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Production, Preservation, and Utilization Patterns of Brewery Spent Grain in Ethiopia

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ይህ የመስክ ጥናት የተካሄደው በ2008 ዓ.ም. ከኦሮሚያ ክልላዊ መንግስት በተመረጡ የሰበታና በደሌ ከተሞች እንዲሁም ከአማራ ክልላዊ መንግስት በተመረጠ የደብረ ብርሃን ከተማ ውስጥ ነበር፡፡ የጥናቱ ዓላማዎች በተመረጡት ከተሞች ውስጥ የሚገኙ የቢራ ፋብሪካዎችን ወቅታዊ የተረፈ-ምርት መኖ አቅም እንዲሁም በየከተሞቹ የሚገኙ ወተት ከብት አርቢዎችን የተረፈ-ምርት መኖዎቹን አከመቻቸትና አጠቃቀም ለማወቅ ነው፡፡ በዋነኛነት በሀገራችን የሚገኙ ፋብካዎች የቢራ ገብስ ጭማቂ መኖንና እርሾን የሚያመርቱ ሲሆን በ2008 ዓ.ም. ብቻ ከ12 የተለያዩ ፋብሪካዎች 26722.8 ቶን የቢራ ገብስ ጭማቂ መኖ (በድርቆሽ ይዘት) እና 360758.1 ሄክቶ ሊትር እርሾ ማምረት ተችሏል፡፡ የመኖ አመጋገብን በተመለከተ በከተሞች መካከል የነበረው የመሰረታዊ መኖ፣ ድንጣ መኖ፣ የቢራ ገብስ ጭማቂ ተረፈ-ምርት መኖ፣ ጨው እና አጠቃላይ ጥቅል ዕለታዊ የመኖ አመጋገብ ልዩነት በጣም የነላ ነበር፡፡ ጠቅለል ባለ መልኩ ሲታይ በሰበታ የሚገኙ ታላቢ ላሞች የመኖ ፍጆታ ከበደሌ እና ደ/ብርሃን ከተማ ከሚገኙት ላሞች ፍጆታ የላቀ መሆኑን ለማስተዋል ተችሏል፡፡ የቢራ ገብስ ጭማቂ በወተት ከብቶች የወተት ምርት፣ ጥራትና እንሰሳት ጤና ላይ የሚያስከትለውን ለውጥ ለማወቅ በአርቢዎቹ ላይ በተደረገ ጥናት የተገኘ ግብረ-መልስ እዳመለከተው ከወተት ጥራት በስተቀር በከተሞቹ መካከል ምንም የነላ የግብረ-መልስ ልዩነት እደሌለ ለመረዳት ተችሏል፡፡የቢራ ገብስ ጭማቂን ሳይበላሽ ለረዥም ጊዜ ለማቆየት በሚያስችሉ ተለምዷዊ ዘዴዎችን ለመለየት በተደረገ ጥናት በጨው መዘፍዘፍ፣ በፀሐይ ሙቀት ማረድረቅና በገፈራ መልክ ማከማቸት እንደ ቅደም-ተከተላቸው ጥቅም ላይ የዋሉ መሆናቸውን ለመለየት ተችሏል፡፡ አቅርቦትን በተመለከተ በበበታ ከተማ የሚገኙ አርቢዎች በተነፃፃሪነት የተሻለ የቢራ ገብስ ጭማቂ ተረፈ-ምርት መኖ አቅርቦት ሲኖራቸው የአንድ ኩንታል ደረቅ ተረፈ-ምርት መኖ ዋጋ በተጠኑት ከተሞች በአማካይ 82.50 እንደሚሸጥ ለማወቅ ተችሏል፡፡ የጥናቱ ከተሞች በዓመታዊ የጥቅል ገቢና ወጪ ክፍያዎቻቸው የሚለያዩ ሲሆኑ የሰበታ ከብት አርቢ በዓመት ለአንዲት ታላቢ ዲቃላ የወተት ከብት ከሚያወጣው ወጪ አንፃር ሲታይ በጥቅሉ በበደሌና ደ/ብርሃን ከተሞች ከሚገኙ አርቢዎች የላቀ ትርፍ በዓመት ማግኘት እንደሚችል ለመረዳት ተችሏል፡፡

Abstract

The study was conducted at Sebeta and Bedele towns in Oromia regional state and at Debre-Berhan town in Amhara regional state during October-January 2016/17. The objectives of the study were; to assess the current feed byproduct production potentials of the breweries, existing storage conditions and the status of brewery spent grain utilization by smallholder dairy farms in the study areas. The result showed that brewery spent grain (BSG) and Brewer's spent yeast (BSY) are the commonly produced byproduct feeds across all beer factories in Ethiopia. There were 12 beer factories producing an estimated 26722.8 tons BSG (DM basis) and 360,758.1 hectoliter (hl) of BSY in 2016 G.C... Substantial differences ($P<0.05$) were observed for the estimated daily average basal, concentrate, BSG, mineral (salt) and total feed DM intakes (TDMI) among the study areas. There was no difference in the views of responding households regarding long term effects of BSG feeding on lactation and health performances of dairy cattle ($P>0.05$). There was however, great variations in farmers' response towards long term effect of BSG feeding on milk compositional changes ($P<0.05$). Commonly used BSG preservation techniques across the surveyed areas included salting, sun drying and ensiling in that order of importance. There was variation ($P<0.000$) among the study areas in terms of preference to the type of preservation techniques used to elongate shelf life of stored BSG. The responding farmers in Sebeta (77.27%)

and Debre Birhan (61.43%) reported to have better access to BSG compared to the dairy farms in Bedele town (P<0.05). Similarly, the price (mean ± SE) of a quintal of brewer`s grain on DM basis was 82.50 ± 0.94 birr and showed variation (P<0.02) among the surveyed areas. Annual feed cost and revenue obtained from dairy farms also showed high variation among the study areas. The finding showed that dairy farms in Sebeta town were spending about 39% more cost for feed and managed to earn 28365.16 and 38509.58 birr more revenue per annum than dairy farms at Bedele and Debre Birhan. The study generally elucidated that availability, storage and proper feeding of BSG were major problems faced by dairy farmers in the study areas.

Introduction

Aside from enhancing household livelihoods, improving the animal productivity in smallholder dairy farms is also essential to the overall competitiveness of the Ethiopian dairy industry. Price volatility and fluctuations in supply of local raw materials are some of the challenges which confront the feed processing industry. These factors contribute to high feed production costs and necessitate the need for alternative feed sources that can partially or wholly substitute the more expensive feed ingredients. Brewer`s spent grain (BSG), a by-product of the brewing industry, for example, had been extensively studied for its use as an alternative animal feed ingredient. It is cheap, available all year round, and has high nutritional value (Mussatto *et al*., 2006). Supply, storage, and transport problems may have impeded its full utilization. Because of its high moisture and high nutrient content, it can deteriorate rapidly (Mussatto *et al*. 2006). Transporting wet BSG would also be expensive because of its low bulk density (Mussatto *et al*. 2006).

In Ethiopia, there are about 12 breweries producing 263,736 tons of WBSG (roughly 22,140.64 tones on DM basis during 2015/2016 (Amare, 2016). BSG availability is dependent on beer production, thus, its supply may not also be as consistent as the other feed ingredients used by commercial feed processing plants. Thus, smallholder urban and pre-urban dairy farms located closer to breweries would be the most ideal users of BSG. There is, however, very limited or no published information on the current potentials of byproduct feeds produced from the local breweries, their utilization and storage practices in Ethiopia. Since BSG may continue to be one of the cheaper alternative feed sources that smallholder dairy farmers can utilize, this study was aimed at addressing the gap by assessing current feed byproduct production potentials of local breweries, existing storage practices and the status of BSG utilization by smallholder dairy farms in selected areas.

Materials and Methods

The study areas

The study was conducted in three selected areas (Bedele, Bebre Birhan and Sebeta) where the breweries are located. Bedele (also called Buno Bedele) is a town and separate district in south-western Ethiopia, in the Buno Bedelle Zone of the Oromia National Regional State. The town is located at 8°27′N latitude and 36°21′Elongitude, and has an altitude ranging from 2,012–2,162 meters above sea level (masl). Debre Birhan is found in North Shoa administrative zone of the Amhara National Regional State and located at 09°36' North latitude and 39°30' East longitude, and has an elevation of 3360 masl. It receives an annual average rainfall of 731-1068mm, and its annual temperature ranges from 6-20^{O}C. Sebeta is part of the Oromia Special Zone Surrounding Finfinne and located between 8°55′N latitude and 38°37′E longitude. It receives an annual rainfall of about 1650 mm, has an elevation of 2356 masl with average annual minimum and maximum temperatures 8 and 19^{0}C, respectively.

Sampling

The on-farm survey was conducted on smallholder dairy farmers randomly selected from the three study areas. Two Keble's from each areas were selected purposively based on their comparative advantages over the others in dairy cattle populations; marketing of major dairy products, WBSG availability and utilization. Respondent households were selected after determining the total population size engaged in the smallholder dairying in each town. The actual number of respondents was calculated using sample size calculator recommended by Fluid Surveys (2014) as: Sample Size = (Distribution of 50%) / ((Margin of Error% / Confidence Level Score) ^{2}); whereas the finite population correction was calculated as: True Sample = (Sample Size X Population) / (Sample Size + Population – 1). *Note that distribution was set at 50% while the margin of error was set at ±0.07. The value for a confidence level score at 95% was 1.96.* Hence, the total populations of smallholder dairy producers were 250, 150 and 300 for Sebeta, Bedele and Debre-Birhan, respectively; out of which respectively, 66, 59 and 70 households were selected for the study. A reconnaissance survey and discussion with zonal and district agricultural extension officers was held on the basis of which the study districts, Kebele's and respondent dairy farm owners were selected. A fully structured pre-tested questionnaire and personal observations were used to collect data from responding households.

Data collection

Data was collected on brewer's grain storage conditions, preservations and feeding practices; and on major challenges associated with brewer's grain utilization (storage, effects on animal health, productive and reproductive performances etc). An assessment was made to collect data on estimated

quantities of feeds (both roughages and concentrates) provided per cow per day indoor by responding households across the study districts. Although lack of routine farm record keeping posed major limitation in this regard, most of the farmers had their own local means of estimating the quantities of feeds offered per cow per day. For instance, they use different local measurements such as bales, sacks, donkey loads, etc to estimate the amounts of roughages (hay, crop residues) fed to a cow per day. With regard to concentrate feeds, it was relatively easier to measure using locally available containers like jug (approximately equal to 0.5kg) and hence estimate the amount fed per cow per day. Data was also collected on major household's input (feed cost) and incomes (sales from milk, milk byproduct and male calves and other culled animals) to calculate feed expenses and revenues obtained in the year 2016 G.C/2008 E.C.

Data analysis

Data was analyzed using Statistical Package for Social Sciences (SPSS, 2002; ver. 20.0). Descriptive statistics such as means, frequency distribution and percentages were also used. Furthermore, one-way ANOVA was used to examine differences between continuous variables. Differences were considered significant at $p<0.05$.

Production, availability and marketing of brewery byproduct

Commonly produced byproduct feeds across all beer factories in Ethiopia are wet brewery spent grain and Brewer's spent yeast. There are currently 12 beer factories operating at different industrial capacities in the year 2016/17. The actual total amount of BSG produced from these breweries in the same fiscal year was 26722.8 tons (Table 1). Major BSG producing companies taken as percentage share of the total produce in the study period were: BGI company (comprise St. George beer factories at Adis Abeba, Kombolcha and Hawassa = 31.2%); Henken Prv. Lmt share company (Harar, Walia and Bedele breweries = 24.1%) and Dashen Brewery (Includes beer factories located at Gonder and Debre-Birhan = 16.6%). St George located at Addis leads the entire beer producing factories in the country with a total BSG production of 2,820 tons per annum. With a minimum actual BSG production of 1,721 tons per annum, Raya brewery stands last among the factories assessed in the study. Similarly, the total spent yeast production from all beer factories available in the country for same fiscal year was 360,758.1 hl (Table 1). BGI company again stood first with a total production capacity of 112,438.9 hl of spent yeast followed Henken (87, 107.5 hl) and Dashen breweries (59,873.9 hl). Almost all BSG produced are daily supplied to individual farmers through the factory themselves; retired workers associations of the factories, social groups called "Edir" and retailers. While spent yeast was supplied to the agents free of charge except that of Walia brewery, BSG in most instances was sold at a very low factory gate price of 0.49 Eth. birr/kg (range: 0.15-1.20 birr/kg). Sometimes, Habesha brewery has reported to offer BSG free of charge.

Retailers sailing price was subjected to high variations across seasons and districts mainly associated with availability of BSG; other agro-industrial concentrate feeds; green feeds, and input supplies to the factories. It was estimated to range three to four folds of the factory gate price for a single load of an ISUZU car (4 m^3 on a fresh matter basis)..Expressed in another way, it can be estimated to roughly amount 2000-3000 Eth. Birr per an ISUZ car. Factory gate price for BSG is as shown in Table 1 below. Despite high nutritional value and huge production potential in Ethiopia, supply of spent yeast to dairy producers so far was not to the level expected. The only factories currently supplying the autolized spent yeast to surrounding dairy farmers' were Meta Abo (at pilot level) and Walia which was supplying a third of its daily produce Bedele and Gonder-Dashen brewery factories have already started supplying the yeast long ago. However, majority of the spent yeast produced by the factories each year is still subjected to disposal as a land fill by the respective municipal sewerage authorities and/or by the factories themselves as such as it is live or after subjecting it to the autolization process.

Table 1. Annual feed byproduct processing efficiency of domestic breweries (2016/17 G.C)

Name of beer factory	BSG production[2] (tons, DM basis)	Spent yeast Production[1] (HL)	BSG to Malt ratio	Factory gate price (Birr/kg DM)	
				BSG	Spent yeast
Meta Abo brewery	2,073.6	27,993.6	0.18	1.20	Disposed
Walia brewery	2684.7	36,243.5	0.16	1.00	0.20
Bedele brewery	1,841	24,853.5	0.36	0.20	Free of charge
Harar brewery	1926.7	26,010.5	NA	NA	NA
St. George,Adis Abeba	2,820	38,070	NA	NA	NA
St. George,Kombelcha,	2,740.1	36,991.4	NA	0.28	Disposed
St. George,Hwassa	2,768.7	37,377.5	NA	NA	NA
Dashen, Debre Birhan	1,832.6	24,740.1	0.2	0.60	Disposed
Dashen, Gonder	2,602.5	35,133.8	0.18	0.31	Disposed
Habesha brewery	1,828.4	24,683.4	0.2	0.25	Disposed
Zebidar brewery	1,883.5	25,427.3	0.32	0.40	Disposed
Raya brewery	1,721	23,233.5	0.25	0.15	Disposed
Total	26722.8	360,758.1			

[1]Spent yeast estimated from a yeast production ratio of 2.7 kg/m^3beer (FAO, 2016); [2]BSG production was estimated from the assumption that 20kg fresh spent grain obtained for each HL of beer produced (Townsley, 1979); HL = hectoliter; NA = not available; BSG = brewers spent grain

During the survey period, while some factories were working at their full capacities, most of the beer factories have been found to operate at 60-70% of their designated potentials. On the other hand, the efficiency with which the BSG is recovered from the original malt from the breweries included in this study was in agreement to that estimated by Townsley (1979). Accordingly, for most of the surveyed factories the value was close to 31% of the original malt weight, representing approximately 20 kg per 100 l (i.e., calculated BSG: Malt grain = 0.2) of beer produced (see table 1). Bedele, Zebidar and Raya breweries were found to be less efficient as they were extracting the malt grain with less efficiency

compared to that suggested by Townsley, (1979). From nutritional point of view, it should be noted that higher ratios could be an additional benefit to the dairy farmer ever since the un extracted starch enriches the nutritional value of BSG. Availability of BSG according to key informants from each beer factory was subjected to seasonal fluctuations. Accordingly, the quantity of BSG produced and supplied to user communities during the long rainy season relatively drops owning to the chilling weather conditions that suppresses beer consumption. In some other districts the drop in the production of BSG comes from the dairy producers' side that the availability of abundant grass and grazing conditions for dairy cattle in same season significantly reduces the demand for BSG. With regard to marketing conditions, despite large disparities in retailing prices, factory gate prices are closely similar across all factories considered in this study. This is because the final retailers cost includes transportation and processing costs in value additions and also some profit margins set by the farmers' organizations and/or the retailers. Except few factories which are currently selling spent yeast, all factories as stated earlier were either supplying it for free or disposing it as a land fill inside or outside the factory compounds. If the wasted spent yeast could otherwise been used as a non-conventional protein source for ruminant livestock, it could presently offsets the cost of autholization and disposal the factories are claimed by local sewerage authorities. Additionally, it won't be justifiable to dispose a feed with high protein feed value in a country where the availability and cost of most conventional protein supplements are currently sky rocketing. Brewer's yeast as a protein feed source to ruminants contains about 40-56% crude protein on DM basis (Heuzé *et al*., 2016).

Estimated daily feed intake of lactating crossbred cows

The different feed types offered and consumed by a dairy cow per day as estimated using the information obtained from respondents is shown in Table 2. Roughage feeds (grass hay, crop residue and their mix) consumed by a lactating crossbred cow on average was estimated at 3.5 kg, d^{-1}, with cows in Sebeta town daily consuming considerably higher ($P<0.05$) roughage than those cows in Bedele and Debre Birhan towns. Similarly, estimated daily concentrate and feed DM consumed by lactating cows in the Sebeta town was significantly higher ($P<0.05$) than cows in the other two towns. While more concentrate (cow^{-1}, d^{-1}) ($P<0.05$) was consumed by dairy farms in Bedele than Debre Birhan towns, variation ($P>0.05$) remained non-significant for estimated total daily feed intake (cow^{-1}, d^{-1}) among these later two towns. Study districts also varied in the daily amount of estimated brewer's spent grain and mineral (salt) consumed per individual cow ($p<0.05$), with values being higher for lactating cows managed by dairy farms in Sebeta and Bedele towns compared to those in Debre Birhan town. The single most frequently utilized mineral source across the survey districts was "table salt". The amount of estimated daily brewery spent grain consumed when

expressed as percentage of the total daily concentrate and feed DM intake was also significantly higher (P<0.05) for lactating cows in Sebeta followed by Bedele and Debre Birhan towns in that order of importance.

Table 2. Estimated daily feed intake (kg DM, cow^{-1}, d^{-1}) of lactating crossbred cows

Intake variable	Sebeta n=66	Bedele n=59	DebreBirhan n=70	P-value
Roughage	3.9±0.17[a]	3.3±0.16[b]	3.3±0.11[b]	0.004
Total concentrate*	5.6±0.21[a]	4.9±0.17[b]	4.2±0.16[c]	0.000
Brewery grain	3.2±0.18[a]	3.0±0.16[a]	1.6±0.10[b]	0.000
Mineral (salt)	0.08±0.007[a]	0.07±0.004[a]	0.05±0.004[b]	0.033
Total feed DM intake	9.5±0.29[a]	8.3±0.24[b]	7.6±0.22[b]	0.026
Brewer's grain				
% total concentrate	62.2 ±2.63[a]	52.0±2.19[b]	37.7±2.77[c]	0.000
% total DM	38.9 ±1.87[a]	30.9±1.43[b]	21.3±1.37[c]	0.000

**Brewery grain also included in the total concentrate ration*

The estimated average amounts of hay DM (3.50±0.09) offered to a crossbred cow per day was much less than the figure (7.5 kg) reported in urban dairy settings of Girar Jarso in northern Shoa zone of Oromia region (Fekede, 2013). Daily basal feed intake from the present study was however comparable to the values (3.37 and 3.72 kg) reported for dairy farms categorized under the large-urban and secondary town urban settings (Yoseph *et al*., 2003). On the other hand, the quantity of concentrate fed to a crossbred cow in Addis Ababa (5.59 kg/day) and urban settings of Girar Jarso town in northern Shoa zone (5.7 kg/d) as reported by the above authors was also higher than the average figure recorded in this study. The overall mean value for roughage to concentrate ratio from the present study (41.37: 58.63) was similar to the 59% roughage: 41% concentrate ratio reported by Fekede (2013) and Yosef *et al.* (2003). On the other hand, the mean total feed DM intake obtained in the present study was in consistent to the value (8.82 kg/day) reported for crossbred dairy cows managed by farmers under large urban settings, but lower than the 10.20 kg/day and 9.38 kg/d reported for same cows managed by dairy farmers under the secondary and intra-urban dairy settings in the Adiss Ababa milk shed (Yosef *et al*. 2003). Discrepancy between the present findings and previously reported values could have been attributed to inadequate nutrient supply in the former, variation in nutrient composition of the feeds considered in the latter and body weight and milk production levels of the cows in the different study areas. Low feed DM intake in the present study could be associated to the higher proportion of supplement (58.63%) in the total diet. The higher total feed DM intake by dairy cows at Sebeta and Bedele compared to Debre Birhan can be linked to the higher ratio of supplement to roughage in the total diet. It has been reported earlier that increasing the proportion of supplements (concentrates) from 45% to 65% could result in increased total feed intake (Istasse *et al*., 1986). On the other hand, the fact that major components of the basal diet of cows in Debre Birhan town was crop

residues might have contributed to the recorded lower daily and lactation milk yield in the area. Barley residue commonly used by farmers in Debre Birhan is known to have lower crude protein and energy contents. Observed variations among the districts for daily BSG intakes in the present study may be partly associated to the difference in the production capacity of the factories and availability of BSG to dairy farmers. The differences could have been also expected to emanate from shortfalls in the availability of other alternative agro-industrial byproducts in the study districts except for farmers at Sebata. In general, the overall proportion of wet brewer's grain used in the concentrate (49.86%) and total ration (29.89%) of lactating crossbred cows in the present study appears to be highly exaggerated. In line with this, previous literature limits the inclusion rate of BSG in lactating cows to 20-25% of the concentrate DM, and 15-20% of the total dietary DM even though, up to 30% inclusion has also been recommended (Ewing, 1997), without affecting milk production in dairy cattle.

Lactation and health performance of crossbred cattle fed on BSG

Reflections of responding households regarding the effect of feeding BSG on lactation and major health performance of crossbred dairy cattle in the study areas is summarized in Table 3. While lactation and health performances as a result of long term feeding of BSG to crossbred cattle showed no variations across the study districts ($P<0.05$), there was high variation in farmers responses regarding milk compositional changes as a result of supplementing BSG to dairy cattle ($P<0.05$). Over all result from the current study indicated that majority of the interviewed households (92.31%) felt positive improvements in lactation milk yield of crossbred dairy cows as a result of feeding BSG. About 74.24, 67.14 and 62.71% of the sample respondents at Sebeta, Debre Birhan and Bedele, respectively reported no change in milk composition from crossbred cows fed on BSG. On the other hand, close to 24, 37 and 33% of the total sample respondents from Sebeta, Bedele and Debre Birhan towns, respectively noted less dense/watery milk upon routine feeding of BSG to lactating dairy cows and only a single farmer from Sebeta claimed that he experienced increments in fat yield (fatty milk). Differences among the study districts for reported major health complications associated with routine feeding of brewers' grain were non-significant ($P<0.05$). Over all mean result from the present study also indicated that more than half (58%) of the respondents from the surveyed districts never have encountered any major health problems in response to feeding BSG. On the other hand, some responding farmers reported to encounter some health complications associated with feeding BSG which include still birth , reproductive disorders (abortions and delayed estrous); nutritional related health problems (Poor feed intake; bloating & diarrhea); blindness in newly born calves. However, this should be further verified by research.

Table 3. Farmers' reflections on the effect of feeding BSG on milk yield, milk compositions and health performance of cross bred dairy cattle (%)

Variable		Sebeta n=66	Bedele n=59	Debre Birhan n=70	P-value
Change in milk yield	No change	4.55	8.47	10.00	0.473
	Increases	95.45	91.53	90.00	
	Decreases	0	0	0	
Change in milk compositions	No change	74.24	62.71	67.14	0.044
	The milk becomes fatty	1.52	0	0	
	The milk becomes watery	24.24	37.29	32.86	
Encountered health problems	NA	57.58	67.80	50.00	0.293
	Still birth	12.12	6.78	12.86	
	Abortion, delayed heat	12.12	10.17	15.71	
	Poor feed intake, bloating, Diarrhea	18.18	15.25	14.29	
	Blindness in newly born calves	0	0	7.14	

N=number of respondents; NA (not applicable)- not encountered any health problems so far

The above result showed that 92.34% of the overall sample respondents observed milk yield improvements from feeding concentrate fortified with BSG. Brewers' grain is mainly classified as a protein supplement and hence its introduction in dairy cows diet has been observed to increase milk yield, and also simultaneously reduce cost due to the greater amount of digestible proteins and crude fat consumption by cows (Biljana, 2013). Moreover, the same author indicated that the effect of BSG on milk production was much more magnified when recommended daily intake of brewers' grains was up to 30% of the daily concentrate allowance (or when it is between 5–10 kg on fresh basis and/or 2.7 to 4.54 kg per cow on DM basis). Despite farmers positive response , observed daily milk yield (9.81 kg, d^{-1},cow^{-1}, Getu *et al*., un published) from high grade cows in the present study was not to the level expected due partly to nutritional limitations of BSG and higher daily allowance might have exceeded recommended nutritional limitations (see Table 2). The finding from this study showed that some 32.28% of the respondents across the study areas observed watery milk, i.e., milk with lower fat contents. The reason for this can be explained by higher moisture contents of BSG and lower basal feed intake of cows in the study districts (Overall mean roughage intake was 3.5 kg/d^{-1}, cow^{-1}, Table 2). Often poor roughage intake has been observed to lower acetic acid formation, major precursor to fat synthesis in milk production (Kassem 2002). There are, however, big disparities among global literature with regard to the effect of BSG on compositional changes of milk obtained from cows fed on BSG. Considerable proportions of responding households (overall=42.05%) in this study believed that routine feeding of BSG could result in poor reproductive performance of dairy cattle. Although, detailed study is required to arrive at the root causes, the reason could be attributed to not only routine feeding but also over consumption of BSG since nutritional limitations are mainly manifested at

higher daily BSG consumptions. On the other hand, poor performances in productive, reproductive and health condition of dairy cattle in the study areas could be linked to over consumption of badly stored BSG that have been exposed to fungal and yeast growth of pathogenic importance. Moulds and yeast have been reported to inflict heavy loss in production and health performances of farm animals (Boateng *et al*., 2015; Adams *et al*., 1993). In line with this, a study by Dawit *et al*. (2016) around Addis Ababa and its surrounding cities revealed higher concentration of mold (aflatoxins) both in the feed and milk samples. The root cause for cattle blindness mentioned by farmers at Debre Birhan could not be sufficiently substantiated by scientific literature, even though the reason could still be speculated to mycotic effects arising from over consumptions of spoiled BSG.

Brewery spent grain preservation practices in the study areas

Table 4 shows the preservation practices of BSG as reported by the sample respondents in the study areas. In general, about 95% of the responding households across the study areas conserve wet spent grains using their own local preservation techniques. Study areas were also observed to vary ($P<0.05$) in the type of preservation techniques they practiced to store the grain. About 74.36% of the overall sample respondents practice soaking fresh BSG in salted cold or boiled water. Sun drying was the second preservation technique preferred by farmers (16.92%) across the study areas. The least practiced preservation technique was ensiling. Among the study areas, soaking was most commonly practiced by farmers at Debre Birhan followed by Sebeta. Sun drying was the most preferred preservation technique practiced by dairy farmers at Bedele followed by Sebeta. Only few farmers at Sebeta and Bedele reported to practice ensiling mainly when they get surplus supply of BSG. The most commonly used storage facilities across the survey areas include plastic sheets, plastic lined fertilizer bags, plastic barrels of different capacities and open concrete made pits. Observed variability in the types of facilities used for storing BSG was highly significant ($P<0.05$). The majority of the farmers (49.74%) use plastic barrels while small proportions of farmers preferred to use plastic sheet for solar drying (16.92%), open concrete pits (16.92%) and plastic lined fertilizer bags (16.41%). Except when ensiling and drying, the storage facilities were used for temporary aerobic preservation of the BSG. Plastic barrel was the most preferred type of storage equipment used by farmers across all the study areas. For the farmers at Bedele, all the three storage facilities were found to be equally important.

Table 4. Major preservation practices of BWG in the study areas (% of respondents)

Variable		Sebeta n=66	Bedele n=59	Debre Birhan n=70	P-value
BSG preservation	Soaking	74.24	59.32	87.14	0.000
	Sun drying	13.64	30.51	8.57	
	Ensiling	4.55	6.78	-	
	NA	7.58	3.39	4.29	
Storage facilities	Plastic sheet	13.64	30.51	8.57	0.000
	Plastic bags	4.55	32.20	14.29	
	Plastic barrel	56.06	30.51	60.00	
	Concrete made silo	25.76	6.78	17.14	

As shown in Figure 1, majority (83.08%) of the sample households reported to receive information related to BSG preservation techniques from neighboring farmers/family members, while about 11.79% reported to obtain trainings/information from local agricultural extension agents. Differences among the study areas were very high ($P<0.05$) with the largest proportion of farmers in the study areas accessing the training/information related to the existing preservation technique from the family members and/or neighboring farmers through informal communications.

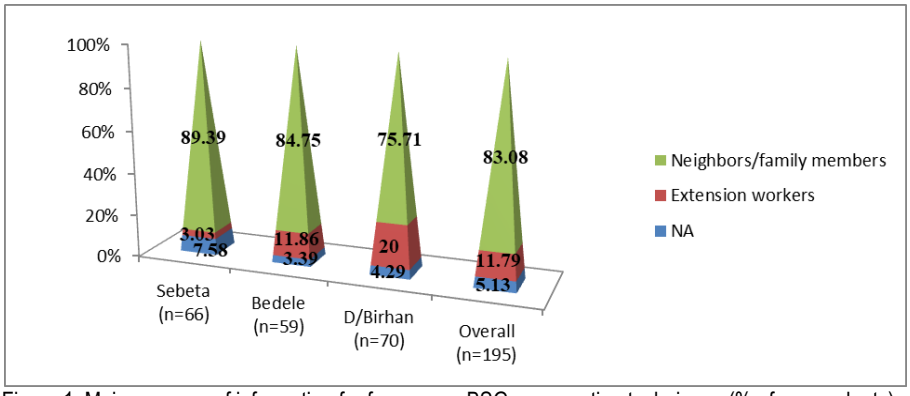

Figure 1. Major sources of information for farmers on BSG preservation techniques (% of respondents)

The feed byproducts (both spent grain and yeast) from the beer industry in the study areas and elsewhere in Ethiopia are supplied to dairy producers in fresh and wet forms. In other words, currently there is no any brewery and/or feed processing plant which supplies processed byproduct feeds to the farmers in Ethiopia. As a result farmers in the current study were heavily dependent on aerobic preservations for longer storage of BSG. These include soaking the BSG in brine solution (boiled and/or cold salted water) using such storage facilities as plastic barrel or concrete pits. Plastic bags of different sizes and fertilizer bags lined with plastics from inside have also been used for storing BSG. Soaking of BSG in salted water was found in this study as a major conservation method of BSG. However, the amount of water and salt used for soaking is not consistent and greatly vary among districts. A rough estimate of 3% salt of the weight of

BSG on a DM basis was used to conserve BSG in the study areas. This appears to be higher than the 5-10% salt on a fresh weight basis or 1.3-2.5% salt on a dry matter basis assuming 25% DM for BSG used to effectively conserve BSG (IPRO's, 2011). Setting the appropriate level of salt used to conserve BSG however, remains to be an area requiring investigation. Osmosis aided by anti-septic nature of brine solution makes the storage condition unfavorable to fungal, yeast and bacteria growth of pathogenic importance during the salting preservation process. Unlike current observations in which farmers have reported to preserve BSG in a brine solution for about 15 days, Philippino dairy farmers were managed to extend shelf life of BSG soaked in salted water only for about 4 days after delivery (Mitra 2001). Drying was the second largest preservation technique used by sample households in the survey areas. Aside from improving its shelf life and lowering the storage volume, drying the BSG could enable users to further explore its incorporation in the rations of other animals. According to personal observations, drying BSG by farmers typically involves exposing the BSG to sun heat for 48-72 hours, depending on the intensity of the solar energy in the surrounding areas. Previous findings in this regard recommended reducing the moisture content of BSG to 10% or less (Crawshaw, 2004; Santos *et al*. 2003). Being in a tropical environment and rich in solar energy, however, sun drying was not the preferred type of BSG preservation techniques by most of the interviewed farmers across the study areas. Besides being weather-dependent, sun drying requires considerable labor which smallholder dairy producers cannot afford or would not want to invest in. Moreover, the farmers claimed that the method is slow, unhygienic and requires large ground surface area. Sun drying is difficult during the rainy season and the method above all is not adequate for commercial production of dried brewers' grain. Future research and/or development work therefore has to come up with less expensive and efficient types of solar dryers. Though less adopted, ensilage could generate a more stable product than the current wet but aerobic storage methods employed in farms (Geron *et al*., 2008). According the sample households, the reason why this method was less commonly adopted in the study areas was attributed to low availability and irregularities in the supply of BSG. Some farmers also claimed the absence of technical trainings related to this type of preservation and storage technique.

BSG supply and marketing

The supply and marketing of BSG in the survey areas is shown in Table 5. There is high variation in the frequency of BSG distribution/supply to beneficiary households across the study areas ($P<0.05$). It was noted that majority of the sample respondents (62.05%) were receiving BSG in every two weeks interval (ranges from one week to four weeks). On a district basis, sample respondents at Sebeta (77.27%) and Debre Birhan (61.43%) have had better access to BSG compared to the dairy farmers at Bedele. Similarly purchasing cost (mean ± SE)

for a quintal of brewers' grain on DM basis across the study areas was 82.50 ± 0.94 Eth. birr (ranging from 35.38 birr/quintal at Bedele to 135.81 birr/quintal at Sebeta). The price showed high variability (P<0.05) among the Study areas.

Table 5. Price per quintal and frequency of BSG distribution to beneficiary households

Variable		Sebeta n=66	Bedele n=59	Debre Birhan n=70	P-value
Frequency of distribution	Every week	6.06	11.86	28.57	0.000
	Every 2 week	77.27	45.76	61.43	
	Every 3 week	12.12	33.90	5.71	
	Every 4 week	4.55	8.47	4.29	
Price per quintal of BSG on DM basis (mean ± SE)		135.81±1.78	35.38±0.59	76.30±0.62	0.021

Currently, the beer industry is at a take off point in Ethiopia. There are about twelve breweries some working at their full while others are operating at their partial production capacity. There are also some breweries being expanded and expected to be completed in the next few years. In the past, piles of fresh brewers` grains left on the ground outside the brewery after spoilage were used to be the sources of environmental nuisance. Since the last few years, however, the demand has risen and presently surpassed the supply in almost all areas where breweries are located in Ethiopia. Associated to the high demand, it is very common to see farmers waiting for their turn for as long as a week to one month to purchase BSG. The problems are attributed to both internal and external factors including: only one brewery (except in Debre Birhan town where we can find two breweries presently) serve almost all the farmers in the study areas; factories working efficiency often goes far below designated potentials due to input supply and service utility problems (water and electric supply); availability of sufficient green feeds used for cut and carry during main rain season and marketing problems particularly during the rainy season when beer consumptions usually reduces. In Debre Birhan town itself, 77% of the responding households were receiving BSG in every two weeks interval. The presence of illegal retailers and middlemen in the spent grain feed value chain extremely exacerbated the situation. Usually, factory gate selling prices are very low and reportedly remained stable over the past few years. In line with this finding, Mesfin *et al.* (2014) reported that the factory gate price (on dry matter basis) of spent grain from Meta Abo Brewery Share Company has remained the same (5.6 Birr/quintal) for the year 2004/05 to 2006/07 G.C and showed a slight increase (6.4 Birr/quintal) in 2008/09 and 2009/10 G.C. The author attributed the reason to the limited utilization of BSG only around production areas associated to its bulky nature, high transportation cost and limited shelf life. Unlike beer factories in Debre Birhan and Bedele, recorded factory gate selling price and retailers' whole sale price for BSG at Sebeta was very high. This can speculated to

the existing high demand for BSG associated with better profitability of dairying business in the area. On the other hand, the availability of alternative non-conventional feed supplements like brewery waste (Atella from local brewing of Tela or Areke); cereal and pulse screenings, rice bran etc at Bedele and Debre Birhan with cheaper price might have also contributed to lower retailing price of BSG in the respective areas. According to the sample respondents in the study areas, the gap between factory gate and whole sale retailers price (be it in a truck or quintal) has kept on widening owning to the rising cost of transportations and sharp increase in the purchase price of other agro-industrial supplements. Demand for BSG from the dairy producers side drops only when green feeds are abundantly available and sometimes when there is a drop in the cost of other agro-industrial feed byproduct.

Annual feed cost and revenues

Annual feed cost and household revenue generated from dairy production in the study areas is presented in Table 6. Feed cost represents the main component of operating cost in dairy farming in the current study areas. On average, sample respondents in the study areas spent 29952.63±107.34 Birr per annum, ranging from 40453.71 Birr (Sebeta) to 24515.57 Birr (Bedele) for buying roughage and concentrate feeds ($P<0.05$). Dairy farmers at Sebeta incurred close to 39% more expense on feed compared to those farmers at Bedele and Debre Birhan. Similarly, estimated annual revenue generated per household across the study areas showed great variations ($P<0.05$) and observed to have followed same trend as that of feed cost. The overall estimated annual average revenue generated per household was 82223.68±324.36 Birr, ranging from 66120.33 Birr at Debre Birhan to 104629.91 Birr at Sebeta. Dairy farmers at Sebeta earned an estimated 28365.16 and 38509.58 Birr more revenue than their counterparts at Bedele and Debre Birhan per year. Percentage share of estimated annual feed cost expressed as a function of total estimated annual revenue per household across the survey areas was on average 39.31±1.01% (range: 34.80% at Bedele to 43.55% at Sebeta). The share of total feed cost compared to the total revenue obtained per household was significantly higher ($P<0.05$) at Sebeta as compared the other areas.

The estimated average total annual feed cost (29952.63 Birr) recorded in this study was higher than the figure (22971.12 Birr) reported for small sized urban dairy farms but was lower than the figure (39413.28 Birr) reported for large sized urban dairy farms in Jima town (Belay and Janssens, 2016). Dairy farms in the present study areas heavily rely on the use of purchased conserved feeds (hay and crop residues) and agro-industrial byproducts purchased once or twice a year. This is in agreement with Staal and Shapiro (1996) who reported that urban and peri-urban dairy producers depend primarily on purchased feeds than on-farm produced feeds. Responding households claimed that feed cost is the major

expenditure of the total cost of their dairy operation. Overall average feed cost expressed as a function of the total revenue obtained from the present study was 39.31% (ranging between 35% at Beadle to 44% at Sebeta). This fully aligns with previous notion given by Belachew *et al*. (1994) which attested that the proportion of feed cost to total production cost of a dairy farm is higher than other cost components. High income from milk sales and large crossbred herd size may seem to have encouraged dairy producers at Sebeta to earn more revenue over the large investment they made on feed. In general, dairy farms in Debre Birhan and Bedele seem to have had limited resources to optimize feeding compared to the farms at Sebeta that according to Yosef *et al*. (2003) they did not have the luxury of being able to select the basal and/or concentrate diet but rather used whatever available at no or low cost.

Table 6. Estimated annual feed cost and total revenue generated from dairying per household in the study areas during 2008 E.C(Mean ± SE).

Variables	Districts			P-value
	Sebeta n=66	Bedele n=59	Debre Birhan n=70	
Total annual feed cost	40453.71± 201.07^{a}	24515.57±146.99^{b}	24634.27±123.83^{b}	0.025
Total annual revenue*	104629.91±698.93^{a}	76264.75±485.68^{b}	66120.33±335.75^{bc}	0.000
Percentage share of feed cost expressed as a function of the total revenue	43.55 ±1.95^{a}	34.80 ±1.53^{c}	39.11 ±1.55^{b}	0.002

**includes revenues from the sale of butter, cheese, male dairy calves and other cattle culled from production*

Conclusion

It can be concluded from this study that availability, storage and proper feeding of BSG are major problems the farmers in the study areas were seen to be confronting with. Other problems associated with the use of BSG include health related issues, rapid deterioration and transportation costs. If research interventions related to these challenges are suggested it would help in ensuring a more effective use of this by-product and thus help in reducing the production cost and the cost of dairy products and byproducts to consumers in the urban dairy production settings.

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