G.J.A.S.R

GLOBAL JOURNAL OF ANIMAL SCIENTIFIC RESEARCH

Journal homepage: www.gjasr.com

Print ISSN:2345-4377 *Online ISSN:2345-4385*

Review Article

Review on utilization of Brewery by-products as protein-rich feed source for efficient livestock production

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ABSTRACT

Utilization of locally available industrial by-products in livestock feed is very important methods to enhance livestock productivity and minimize feed cost. The objective of this paper is to review the utilization of brewery by-product as a protein source feed for efficient animal production. Brewer's by-products like brewers spent grain and brewers spent yeast are the major by-products produced by the brewing factory. They are produced all year round with the same volume and with simple cost and used as animal feed. These materials provide animals with high-quality protein (about 35% CP) and can improve feed quality and animal production. It can replace high-quality protein source feed such as soybean. The optimum contents of fibre and protein in brewer's by-product together with the low cost of this by-product make it a substrate of great interest for use as livestock feed. Quality apprehension is the major things need attention when those by-products are given for animals since brewer's grains are susceptible to bacterial and fungal contamination (mycotoxins) and care should be taken to feed only unspoilt brewers grains.

Keyword: brewery by-product, feed, livestock 'utilization

INTRODUCTION

Feed is the largest single cost for livestock production constitutes 60-70% of the total cost. There is a need to improve the scientific knowledge for utilizing low cost locally available industrial by-products in livestock feed in order to reduce these feed cost. As feed covers the largest cost of production, any attempt to reduce the feed cost may lead to a significant reduction in the total cost of production (Swain and Barbuddhe, 2008). Farmers and livestock producers should feed their livestock on locally available cheap industrial by-products to minimize the cost. Protein source feeds used in animal diets such as fish meal, meat and bone meal, soybean meal, oil seed cake etc. are becoming expensive in developing countries (Thirumalaisamy *et al.*, 2016). There is scarce protein sourced feed ingredients for livestock

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Cite this Article: Miresa, A. & Mulugetam, M. (2020). Review on utilization of Brewery by-products as protein-rich feed source for efficient livestock production. *Global Journal of Animal Scientific Research,* 8(2), 1-13.

Retrieved from http://www.gjasr.com/index.php/GJASR/article/view/39

Article History: Received: 2020-05-28 Accepted: 2020-08-06

feed since the expensive cost of the raw material and increasing competition for those food items with human beings.

Brewery industry yields different by-products all year round, such as brewer's grains and yeast, all of which could be used as an alternative component of supplementary concentrate to reduce production costs. It is cheap, available all year round, and has high nutritional value (Mussatto, 2014). Brewery by-product provides animals with high efficient micro-protein, phosphorus and vitamin B complex and can improve the feed quality and growth performance (Braude, 1942). Brewery spent grain can be available as dried or wet form for livestock feed. They are palatable and voluntarily consumed by livestock when in good state. Brewer's grains are quite rich in protein, which makes them a valuable source of protein (Heuzé V. *et al.*, 2017). Dried brewers' grains can be used instead of soybean meal in dairy cow feed as it provides improvements indigestibility, milk production efficiency, and economic return to the producer without affecting microbial efficiency (Faccenda *et al.*, 2017). Brewery yeast is the other abundant by-product of the brewing industry used as animal feed. Dried brewery yeast has a very fine texture and contains approximately 35% crude protein (Rufino *et al.*, 2013). Therefore this paper aimed to review the utilization of different brewery by-product as protein-rich feed for efficient livestock production.

Overview of Brewery By-Products

Beer is one of the most consumed types of alcoholic beverage across the world. It is made up of water, malt and hops as primary ingredients. Global leading countries in beer production are China, the United States and Brazil (Colen and Swinnen, 2010). In 2018, the global beer production amounted to about 1.94 billion hectoliters(Jan Conway, 2019). During beer production in the brewing industry, there are different residues and by-product are produced. The most common by-product produced during the process of beer production are brewery spent grain, spent hops and excess yeast, which are generated from the main raw materials (Mussatto, 2009). Commonly produced byproduct feeds across all beer factories in Ethiopia are wet brewery spent grain and Brewer's spent yeast. The actual total amount of BSG produced from these breweries in the same fiscal year was 26722.8 tons (Kitaw *et al.*, 2018).

There are currently 12 beer factories operating at different industrial capacities in the year 2016/17. Throughout a year a large amount of brewery by-product is produced in Ethiopia. However, the by-product has not yet been extensively utilized as animal feed. Small amounts and large volume is accumulated at the production sites which causes disposal and public health problems. The actual total amount of BSG produced from these breweries in the same fiscal year was 26722.8 tons/DM basis (Kitaw *et al.*, 2018). 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. BSG in most instances was sold at a very low factory gate price of 0.49 Ethiopian birr/kg (range: 0.15-1.20 Ethiopian birr/kg). 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.

Brewery spent grains

The brewers' spent grain (BSG) is the main solid waste produced in large quantities by the beer industry, resulted after mashing and filtration stage (Fărcaş *et al.*, 2017). Large breweries typically have their spent grain removed by animal feed producers who process the spent grain as a base material for animal feed, rather than having it delivered directly to farms (Clare Kerby and Frank Vriesekoop, 2017). Spent brewers' grains are an abundant brewery by-product that is high in protein (more than 20%) and fibre, which can be used as animal

feed or, in some instances, spent grain can be used in foods for human consumption (Clare Kerby and Frank Vriesekoop, 2017).

Spent brewer's grains are a common brewery by-product that is high in protein (more than20%) and fibre and can be used as supplements for animal feed, replacing other, more expensivefeed materials within diet formulations(Stewart *et al.*, n.d.). With regards to animal feed, brewers' grains may be wet or dry in their final form for animal feed, with the wet grains typically being sold as cake for ruminant feeds, while dry spent grain is used for monogastric feeds (Stewart *et al.*, n.d.). Brewers' spent grain provides the essential nitrogen-containing nutrients animals require in their feed (Fărcaș *et al.*, 2014). Large breweries typically have their spent grain removed by animal feed producers who process the spent grain as a base material for animal feed, rather than having it delivered directly to farms (Clare Kerby and Frank Vriesekoop, 2017). Spent grain offers an economic advantage to the animal feed market because it is a low-cost alternative to costly materials, such as soybean.

Dried Brewers' Grain

Brewers dried grains are the dried extracted residue of barley malt alone or in mixture with other cereal grain or grain products resulting from the manufacture of wort (Swain *et al.*, 2014). Brewer's dried grain is a valuable by-product of the brewery which has the potential to be used as supplementary feed for livestock and poultry (McCarthy *et al.*, 2013). These materials are considered to be good sources of un-degradable protein, energy and water-soluble vitamins (Swain *et al.*, 2014). They have been used in feeding of both ruminant and monogastric animals (monogastric using predominantly the dried forms) (Swain *et al.*, n.d.). Since the BDG is rich in fibre, the addition of fibre degrading enzyme may be useful in improving its feed value (Iyayi and Davies, 2005).

Wet Brewer's Grain

Brewer's wet grains are the extracted residue resulting from the manufacture of wort from barley malt alone or in mixture with other cereal grains or grain products (Clare Kerby and Frank Vriesekoop, 2017). The guaranteed analysis should include the maximum moisture (Westendorf and Wohlt, 2002). More specifically, after the mashing process and formation of wort for beer or malt, the medium is filtered off resulting in a high-moisture residual (Mussatto and Roberto, 2006). The process of using Wet Brewer's Grains (WBG) is not a newly discovered trend, but increases in production, micro-brewery location, and availability have stimulated new interest in this product (Parmenter, 2017). Blending WBG with other feeds such as corn silage, hay, or soybean hulls results in a ration with increased dry matter and increases the shelf-life by a small number of days (Thomas *et al.*, 2010). The authors also observed blending of WBG decreased the amount of gut-fill or distention produced through high levels of water intake. Wet brewer's grains, because of their thin, wet, perishable nature, were usually fed on farms located near breweries to minimize the occurrence of spoilage.

Wet brewer's grain is useful as feedstuff than dried brewer's grain for several reasons:

1) High costs of drying favour the production of wet brewer's grains.
2) There is an increased demand for wet brewer's grains, particularly as a dairy feed.
3) The seasonality of beer production results in a situation in winter months where nearly all spent grains must be marketed as wet brewer's grains to meet demand, making the maintenance of drying facilities less economical.
4) Finally, the ability to transport and feed wet brewers grains in a timely manner is much improved from the past.

Brewers spent yeast

Brewer's yeast is a by-product from the breweries, which use the micro-organism and fungal yeast *Saccharomyces cerevisiae* (Heuzé V. *et al.*, 2018). It is the second major by-product of the brewing industry (Stewart *et al.*, n.d.), with environmental impact due to the disposal of a large quantity of biomass (1 hl of beer generates 2.0–4.0 kg of BSY) (Hellborg and Piškur, 2009). BSY is an excellent source of high-quality protein, comparable in value with soya bean protein. Brewer's yeast is mainly a source of protein, vitamins and minerals(Yamada and Sgarbieri, 2005). Yeast inactivation is necessary to prevent further fermentation after consumption by animals that may cause severe gastrointestinal problems in pigs. Inactivated brewer's yeast is a highly valuable source of protein, phosphorous and B vitamins (Crawshaw, 2009). Brewer's yeast may be fed fresh (liquid form) or dried (brewers dried yeast), which is costly and thus only used in speciality feeds (Crawshaw, 2003).

Similarly to spent grain, some breweries sell their spent yeast as animal feed as a source of protein and water-soluble vitamins (Levic *et al.*, 2010; Stewart *et al.*, n.d.). Various trials have been published which examine the use of brewers' spent yeast as a feed supplement in diets for ruminants, horses, poultry, swine, and fish. Majority of the spent yeast produced by the factories each year is still subjected to disposal as a landfill by the respective municipal sewerage authorities and/or by the factories themselves as such as it is life or after subjecting it to the utilization process(Clare Kerby and Frank Vriesekoop, 2017).

Nutrient Content of Brewers' By-products

The nutritional contents of brewer's by-products vary according to grain used (barley, wheat, corn, maize, rice, sorghum, millet. etc.), harvest time, malting and mashing conditions, and the quality and type of adjuncts added in the brewing process (Huige, 1995; Santos *et al.*, 2003), (Senthilkumar *et al.*, 2010).The main chemical compositions of spent grains include cellulose, hemicellulose, and lignin(Kao, 2018). Cellulose and hemicellulose account for 50% of all spent grains. Moreover, spent grains are rich in protein, essential amino acids, minerals, and single sugars (glucose, xylose, and arabinose) (Mussatto and Roberto, 2006).

The average CP content of brewers' grains ranges from 21% to 29% CP/DM (Heuzé V. *et al.*, 2017; Westendorf *et al.*, 2014) with the variation existing in all sources of grains. The protein value can be affected by the heat applied during the brewing process, which can be beneficial to ruminants but tend to be detrimental for monogastric animals (Heuzé V. *et al.*, 2017). Different authors reported as brewers' grains containing as 23% to 33% CP/DM (Table 1). This increase in CP content could be due to improved varieties of barley, corn, and rice being used as foundation grains, different brewing methods, or changes in the recovery or pooling of wastes generated during the brewing process (Westendorf and Wohlt, 2002). Its CP value may be greater in ruminant diets because of its value as a bypass source of protein. The DM contents of DBG accounts about 91-92% (Heuzé V. *et al.*, 2017; Waller, 2010). The values for all nutrients in brewery's grain are almost similar except CP. According to Altizio *et al.*, (2000), this difference in CP values is probably due to a more incomplete carbohydrate extraction during malting and mashing phases. This would dilute the protein in the final product. Also, spent microorganisms may be added to the brewers' grains at larger breweries. This would be a source of protein not added back in at micro-breweries. Brewer's grains are also relatively rich in fibre (ADF 17-26% DM), which makes them suitable for ruminants fed concentrate-rich diets, but less so for pigs and poultry (Heuzé V. *et al.*, 2018). Wet brewer's grains are a bulky feed with low energy content, which can limit their use (Heuzé V. *et al.*, 2017).

Brewer's yeast is mainly a source of protein as it contains about 50% DM of crude protein (40-56% DM). Depending on the process, brewer's yeast can contain fibre, starch and lipids, in amounts ranging from negligible to small but significant (Heuzé V. *et al.*, 2018). Brewer's

yeast is an excellent source of B-complex vitamins, nucleic acids, vitamins and minerals, including a biologically active form of chromium known as Glucose Tolerance Factor(Ferreira *et al.*, 2010). Nutrient content of brewers by-products analyzed by different authors are summarized in table 1 below

Table 1 –Average chemical composition of brewers' by-product by different authors

By-products	Chemical composition (% on DM)								
	DM	CP	CF	NDF	ADF	ADL	EE	Ash	ME (MJ/kg DM)
DBG	91.93	25.40	16.88	55.45	24.70	6.90	5.54	5.87	6.32
WBG	20.30	25.65	10.65	49.60	21.90	5.70	6.75	4.90	10.00
DBY	93.30	47.9	2.45	8.80	3.25	0.80	1.65	7.10	13.40

Sources: (Waller, 2010),(Heuzé V. *et al.*, 2017),(Senthilkumar *et al.*, 2010),(Gebremedhn *et al.*, 2019), (Swain *et al.*, 2012), DBG= Dried Brewery Grain, WBG = Wet Brewery Grain, DBY = Dried Brewery Yeast.

Quality and Spoilage Concern of Wet Brewers Grain

The brewing industry currently produces significantly wet than dry grains. Due to the high moisture and fermentable sugar content, WBG is a very unstable material and is liable to deteriorate rapidly due to microbial activity (Mussatto and Roberto, 2006). Wet Brewer's spent grain can rapidly spoil if it is not used on time. This results in a less palatable product that may cause health concerns. When feeding wet brewers grains it is important to use them quickly; costs will rise rapidly if spoilage occurs. Small dairies or feedlots may find it difficult to keep feeding rates ahead of spoilage; this will be especially difficult during hot spells. The moisture content will change as moisture drains away and palatability will also decrease (Westendorf and Wohlt, 2002). The high-moisture nature of wet brewers grains makes them a less useful feed for swine or horses, although Cunha (1991) reported that they have been fed to horses provided spoilage concerns are managed. WBG was often spoiled at the time of feeding and sometimes were the exclusive feedstuff in the diet. These wet brewers grains were usually used as feed near breweries. Improvements in transport and management have improved the usefulness of wet brewer's grains.

The varying physical composition of WBG becomes important to consider when assessing the feasibility of incorporation into livestock feed. Studies conducted have conveyed general considerations concerning the physical properties such as spoilage rates, transportation, and efficient utilization of WBG as a supplemental feedstuff. The relationship between spoilage rate and utilization rate is a primary issue with WBG, due to loss in economic returns if utilization rates fall below that of the rate of spoilage. The high moisture content in WBG dramatically decreases the duration of time before spoilage (Mussatto *et al.*, 2006). High-moisture levels also increase susceptibility to weather conditions such as spoilage from heat and freezing from low temperatures (Thomas *et al.*, 2010)

Another concern associated with the feeding of brewers grains is the possibility of mycotoxin contamination, which can have profound effects on animal health. According to Ames (Ames, 1989), the primary factors determining whether mycotoxins will be found on the spent grains is the amount present in the malted barley or corn adjunct, as well as the water solubility and heat stability of the toxin. If the toxin is more water-soluble, much of the toxin will be transferred to the beer, and less will remain on the spent grains. The boiling process associated with brewing will destroy toxins that do not heat stable.

Producers must have proper storage facilities and feeding practices to ensure that grains are fed rapidly, minimizing spoilage. During hot weather, untreated grains can deteriorate within several days. Several methods have been proposed to prolong brewer's wet spent grain (WBSG) storage time as a result of its high moisture content. Drying has been viewed as a possible preservation method, with the benefit of decreased product volume, thus decreasing

transportation and storage costs (Kamboh, 2017). Drying of WBG is commonly accomplished with rotary-drum dryers, but is not cost-effective and is energy-intensive, along with the possibility of air-pollution through burning/over-cooking grains (Mussatto and Roberto, 2006). Multiple alternative methods of drying have been studied such as oven-drying, freeze-drying, mechanical pressing, and superheated steam; but all have their own set of benefits and drawbacks. According to Bartolome (Bartolomé *et al.*, 2003), preservation by oven drying or freeze-drying reduces the volume of the product and does not alter its composition, while freezing is inappropriate as it affects the composition of some sugars such as arabinose.

Ensiling anaerobically is an alternative for the storage and utilization of WBSG without spoilage the other storage and preservation methods of these by-products. It ensures anaerobic fermentation for lactic acid, reduction in pH and, consequently, preservation of the quality of ensiled material Souza *et al.*, 2012). Wet brewery grain can be ensiled in combination with dry feed resources or alone depending on the interest of cattle producers (Makkar, 2011). Keeping wet brewers grains sealed with plastic may help to prevent aerobic spoilage. An uncovered pile of wet brewers' grains will probably have a storage life of less than 5 to 7 days. There should be enough amounts of livestock in the farm those consume all delivered WBG before another load arrives.

Use of Brewers' By-products in Livestock Feed

Brewers' by-products provides the essential nitrogen-containing nutrients animals require in their feed (Mussatto, 2014). It provides protein, energy, and fibre in livestock diets, but product variability can influence their utilization and necessitate a testing program to determine nutrient content (Stewart *et al.*, n.d.; Westendorf and Wohlt, 2002). The high contents of fibre and protein in BSG together with the low cost of this by-product make it a substrate of great interest for use as animal feed. When combined with inexpensive nitrogen sources such as urea, for example, BSG is able to provide all the essential amino acids needed for animal nutrition (Huige, 1995). They have been used primarily as a protein source, but have also been used to replace concentrate feeds in rations for dairy and beef cattle, sheep, swine, and horses. Morrison (1956) recommended dried brewers grains as a concentrate replacement for livestock.

Use of Brewers' Grains in Monogastric Diets

Pigs: Brewer's grains is more suitable for pigs with low energy requirement like gestating sow and boars than growing and lactating sow since it contains high fibre and low-quality protein (Blair, 2017; Crawshaw, 2009). In tropical and subtropical countries, dried brewers grains are a valuable alternative ingredient for growing and finishing pigs (Heuzé V. *et al.*, 2017). They can be part of the basal diet in combination with palm kernel meal or cassava meal (Amaefule *et al.*, 2009; Fatufe *et al.*, 2007). Pettigrew *et al.*, (1991)listed several advantages for using fibrous by-products, such as dried brewers grains, in swine diets. They may provide a source of energy to the pig as a result of fermentation in the cecum and large intestine. They can act as diluents or bulking agents in sow diets, and some by-product feeds can provide a protein source in the diet.

Brewer's yeast is a valuable component of pig diets (Heuzé V. *et al.*, 2018). An excellent source of protein for swine, brewer's yeast contains most of the essential amino acids in adequate quantities. However, it is somewhat deficient in methionine and cysteine (Huige, 2006). Liquid pig diets allow the use of fresh brewer's yeast (Heuzé V. *et al.*, 2018). Inactivated yeast is generally recommended for animal feeding since live yeast may grow in the intestinal tract and compete for nutrients (Blair, 2017). It is recommended that brewer's yeast represents 2-5% of the diet, and it can replace up to 80% of the protein (Blair, 2017).

Poultry: Brewer's grains can be fed to poultry but the high fibre content and reduced protein digestibility tend to decrease their nutritional value and metabolizable energy compared to the original grain. According to Iyayi and Davies (2005), brewers' grains are not well suited to the feeding of poultry with high energy requirements such as young broiler. They are better tolerated by older broilers and laying hens (Heuzé V. *et al.*, 2017). According to Gebremedin *et al.*, (2019) there is no significant difference in body weight change of poultry fed on BSG. However, there is a significant difference in egg weight change. He also concluded that BSG is complementary with soya bean meal by essential amino acid content such as lysine and methionine. Brewers' grains are usually fed dried to poultry, as they are easier to store and more stable than the wet form(Onifade and Babatunde, 1998). In broilers from 12 to 33 days, 10 to 20% inclusion of dried brewers' grains supported acceptable growth and feed utilization and appeared to favour the development of a well-functioning gizzard (Denstadli *et al.*, 2010) Brewers; grain is a good source of protein for laying hens like soybean meal if its inclusion rate is equal with the required amounts. BDG could be incorporated up to a level of 20% in the diet of Vanaraja chicks by partial replacement of maize, soya bean meal and deoiled rice bran for better carcass traits and higher profit margin without affecting growth performance (Swain *et al.*, 2012). However, levels higher than 30% depressed performance and a 90% inclusion rate caused very large bodyweight losses and inhibition of laying (Lopez-Guisa and Satter, 1991). Brewer's yeast is usually included at levels of 2-5% in poultry diets, but if its price is low, it can replace up to 80% of the animal protein that additional calcium is added. Dried brewer's yeast replaced fish meal at up to 9.3% in broiler diets with no differences in growth and feed efficiency (Heuzé V. *et al.*, 2018)

Fish

Brewer's grains can be used in fish feeding but they cannot be included in large amounts in the diet due to their high fibre content: recommended levels range from 10 to 15%. They should be offered to fish species that are not finicky feeders (Hertrampf and Piedad-Pascual, 2012). Another issue with brewer's grains is their low pelletizing ability and the poor durability of the pellet when brewers grains are included. Brewer's yeast has potential in fish diets as a replacer of fish meal (Oliva-Teles and Gonçalves, 2001). It has subsequently been introduced in commercial diets for several fish species, including salmonids (Ferreira *et al.*, 2010). As the cell walls in brewer's yeast may be of low digestibility in fish, they can be removed or disrupted to improve brewer's yeast feed value in fish (Rumsey *et al.*, 1991)

Use of Brewers' Grains in Ruminant Diets

Cattle

Brewers' spent grains are a good ingredient for ruminants, quite typical in beer-producing areas. When BSG was incorporated into the diet of cows, milk yield, milk total solid content and milk fat yield were increased (Belibasakis and Tsirgogianni, 1996). Dried brewers grains were found to successfully replace part of the forage in the diet (Younker *et al.*, 1998). However, replacing soybean meal with wet or dried brewers' grains in lactating dairy cattle was detrimental to performance (Hoffman and Armentano, 1988). According to Faccenda *et al.,* (2017), lactating cows fed on DBG instead of soya bean meal shows that decreased body weight and feed intake with the increase in the level of DBG because the diets with DBG had lower energy density Organic matter, CP, and NFC intake decreased as a result of a reduction in DM intake.

Fayisa *et al.,*(2015)concluded that supplementing low-quality basal diets with breweries dried grain and maize bran could be alternative sources of dairy feed supplements to provide adequate and required amount of protein and ME for dairy animals. Thus, it can be concluded that the different proportion of breweries dried grain and maize bran mixtures have a

potential to replace the concentrate mix without significant reduction in milk yield of lactating crossbred cows fed a basal diet of natural pasture hay and able to support the observed milk yield (Feyisa *et al.*, 2015).In growing cattle inclusion rates as high as 40% have been considered acceptable (Ewing, 1997). Up to 24%, DM brewers' grains in male growing cattle did not alter rumen fermentation (pH, efficiency of microbial protein synthesis and NH_3) and OM digestibility (Geron *et al.*, 2008). Using a pH stabiliser in cattle fed 1-2 kg of ensiled brewers grains resulted in similar performance and carcass quality as in the control group (Morel I., 1997). Brewers' grains were found to be a satisfactory replacement for corn gluten meal in rations for growing heifers (Lopez-Guisa and Satter, 1991).

Brewer's yeast can be used as a feedstuff in ruminant diets. Large quantities of yeast are discharged as slurry from breweries or from the alcoholic fermentation of sugarcane and might be as useful as the vegetable meals (especially cottonseed meal) for ruminant diets (Hennessy and Williamson, 1993). In dairy cattle, the inclusion of dried brewer's yeast as a replacement for soybean meal at up to 20% of the total dietary DM did not affect intake, digestibility or performance (Nursoy and Baytok, 2003). Some positive effects were observed, such as a low rumen NH_3-N level and a high acetic acid concentration Nursoy and Baytok, 2003).

Sheep and goats

Feeding dehydrated brewers' grain to lambs at up to 40% of the diet DM resulted in good growth performance, feed conversion ratio, and in fatter carcasses than with less dried brewers' grains (Bovolenta *et al.*, 1998). In tropical and subtropical areas, high inclusion rates have been used in growing sheep without depressing performance or digestibility (Aguilera-Soto *et al.*, 2007; Lúcio Salomon Cabral Filho *et al.*, 2007). According to Olorunnisomo *et al.*, (2006) the inclusion of 64% dried sorghum brewers grains resulted in higher growth performance than a diet based on maize bran, but adding urea to the latter diet gave a similar performance. Wet brewers' grains replaced up to 25% of the concentrate in diets for goats at the end of lactation but higher rates depressed diet digestibility(Silva *et al.*, 2010). Wet brewers grains included at 20 to 40% in a total mixed ration resulted in lower nutrient digestibilities, but DM intake was higher at the 20% rate(Choi *et al.*, 2006). In Samoa, a comparative study showed that dried or wet brewers grains were valuable feeds for goats (Aregheore and Ting, 2002). According to Rufino *et al.*, (2013) 100% inactivated dried yeast in lamb diets could even improve the carcass and meat quality by reducing the deposition of subcutaneous and intramuscular fat.

Health and Production Performance of Animal Fed on Brewer's By-Products

According to Kitaw *et al.*,(2018) dairy cattle fed on supplementing BSG was milk compositional change when compared to dairy cattle didn't feed on BSG supplement. Barley, malt and several by-products associated with the production of beer are susceptible to fungal contamination and the consequent production of mycotoxins. Fungal growth can lead to the loss of nutritive substances and may also result in contamination by mycotoxins, which may be harmful to animals (Gonzalez Pereyra *et al.*, 2011). Overconsumption of badly stored BSG that have been exposed to fungal and yeast growth can affect the health and production performance of livestock. Moulds and yeast have been reported to inflict heavy loss in production and health performances of farm animals (Boateng *et al.*, n.d.). Boateng *et al.*, (n.d.) indicated that the addition of the product to the diet of pigs normally increased the incidence of diarrhoea, especially in the piglets.

CONCLUSION

Locally available by-products obtained from the brewery factory are the major ways to reduce the cost incurred for livestock production. Brewer's by-products produced by different brewery factory across the beer-producing country can produce a huge amount of by-products used as livestock feed. Brewer's by-products such as brewer's grain and brewer's yeast are the major livestock feed which can replace expensive protein sources feedlot. It provides protein, energy, and fibre in livestock diets. High protein value of brewer's by-product can meet animal protein requirement and it is the major source of fibre for a ruminant. Because of the cost of brewer's by-product is so cheap and even distributed for the farmers and livestock producers free of cost it had a bilateral advantages (i,e economically it is feasible and can replace expensive protein source feed like soybean meal). However, there should be precaution when wet brewer's grain fed to animals because of the negative effects of these materials. The major problems associated with feeding wet brewers grain is the development of mould growth which can harm the health of animals. Generally, brewer's by-product is the alternative protein source for animals and producers and farmers must utilize the resources efficiently.

ABBREVIATIONS

ADF: Acid detergent fibre, ADL: Acid detergent lignin, CF: Crude fibre, CP: Crude protein, DBG: Dried Brewery Grain, DM: Dry matter, DBY: Dried Brewery Yeast, EE: Ether extract, NDF: Neutral detergent fibre, NFC: Non-fiber carbohydrate levels, WBG: Wet Brewery Grain.

ACKNOWLEDGEMENTS

Not applicable.

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