importing WB during the past one and a half decades (Ganbat and Sakazume, 2012). Therefore, increasing the domestic production of concentrate is currently required.

Brewers’ grain (BG), the by-product of the beer-making process, is rich in energy, protein, fiber, and fat (NARO, 2009), but the usage of BG is restricted because of its high moisture content, ease of decay, and high cost of transportation (Yamasaki et al., 2014). To store and conserve its nutritional value, the wet BG must either be ensiled or dried. The country’s production of beer takes place mostly in Ulaanbaatar (UB; area, 4700 km²), the capital of Mongolia. The annual amount of beer production increased rapidly from only 3.0-4.3 million L during 2001-2003 to 67.7 million L in 2014 (NSOM, 2005, 2015). It means the potential use of BG as animal feed, i.e., the amounts of the nutrients which are presently under-utilized, and the area where the nutrients are expected to be utilized, are now increasing. Hence, we estimated the potential use of BG as an animal feed with respect to the production and utilization of WB, including aspects of nutrients and costs to improve feeding systems in and around the capital of Mongolia.

2. Materials and Methods

2.1. Areas and animals

The number of animals expressed in sheep units (SU) in
3) Number of animals in the area / number of the country total ×100%.

Mongolia (Means, 1993; Dietz et al., 2005) was historically highest at the end of 2014, and reached over 86 million SU (FAO, 2015). The target areas were UB and Tuva Prefecture (TP; area, 74,000 km²), which is surrounding UB. The number of animals in UB and TP accounted for 1.1% and 8.7% of total animals in the country, respectively, of total animals in the country (Table 1). The areas of UB and the combined area of UB and TP (78,700 km²) were assumed to be circles, which had a radius of 38.7 km and 158.3 km, respectively. We also assumed that all animals were grazed homogeneously within each area.

2.2. Potential use of BG as animal feed from the aspect of the amount of nutrients

Annual wheat production in the country was 488,300 t in 2014 (NSOM, 2015). It was assumed that the ratio of WB production from wheat was 30% (Eliasson and Larsson, 1993), and WB was used homogeneously in the country. The amount used in the each country production was calculated by the multiplication of the country production of WB, and the proportion of animal numbers in each area to that of the country total.

As most of the major breweries are located in UB, it was assumed that all BG was produced at the center of the circle. For the purposes of this study, the tendency toward increasing beer production over time was assumed to continue. Therefore, beer production was estimated as 70 million L per year. Approximately 3.77 t of BG, including yeast, is produced daily as a by-product for 13.3 thousand L of beer (personal communication with a brewer). Therefore, we estimated that 19,840 t of BG was created in a year. The production of WB, and the total digestible nutrition (TDN), 69.5% DM, and BG: DM, 12.0%: CP, 24.7% DM; and TDN, 67.8% DM. Then, the potential use of BG as animal feed was determined from the aspect of the amount of nutrition, with respect to production and utilization of WB in the areas of interest.

2.3. Potential use of BG as animal feed from the aspect of the areas where nutrients of BG are expected to be utilized

It was assumed that ensiling of BG was performed during the warm months for long-term storage using 120 L capacity plastic containers, bags, and so on, and the silage was stored in the shade until the use for feeding. After the weather became cold, it was put in a warm place such as the herders’ houses to melt before feeding to animals. Feed and transportation costs, fuel cost, and the efficiency expressed by km/L, calculated on the basis of our survey in August, 2011 and in August, 2015, were used as estimates. The market prices of WB, BG, and fuel were 5060 tugrik (tg)/25 kg, 7800 tg/1.3 t, and 1470 tg/L in August 2011, and 12,075 tg/25 kg, no cost, and 1747 tg/L in August 2015, respectively (tg: USD1.0 = approximately 1220 tg in August 2011 and 1975 tg in August 2015). Fuel efficiency was 4 km/L. Each 1.5 t of WB and BG was transported separately by a truck. At the point where there is no difference in feed and transportation cost on CP or TDN basis, the following equation is formulated.

\[
\frac{\text{Radius} \times F + P_{\text{BG}}}{\%_{\text{BG}}} = \frac{\text{Radius} \times F + P_{\text{WB}}}{\%_{\text{WB}}}
\]

where, radius; distance from the center of the area to the circumference, km, %BG; CP or TDN contents of BG on a FM basis (CP; 3.9%, TDN; 8.1%), %WB; CP or TDN contents of WB on a FM basis (CP; 16.5%, TDN; 60.5%), PBG; price of 1.5 t BG (9000 tg and no cost in August 2011 and August 2015, respectively), PWB; price of 1.5 t WB (303,600 tg and 724,500 tg in August 2011 and August 2015, respectively), F; fuel cost per 1 km calculated on fuel price and efficiency (368 tg/km and 437 tg/km on August 2011 and August 2015, respectively).

Then, the radii of the areas where raw BG has advantage over WB from the nutritional aspect based on feed and transportation costs were estimated using the equation provided below, and the results were compared between August 2011 and August 2015.

\[
\text{Radius} = \frac{\%_{\text{BG}} \times P_{\text{WB}} - \%_{\text{WB}} \times P_{\text{BG}}}{(\%_{\text{WB}} - \%_{\text{BG}}) \times F}
\]

In addition, areas where BG has advantage over WB with regard to feed and transportation costs were calculated from the radii, and they were compared with the combined area of UB and TP.

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### Table 1. Number of animals in Mongolia and the population centers in 2014 (%)<sup>3</sup>

<table>
<thead>
<tr>
<th>Sheep unit, ×1000 SU</th>
<th>Proportion to country total, %&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UB</td>
</tr>
<tr>
<td><strong>Sheep</strong></td>
<td></td>
</tr>
<tr>
<td>23,214.80</td>
<td>158.9</td>
</tr>
<tr>
<td><strong>Goats</strong></td>
<td></td>
</tr>
<tr>
<td>19,808.00</td>
<td>104.3</td>
</tr>
<tr>
<td><strong>Cattle</strong></td>
<td></td>
</tr>
<tr>
<td>20,483.10</td>
<td>459.4</td>
</tr>
<tr>
<td><strong>Horses</strong></td>
<td></td>
</tr>
<tr>
<td>20,970.30</td>
<td>237</td>
</tr>
<tr>
<td><strong>Camels</strong></td>
<td></td>
</tr>
<tr>
<td>1745.5</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>86,222.7</td>
</tr>
</tbody>
</table>

<sup>1</sup> Data taken from NSOM (2015) were converted by to sheep unit (SU). SU, Sheep unit (sheep:goats:cattle:horses:camel = 1:0.9:6:7:5 (Means, 1993; Dietz et al., 2005).<br><sup>2</sup> Population centers consist of Ulaanbaatar (UB; area, 4700km²) and Tuva Prefecture (TP; area, 74,000 km²).<br><sup>3</sup> Number of animals in the area / number of the country total ×100%.
Table 2. Potential use of brewers’ grain as animal feed from an aspect of the amount of nutrients with respect to production and utilization of wheat bran in the population centers in Mongolia, 2014<sup>4</sup>.

<table>
<thead>
<tr>
<th>Production, ton/year&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Utilization of WB, ton/year&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Proportion of BG, %&lt;sup&gt;4&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;br&gt;WB</td>
<td>&lt;br&gt;BG</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>FM&lt;sup&gt;3&lt;/sup&gt;</td>
<td>146 490</td>
<td>19 842</td>
</tr>
<tr>
<td>DM</td>
<td>128 179</td>
<td>2381</td>
</tr>
<tr>
<td>CP</td>
<td>24 354</td>
<td>588</td>
</tr>
<tr>
<td>TND&lt;sup&gt;5&lt;/sup&gt;</td>
<td>89 084</td>
<td>1614</td>
</tr>
</tbody>
</table>

1) Population centers consist of Ulaanbaatar (UB; area, 4700 km<sup>2</sup>) and Tuv Prefecture (TP; area, 74,000 km<sup>2</sup>).
2) Annual wheat production in the country was 488,300 tons (t) in 2014 (NSOM, 2015). It was assumed that the ratio of wheat bran (WB) production from wheat was 30% (Eliassson and Larsson, 1993). Beer production was estimated as 70 million L/year from NSOM data (2015). Approximately 3.77 t brewers’ grain (BG), including yeast, is produced daily as a by-product for 13.3 thousand L of beer (personal communication with a brewer).
3) It was assumed that WB was used homogeneously in the country, and the amount of utilization in the each area was calculated by the following formula: Country production × number of animals in each area / number of the country total ×100.
4) It was assumed that all BG was produced at the center of UB. Proportion of BG was calculated by the following formula: BG production / WB utilization in the area × 100%.
5) FM; fresh matter, DM; dry matter, CP; crude protein on a DM basis, TDN; total digestive nutrients on a DM basis. WB: DM, 87.5%; CP, 19.0% DM; TDN, 69.5% DM, and BG: DM, 12.0%; CP, 24.7% DM; TDN, 67.8% DM (Yamasaki et al., 2014).

3. Results and Discussion

The potential use of BG from an aspect of the amount of the nutrients with respect to production and utilization of WB was estimated, and the results are shown in Table 2. It was shown that BG has a possibility to supply more CP and TDN to the UB area than that from WB (CP; 216.8%, TDN; 162.7%). On the other hand, compared with the WB utilization in the combined UB and TP area, the calculated potential of BG comprised 24.7% and 18.5% for CP and TDN, respectively.

The amounts of either BG or WB were not enough to meet the nutrient requirements of all animals during the cold months even when only UB was taken into consideration. The production of WB was 146,490 t FM/year (Table 2), and there were 86,222.7 thousands SU in the country in 2014 (Table 1). The amount was equivalent to 1.70 kg FM/SU/year, or 1.49 kg DM/SU/year. Assuming that the average body weight (BW) per SU is 45 kg, daily forage intake is 3.5% of BW on a DM basis, and 30% of the intake is WB, which is the amount appropriate for 7.0 days. To feed the animals in UB the same amounts of nutrients as in WB, BG production fulfill only 15.2 and 11.4 days for CP and TDN, respectively. Therefore, the amount of BG and number of recipient animals for supplementation is quite limited, as reported in the former study (Yamasaki and Ishida, 2004).

Table 3. Areas where raw brewers’ grain had advantage over wheat bran from a nutritional aspect with regard to feed and transportation costs in and around population centers of Mongolia in August 2011 and August 2015<sup>4</sup>.

<table>
<thead>
<tr>
<th>Radius, km&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Area, km&lt;sup&gt;2&lt;/sup&gt;</th>
<th>% of UB &amp; TP&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP&lt;sup&gt;1&lt;/sup&gt;</td>
<td>150.7</td>
<td>71 306</td>
</tr>
<tr>
<td>TDN</td>
<td>100.1</td>
<td>31 508</td>
</tr>
<tr>
<td>August, 2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>362.5</td>
<td>412 775</td>
</tr>
<tr>
<td>TDN</td>
<td>257.9</td>
<td>209 025</td>
</tr>
</tbody>
</table>

1) It was cheaper to use brewers’ grain (BG) in the circled areas, and the total cost for wheat bran and BG were the same on the circumferences.
2) Radius was calculated using following formula: (%BG × PBG− %WB × PWB)/ (%WB− %BG) × F, where, %BG; crude protein (CP) or total digestive nutrients (TDN) contents of BG on a fresh matter (FM) basis (CP; 3.9%, TDN; 8.1%); %WB; CP or TDN contents of WB on a FM basis (CP; 16.5%, TDN; 60.5%); PBG; price of 1.5 t BG (9000 tg and no cost in August 2011 and August 2015, respectively), PWB; price of 1.5 t WB (303,600 tg and 724,500 tg in August 2011 and August 2015, respectively), F; fuel cost per 1 km calculated from fuel price and the efficiency (368 tg/km and 437 tg/km in August 2011 and August 2015, respectively).
3) Proportion compared with the combined area of Ulaanbaatar (UB) and Tuv Prefecture (TP) (78,700 km<sup>2</sup>).
4) CP; CP on a dry matter (DM) basis, TDN; TDN on a DM basis.

Table 3 summarizes the results of the estimations of the potential use of BG from the aspect of areas where the nutrients are expected to be utilized or the area where raw BG had an advantage over WB for utilization with regard to feed and transportation costs. Although raw BG contains a high proportion of moisture (thus, less CP and TDN could be transported by truck compared with WB), it has an advantage with regard to the costs in 90.6% and 40.0% of the combined area of UB and TP for CP and TDN, respectively, in August 2011. Furthermore, on August 17, 2015, the price of WB increased, whereas BG was obtained at no cost. In this scenario, the proportions of the areas where BG had an advantage over WB to the combined area of UB and TP were widened: 524.5% for CP and 265.6% for TDN. Therefore, it was understood that the opportunity to introduce BG for herders’ feeding management was increasing, especially from an economical aspect.

In the above limited conditions on the amounts of nutrients and costs, effective distribution of the feed resources would be needed for effective use. There are two main directions of BG use as animal feed in and around the population centers. The first is to prepare BG silage for saving against emergencies such as dzud, with the support of central and/or local governments. If this option is adopted, the amount of supplemental feeds in the area will increase and greater amounts of WB could be transported to remote areas to increase the amount of feed and to prepare for dzud. The second direction is to supply BG for herders with its market

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price. In this case, factors enabling herders to access BG are highlighted. The first factor is location and accessibility to BG. It is more beneficial to be located nearby breweries, but even more remote areas along the main roads from the center have access to BG, as shown in Table 3. The second factor is labor and machineries such as a truck and a lift, which help to transport and convert raw BG to silage, and to feed the animals. The third factor is benefit. The numbers of intensive farms of dairy, poultry and swine in and around population centers are now increasing, and they require concentrates to feed their animals and increase production (Ganbat and Sakazume, 2012). These factors are related to each other; e.g., a truck, which intensive farmers often use, helps to load BG, and has the benefit of avoiding depreciation, maintenance or rental fee when a truck is owned by the farmer.

In addition, there are some conditions for the estimations of the area where BG can be used for animal feed and directions for its utilization. First, assessing the differences among conditions with respect to the herders will improve the accuracy of our calculations, secure for disaster, and improve the economy. For example, some materials such as plastic containers and bags to store the silage were not accounted for in the cost estimation. In some households, the containers are commonly used as a cistern and are easy to obtain at markets in UB and possible to use repeatedly. Therefore, for herders located in the target area, the cost of preparing BG might be little or negligible and the containers are already available. On the other hand, conditions such as possession of machinery and labor force are different according to household. These differences will affect the possibility and benefit of BG utilization as feed. The second condition is whether more information for the optimal utilization of BG is provided to the herders and governments. For example, raw BG is difficult to prepare for silage because of its high moisture. Therefore, Yamasaki et al. (2014) recommended from their results on the fermentation quality and the costs to use WB as additives and to mix 10% on FM basis to BG. Information on optimal methods of silage preparation, including fermentation qualities, technique of using BG silage during the cold weather, and required amount of feed to improve productivity of animals are needed.

The overall results show the possibility of using BG as animal feed, especially in and around population centers, and that the opportunities for its use by herders are now increasing.

References


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モンゴル国都市近郊におけるビール粕の飼料としての利用可能性

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要旨：ビール粕（BG）の飼料としての利用可能性を、モンゴル国のウランバートルとトゥブ県を対象として推定した。国および対象地域における家畜頭数等の関連情報、BG と小麦フスマ（WB）それぞれの生産量、化学成分含有率と購入・運搬費を用いた。地域内での BG の利用可能量は WB の推定使用量より少ないものの、その利用により地域内の中心地に近いほど費用を低減でき、また地域外においても利用機会が拡大していた。本研究の結果より、
BG が飼料として有効利用しうることが示唆された。

キーワード：ビール粕、ゾド、補助飼料、可消化養分総量、小麦フスマ.


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