Potential use of liquid spent brewer’s yeast for animal feed in Ethiopia

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Report 1392

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This report is the outcome of a Seed Money Project (SMP21.17) funded by the Topsector Agri&Food Consortium for Knowledge and Innovation (TKI A&F).

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Samenvatting NL
Biergist is een waardevol veevoeringredient, maar moeilijk toe te passen in krachtvoer vanwegen het hoge vochtgehalte. In dit project is de technologie ontwikkeld om biergist te gebruiken in krachtvoer productie zonder droging vooraf.

Summary UK
Spent brewer's yeast is a highly valuable animal feed ingredient, but difficult to apply due to its high moisture content. In this project the technology has been developed to directly use liquid spent brewer's yeast in concentrate production without having to dry it first.

This report can be downloaded for free at https://doi.org/10.18174/579009 or at www.wur.nl/livestock-research (under Wageningen Livestock Research publications).

Public Wageningen Livestock Research Report 1392

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Foreword

This report is the outcome of a Seed Money Project (SMP21.17) funded by the Topsector Agri&Food Consortium for Knowledge and Innovation (TKI A&F). Seed Money Project support SME (Small and Medium Enterprises in exploring options for collaboration in international activities. SMPs are initiated by consortia of companies active in innovative new developments in international collaboration. SMPs serve as a first step for a new initiative, upon which follow up activities can be formulated.

In this SMP, a consortium consisting of Koudijs Feed Company, Heineken Breweries, Swinkels Family Breweries, Ottevanger Milling Engineers, the Ethiopian Feed Manufacturers Association, the Ethiopian Commercial Dairy Producers Association, Aeres University of Applied Sciences. The project was implemented and coordinated by Wageningen Livestock Research, with the help of an intern of Aeres University of Applied Sciences and a private consultant from Ethiopia. Hiring a local private consultant was necessary due to the then applicable Covid measures, which did not allow for travel from the Netherlands to Ethiopia.

The project leads to interesting new insights in the use of liquid beer yeast in concentrate feeds, opening the way for a more sustainable use of beer yeast in the animal feed industry.

Adriaan Vernooij
Project leader SMP 21.17.

Summary

This report analyses the current situation of spent brewer's yeast in Ethiopia, i) the production potentials of breweries, ii) the characteristics and particularities of the product, iii) the state of use of spent brewer's yeast in animals and potential uses, iv) environmental contamination, and v) logistics and storage. This information has then been used to propose future actions to optimize the efficiency of the utilization of spent brewer's yeast in Ethiopia.

The breweries in Ethiopia have a potential capacity of 10.660.000 hl of beer per year, producing an estimated 21.161, Kton of spent brewer's yeast offering an excellent opportunity for the feed industry as an accessible protein source, potentially replacing approximately 2.116 Kton/year of soybean meal. Spent brewer's yeast (SBY) is a moist product with a low dry matter content (8-10 % with 50 % crude protein, soybean meal has a high dry matter content (85-90 % with 40-50 % crude protein).

Despite its high protein value, there is no current specific use of spent brewer's yeast in Ethiopia as a commercial animal feed ingredient. Most of the breweries either mix it with the spent brewer's grain, discard it with the wastewater or take it to landfills.

Spent brewer's yeast can be utilized as a potential source of animal feed protein for overcoming Ethiopian feed protein demand. In order to do that in an economical way, the inclusion of the animal feed formulation in a fresh liquid form appears to be the best option. With this objective, the feed plant needs to have a storage capacity according to the amount of spent brewer's yeast used on a weekly basis, and the technology necessary to homogenize the product previous incorporation to the feed mixer.

Based on these assumptions, the feed plant must be located within a radius of no more than 60 km from the supplying brewery to avoid high transport costs. Comparing this with soybean meal's current prices, spent brewer's yeast could be an interesting product to be considered as an alternative animal feed ingredient.

According to the information gathered, we conclude that spent brewer's yeast is an interesting ingredient to be considered by the feed industry in Ethiopia in the future. However, considerations related to distance to the brewery, as well as potential investments for handling and storing the product need to be further analysed, based on accurate transport and material costs and the costs of competing protein ingredients.

Similar studies will have to determine the feasibility of this approach in the context of other countries.

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List of abbreviations

CP	Crude protein
DM	Dry Matter
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
OPNV	Overleggroep Producenten Natte Veevoeders (Consultative Group of Producers of Wet Cattle Feed)
SBG	Spent brewer’s grain
SBY	Spent brewer’s yeast
SMP	Seed Money Project
SNNPR	Southern Nations and Nationalities Peoples Region

1 General Background

Ethiopia is the country with the largest livestock population in Africa and with a poultry sector that has grown strongly over the past decade. Therefore, the demand for livestock commodities is rapidly increasing. The prices of feed ingredients and compound feeds have increased significantly and technical solutions in using alternative feed ingredients are needed to cope with these changes.

In recent years, as the economy has begun to grow, Ethiopia has experienced one of the fastest increases in beer consumption, with consumption growing by as much as 90 percent between 2002 and 2011 (FAO, 2018). Ethiopia's beer consumption per capita is about 4.0 L/year, which it is relatively low when compared with Kenya (11.0 l), Uganda (9.5 l), and South Africa (55 l) and thus still has a big potential to increase.

This increment in beer consumption has produced a rapid expansion of brewery factories. The disposal of spent brewer's yeast (SBY) has become a problem for many breweries. However, due to the nutritional characteristics of this by-product, especially its high-protein content, it could be an alternative ingredient to be considered by the animal feed industry. Although, its particular characteristics also present challenges at a technical level in relation to its use. This report looks at the potential use of SBY as an ingredient in the animal feed industry under the Ethiopian context.

2 Data collection

This report is the outcome of a Seed Money Project carried out in Ethiopia in 2021. Seed Money Projects (SMP) are feasibility studies into potential innovations in the agricultural and livestock sector funded by the Topsector Agri&Food.

In Ethiopia, the SMP Sustainable and circular use of agro processing by-products: the case of spent brewer's yeast in Ethiopia was carried out in 2021. The aim of this project was to to develop technologies that will allow improved use of SBY through adaptations in existing feed milling facilities in Ethiopia. Current milling facilities do not have the option to use brewer's spent grain without it being dried first. The possibility to use it in its liquid form has several advantages. It saves energy for drying, will add moisture to raw materials for feed, which are relatively dry under Ethiopian production circumstances, and will improve efficiency in the use of valuable by-products. Thus strengthening circularity in the Ethiopian animal industry.

The project was implemented by a consortium of seven parties and coordinated by Wageningen Livestock Research. The consortium consisted of the feed company De Heus/Koudijs, beer brewing companies Swinkels Family Brewers and Heineken, milling technology producer Ottevanger, the Ethiopian Animal Feed Industry Association and Aeres University of Applied Sciences.

The data collection was carried out by a student from Aeres University of Applied Sciences. Due to the travel restrictions because of the Covid pandemic, assistance to data gathering in Ethiopia was provided by Dawud Mohammed, private consultant. Further information was obtained from Piet Schutter, the manager of the Alema/Koudijs feed mill in Ethiopia.

A questionnaire was used to figure out detailed capacity and usage of SBY in Ethiopia. This questionnaire is attached in the Annex 1 below. Data was collected between April-July 2021.

Due to privacy and data protection policies, the names and capacity of each brewery are anonymized.

3 Ethiopian feed industry

In the Ethiopian commercial feed sub-sector, feed processing plants are owned by private companies and farmers' unions. These are engaged in production of compound feed using inputs provided by local producers and importers or manufactures of supplements (premixes, feed additives, etc.) and of feed processing machineries/equipment.

Domestic production of feed supplements is currently limited to mineral supplements and effective microbes and delivery of premixes depends on import. Major categories of premixes include premixes for egg production (rearing premix, starter premix and layer premix), broiler premix (broiler starter, broiler grower and finisher) and ruminant premix which contains vitamins, trace elements, minerals and other additives (Bediye S. et al, 2018).

The commercial feed sector in Ethiopia, like any other emerging sector along the path of market led economy, is currently facing a number of challenges such as i) ingredient supply, ii) high prices of feed ingredients, iii) feed safety and quality, iv) uncertainty surrounding demand of compound feed, v) imports of premixes, minerals and vitamins due to difficult access to foreign currency, vi) feed quality and safety analytical service, among others.

Food industry by-products are not yet fully utilized for animal feed production. The increasing number of upcoming sugar industry projects, breweries and agri-food industries could provide opportunities for improving feed supply through utilization of alternative feeds.

3.1 Feed ingredients price trends.

The price of animal feed ingredients surged sharply in Ethiopia in 2021, with concentrate feed price doubling from what it was in November 2020. Soybean cake, that used to be traded for 16.000-18.000 Birr/[1]T at the end of 2020, costs 45.000 Birr/T in July 2021. The wheat bran that used to be sold for 7.000-11.000 Birr/T five months ago, costs 16.000 Birr/T (Table 1) during the study period.

Since the ingredients that are used to produce animal feeds are wastes from different food processing companies, there is no guideline and controlling mechanism on how the price and market works. Apart from this, the interference of intermediaries in the market and hoarding of feed by companies and farmers also contributes its share to escalating prices.

Table 1 *Comparison between feed ingredients (price trend and current protein cost)*

INGREDIENT	Price per T (Fresh) 2011	Price per T (Fresh) 2016	Price per T (Fresh) 2019	Price per T (Fresh) 2020	Price per T (Fresh) 2021	DM content %	Price per T (DM) 2021	Protein Content	Price Protein Unit
	ETB	**ETB**	**ETB**	**ETB**	**ETB**		**ETB**	**%**	**ETB**
Soybean	7500	12000	18000	16000	45000	90	50000	49	**1,02**
Noug cake	3000	4800	24000	35000	35000	90	38889	28	**1,39**
Wheat Bran	2800	4170	7000	11000	16000	87	18391	17,3	**1,06**
Linseed cake	5000	10000	20000	25300	43000	90	47778	34,1	**1,40**

[1] Exchange at the time of the study July 2021) was 45 Birr per Euro.

4 Breweries

The industry has responded to the growing demand by expanding their scale of operation. The government invited two of the world's largest breweries (i.e. Heineken and Diageo) to set up operations and now more pilot plants are underway to promote the production of malt barley. For instance, the Dashen Brewery, one of the holding companies in the country, is quadrupling its production capacity (from 1 million hl to 4 million hl) and exploring options for domestic sourcing of barley.

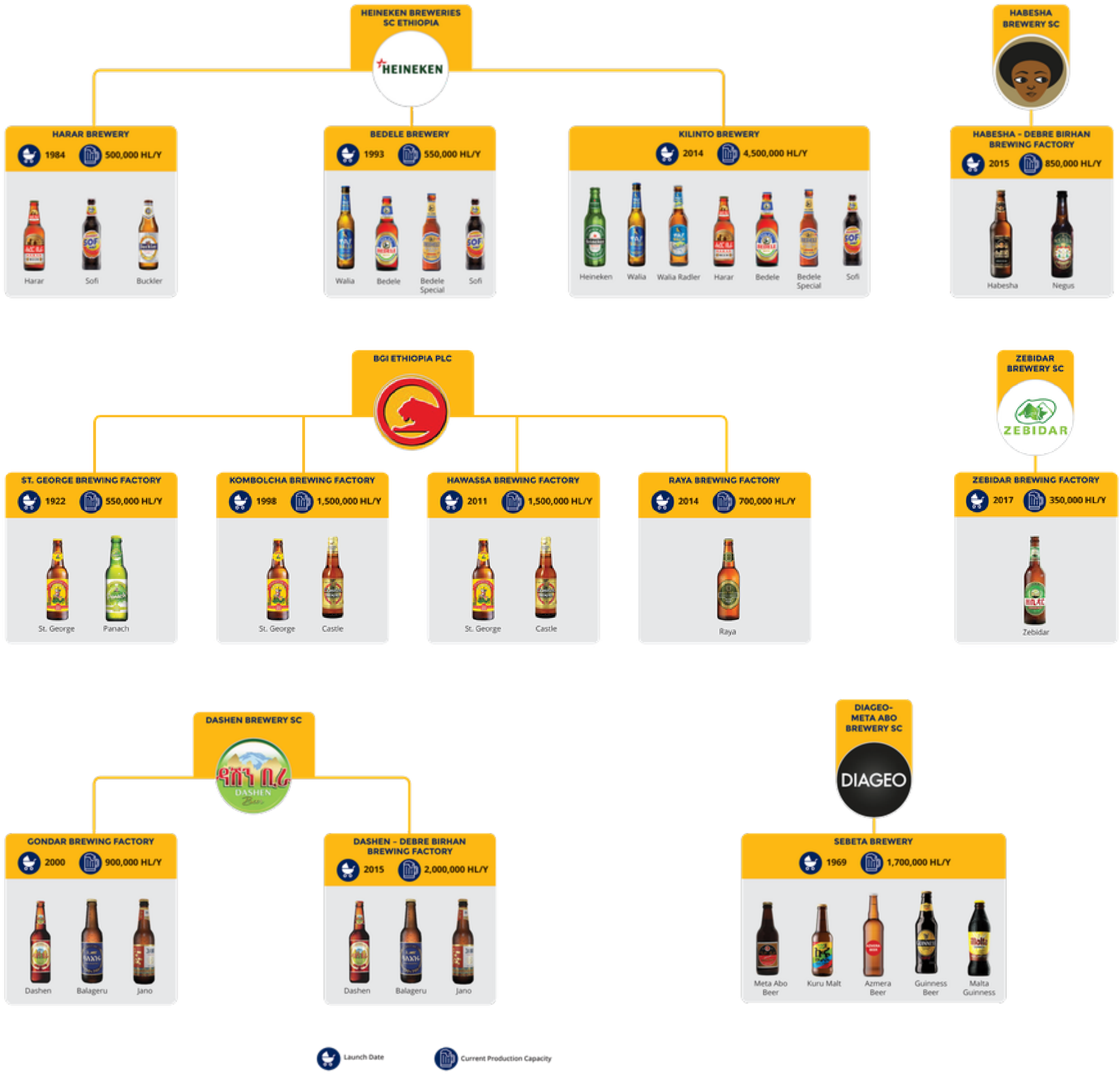

Figure 1 *Ethiopian Breweries.*

In Ethiopia, there are currently six main brewers that together own 12 breweries (Figure 1). The 12 breweries are spread over roughly half of Ethiopia's administrative regions and chartered cities. There are four in Amhara, two in the capital, Addis Ababa, as well as the regions of Oromia and Southern Nations, Nationalities and Peoples (SNNPR), and one each in Harari and Tigray.

4.1 Brewery byproducts

The three main by-products from the brewing process of significant use as feedstuffs are brewer's spent hops, brewer's spent yeast and wet or dry brewer's grain (Westendorf et al., 2002). The by-products are removed from the brewing process at different stages starting with brewer's condensed soluble, the brewer's grains is then removed from the brewing process before the addition of yeast to start fermentation process; as a result, the first two by products contain no brewer's yeast. Fermentation is thus allowed to continue upon completion until cooling of beer takes place and the yeast drops to the bottom of the fermentation vessel, where it is drained from the beer (Rijnders et al., 2000) (Figure 2).

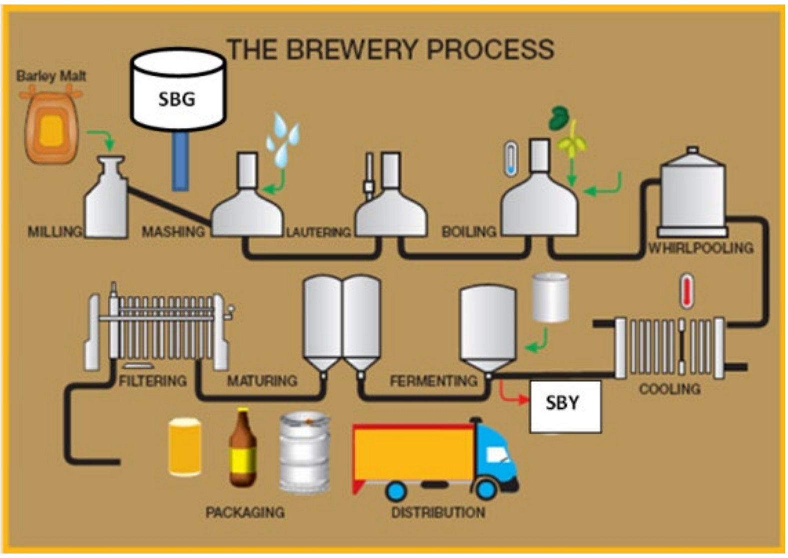

Figure 2 *The brewery process, with two by-products: spent brewer's grain (SBG) and spent brewer's yeast (SBY)*

4.2 Ethiopian spent brewer's yeast volume.

Commonly produced by-products from all beer factories in Ethiopia are spent brewer's grain (SBG) and spent brewer's yeast (SBY). The typical volume of spent brewer's yeast collected from a lager fermentation is approximately 2 kg/hl of the final volume of beer produced (Mathias et al., 2014). The actual production capacity of SBY produced from all the breweries in the year 2021 is estimated to be 21.161,33 tonnes (Table 2).

Table 2 *Ethiopian Breweries Production Capacity*

Brewery	**Beer Annual Production Capacity**	**Spent Brewer's Yeast**	**Spent Brewer's Yeast**
	(Hectolitres)	(Tonnes Wet)	(Tonnes Dry Matter*)
Factory 1	200,000.00	400.00	44.00
Factory 2	600,000.00	1,200.00	132.00
Factory 3	2,400,000.00	4,800.00	528.00
Factory 4	1,500,000.00	3,000.00	330.00
Factory 5	1,500,000.00	3,000.00	330.00
Factory 6	780.000,00	1.560,00	171,60
Factory 7	350.000,00	700,00	77,00
Factory 8	800.000,00	1.600,00	176,00
Factory 9	541.666,00	1.083,33	119,17
Factory 10	709.000,00	1.418,00	155,98
Factory 11	700.000,00	1.400,00	154,00
Factory 12	500.000,00	1.000,00	110,00
Total	10.580.666,00	21.161,33	2.327,75

*Calculated based on 2 kg spent brewer's yeast / hl beer produced (Mathias et al., 2014). *Based in 11% DM content

4.3 Current Uses of SBY in Ethiopia

Although it varies from factory to factory, the current use of SBY is very limited. It is either delivered to the farmer in mix form with SBG or discarded with the wastewater from the plant or simply dumped as waste on landfills and other areas. In Ethiopia, 6 breweries out of 12 disposed the SBY as such to the landfills creating waste pollution while only one factory sends it to a water treatment plant for disposal (Table 3).

Table 3 *Current usage of SBY in Ethiopia/ Brewery.*

Brewery Factory	SBY Usage
Factory 1	Disposed
Factory 2	Disposed
Factory 3	Temporary storage within factory, then given free of charge to farmers
Factory 4	Disposed
Factory 5	Data not available
Factory 6	Disposed
Factory 7	Mixing with SBG, storing on tanker, then the distribution is outsourced
Factory 8	No use/dumping to wastewater treatment plant
Factory 9	Disposed
Factory 10	Disposed
Factory 11	Mixed with SBG
Factory 12	No Use

4.4 SBY Seasonality/availability

There is no specific data available on the variation of the production of SBY, but a general increase in the consumptions and production of beer and the subsequent availability of brewer's grain and yeast can be seen with the post harvesting period (a time of festivities such as weddings), summer season, national holidays and Ethiopian festivals like Timkat (19-20th January), Fasika (Easter April/May), Meskel (September), Genna (Christmas, 7TH January). Decrease in brewery product consumption is seen in winter, during Ramadhan fasting and in rainy season from March-April.

5 Spent brewer’s yeast

During the fermentation process, yeast cells can multiply numerous times, which results in markedly greater yeast mass than what is added at the start of fermentation. The yeast growth rate is influenced by the fermentation conditions at each brewery. It is estimated that 2 kg spent brewer’s yeast are produced per hl of finished beer (Mathias et al., 2014).

5.1 Composition and nutritional characteristics

A brief overview of the composition of SBY is given in table 4.

The potential of SBY as a source of protein, minerals and B-complex vitamins, and high quantities of essential amino acids and other nutrients might provide additional opportunities like animal feed ingredient if it is used correctly.

The water content of this product is very high (88-90%), and the main nutrients (Table 4) are in suspension, which limits its direct use on farms, unless a special strategy aimed to address this matter is used. This should involve the homogenization of the product before being used (agitator, mixer, homogenizer) to avoid sedentation

Table 4 *Nutritional composition of wet spent brewer’s yeast (source: Feedipedia).*

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	93.6	1.8	89.1	97.0	107
Crude protein	% DM	48.9	3.8	39.3	56.8	108
Crude fibre	% DM	1.8	1.3	0.1	4.4	56
NDF	% DM	8.8	9.4	0.0	20.7	6
ADF	% DM	2.5	2.5	0.0	5.7	6
Lignin	% DM	0.8	0.8	0.0	1.7	6
Ether extract	% DM	2.4	2.4	0.0	8.2	34
Ether extract, HCl hydrolysis	% DM	4.1	1.2	2.2	6.0	34
Ash	% DM	7.0	1.1	5.1	9.3	86
Starch (polarimetry)	% DM	10.9	7.0	0.0	17.5	5
Total sugars	% DM	1.9	1.3	0.3	2.8	3
Gross energy	MJ/kg DM	19.6	1.3	18.1	20.4	3 *

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	2.9	1.1	1.0	5.4	31
Phosphorus	g/kg DM	13.1	2.4	9.6	20.0	34
Sodium	g/kg DM	1.8	1.2	0.4	3.7	6
Magnesium	g/kg DM	2.4				1
Manganese	mg/kg DM	34	18	7	43	4
Zinc	mg/kg DM	114	44	55	154	5
Copper	mg/kg DM	23	33	1	80	5
Iron	mg/kg DM	78	44	27	107	3

Brewer’s spent yeast is a high-protein by-product. It contains on average 50 % protein (https://www.feedipedia.org/node/72) and is generally regarded as safe. When compared to Saccharomyces cerevisiae and rootlets, another by-product of the brewing industry, SBY has a high level of essential amino acids, as seen in Figure 4.

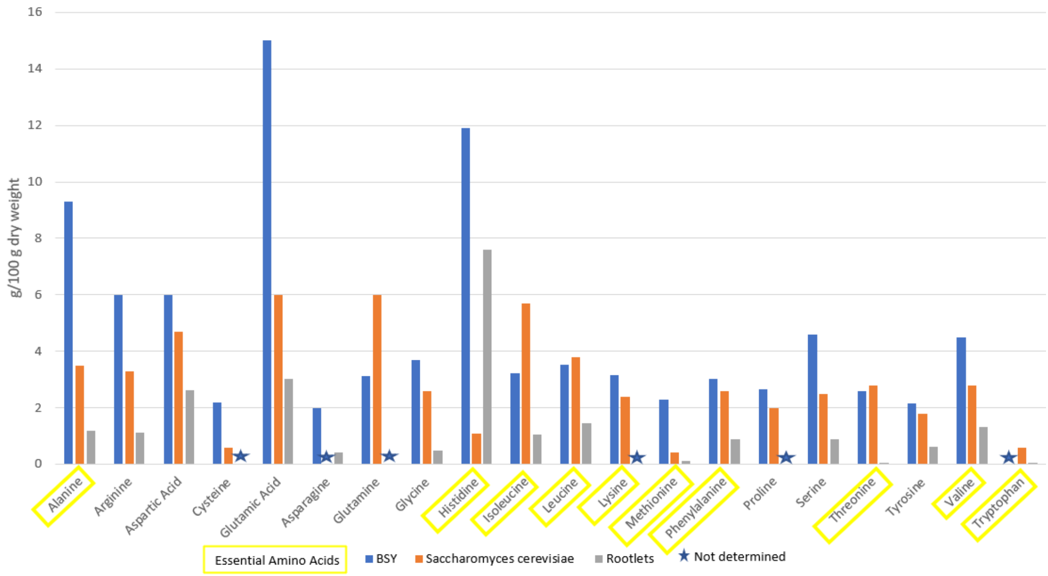

Figure 3 *Amino Acid Profiles of Brewer's Spent Yeast in comparison to Saccharomyces cerevisiae and rootlets, with the essential amino acids highlighted in yellow.*

A high percentage of SBY polysaccharides are insoluble, approximately 83% of total polysaccharide content. SBY polysaccharides are mainly comprised of β-glucans, mannoproteins and glycogen.

Others nutritional aspects that need to be considered are the i) mineral and vitamins content of SBY, especially its high vitamine B complex content, ii) phenolic compounds, and iii) glutathione (GSH).

Liquid SBY contains 4-4,5% ethanol residues (OPNV website[2]), which can have benefits for pigs (quiet pigs and healthy skin tone, see Bonda website[3]), however the prescribed amount is limited from 5 kg/day for piglets to 12 kg for fattening pigs with a liveweight of more than 50 kg. In case of drying the SBY, the ethanol evaporates, which means a total loss of valuable feed energy.

5.2 Storage, processing of SBY

SBY has a limited shelf life and may suffer quick losses of total solids during storage. The Ethiopian climate type is tropical monsoon, with a wide topographic (altitude) induced variation. Such conditions contribute to the formation of a relatively humid atmosphere, which speeds up the proliferation, and activity of molds and some facultative bacteria such as E. coli, Klebsiella sp., and Proteus sp. in SBY.

Live yeast in storage is prone to contamination, they consume their glycogen reserves which makes them more susceptible to rupture and can result in the release of their content in the liquid phase where bacteria can feed off the nitrogen released, and multiply rapidly. The yeast slurry needs to be as contamination free as possible when stored (Huige et al., 2006).

In Kenya, feed companies are selling the liquid product directly to farmers, the by-product is subjected to autolysis at 80°C for 45 seconds-1 minute to destroy all yeast cells and cooled to a temperature of 50°C. Thereafter, viability test is carried out to ensure that all viable cells are destroyed. The autolysis process is repeated, should the test turn positive. The aim is to safeguard use of the by-product by unscrupulous persons for production of other alcoholic beverages and protect animals against plasma ethanol toxicity,

[2] https://www.opnv.nl/index.php/nl/vochtrijke-diervoeders/productgroepen-2/item/biergist-laag-eiwit

[3] https://www.bonda.nl/varkens/alle-producten-varkens/biergist/#:~:text=De%20rest%20wordt%20onder%20andere,smakelijk%20en%20rijk%20aan%20vitaminen.

which can occur when animals are fed more than 2.3 liters of live yeast cells. The by-product is then supplied to distributors and farmers under brand name of 'Chachu' (Muema, 2018).

The study from Peter et al. (2018), under Kenyan conditions, identified major sources of contamination of SBY with spoilage microorganisms due to unhygienic handling by distributors and farmers. In the same study, temperatures between 10°C to 30° C did not show the difference in the preservation and the study concluded that the appropriate storage time of SBY is seven days, thereafter, a significant increase in microbial load is observed.

Another study indicates a loss of dry matter, accompanied by a decrease in true protein and increases in crude protein (dry basis), ammonia, and nitrogen solubility when brewer's yeast slurry was stored at 21 °C or higher temperatures. Most of the changes occurred within 2 weeks of storage. Cool temperature (4 °C) storage prevented most of the changes, while addition of specific acids (acetic, propionic acid, or formic acid and formaldehyde) reduced changes in dry matter, crude protein, ammonia, and cell numbers but had no beneficial effect on true protein loss or increase in nitrogen solubility. The mixture including formic acid and formaldehyde appeared to be more effective than acetic and propionic acids alone (Steckley et al., 1979).

Hamasaki showed a gradual increase in population of lactic acid producing bacteria from days 0 up to a maximum level at day 14 and then a decrease at day 21. This is an indication of possible depletion of nutrients due to the multiplication of lactic acid producing bacteria during the storage period of yeast.

In summary, liquid by-products are more perishable than solid ones. Its high water content makes fermentation unavoidable; bacteria and yeasts multiply at high speed. These microorganisms feed on the dry matter of the by-product, so when fermentations occur in large quantities, the DM content decreases rapidly (Braun and De Lange, 2004). Its nutritional content (CP, etc.) also decreases and the content of organic acids (lactic acid and acetic acid) and pH varies. This not only involves a cost at an economic level, but perhaps change to it can also be a cost at a productive level. Bacteria, especially coliforms, also break down amino acids from by-products rapidly, especially free amino acids. That is why it is important to control the fermentation, and to give high rotations to the by-products. As a general rule, a liquid by-product should be used in 7 days. It is also important to let the tanks drain completely between flushes. If some product remains in the tank and fresh product is discharged on top, it acts as an accelerator of the fermentations. Brewer's yeast can reach the feed plant dead or live. In the first case, it is the brewing industry that inactivates the yeast by heat, thus reducing the fermentations. In the event that it arrives alive, it must be immediately inactivated.

Several strategies have been proposed for the processing of SBY into forms that do not deteriorate easily: i) heat treatment (80°C), ii) addition of organic acids, iii) cold temperatures can help slowdown bacterial growth (below 5°C), iv) mixing SBY with dry ingredients like rice bran or wheat bran and then drying (El-Shafey et al., 2004), v) addition of either beet molasses (in 1:1 ratio) or urea (3%) to yeast pulp has been suggested for osmo-active preservation of SBY (Bednarski et al., 1983)..

The research recommends storage of the by-product in hygienic containers and to avoid pooling of fresh SBY with previously supplied product. Storage in a cool and less humid environment, and regular cleaning of feed containers to prevent contamination of fresh feeds, are some of the good handling practices that need to be observed along the supply chain. This will enable prevention of major risk factors that can contribute to microbial contamination of SBY. The solid and liquid fractions of yeast tend to separate rapidly, for this must be mixed before being used, but not excessively, since the supply of oxygen favors fermentation.

The best temperature to store SBY is below 21 °C, with a pH of 4-5.

5.3 Other quality aspects

Removal of bitterness: If the yeast contains hop residues, it may have a bitter taste that makes the feed unpalatable, if included in large amounts. The bitter taste can be removed by mixing the slurry with a solution of sodium hydroxide and sodium phosphate that raises the pH to 10, after which the mixture is concentrated, washed and dried (Huige et al., 2006). In another study, rotary microfiltration was used for both debittering as well as debris separation in the process of yeast extract production from SBY (Shotipruk et al., 2005). They showed that a considerable reduction in bitterness can be obtained by autolysis of cell homogenate prior to filtration and rotary filtration of the homogenate at pH 5.5.

Drying: Dried will obviously better maintain its quality. Yeast is usually drum-dried, which requires expensive machinery and energy. The process is economical only in large breweries. The yeast can also be mixed with brewer's grain and dried as a mixture in a steam-tube drier. This method increases the value of the spent grain. SBY has to be ground after drying (Hertrampf et al., 2000) it is thus necessary to inactivate (kill) it, before using it. This can be done through heat treatment (80°C at the brewery) and/or by addition of organic acids on the farm

5.4 Potential uses of SBY in Animals feed & other uses

SBY, in its raw and processed forms, has had very limited applications to date in Ethiopia. While many potentially exciting technologies have been investigated, few have been implemented on an industrial scale, with animal feed being the main outlet for BSY currently. Figure 4 provides an overview of the current and potential applications of BSY.

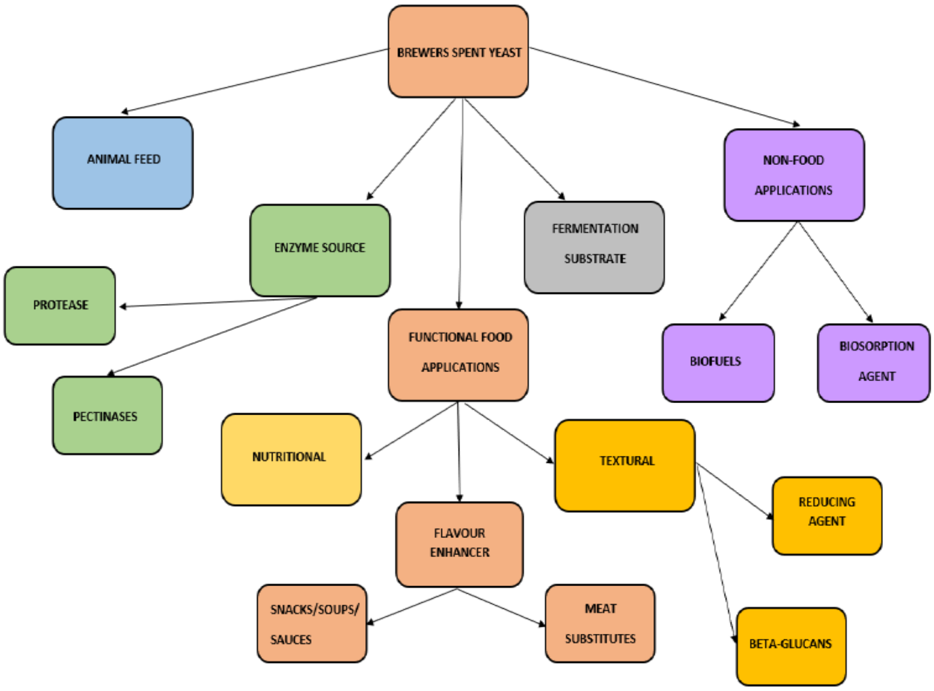

Figure 4 *Overview of Current and Potential SBY Applications*

5.4.1 Animal Feed

Currently, worldwide, the most well-known and commonly used outlet for brewer's SBY is as a constituent of animal feeds, mainly as a cheap source of protein as well as a source of minerals and B vitamins. The spent yeast may be incorporated as a wet slurry or can be dried before feeding. The addition of yeast to animal feeds has been shown to have positive effects on feed quality and feed utilization (Bediye *et al*, 2018) .

SBY as a protein supplement has long been incorporated in ruminant diets. It has been demonstrated under in vitro conditions that craft beer SBY, which contain antimicrobial α- and β-acids, as a protein supplement can prevent excessive rumen protein degradation by rumen hyper-ammonia producing bacteria (Harlow et al., 2016).

Sheep: Cost reduction in the sheep diet can be achieved by substitution of dried SBY for up to 100% of corn meal in the feed formulation, with no observable adverse effects on digestibility or feeding behavior (Oliveira et al., 2016). An increase in positive meat performance indicators was observed, including body weight, daily gains, growth rate, muscle dimension and fat thickness. Also, inactivated dried yeast in lamb diets could even improve the carcass and meat quality by reducing the deposition of subcutaneous and intramuscular fat (Rufino et al., 2013).

Dairy & Beef cows: Brewer's yeast slurry, can be fed to dairy cattle as an alternative to soybean meal, up to 12% of the DM diet, without any detrimental effect on DM intake, milk production and milk organoleptic quality (Steckley et al., 1979). The inclusion of dried brewer's yeast as a replacement for soybean meal up to 20% of the total dietary DM did not affect intake, digestibility or performance (Nursoy et al., 2003; Freitas et al., 2015).

Poultry feed: The use of SBY in feeds to replace soybean meal has been shown, to have potential to replace soybean meal up to 20%, providing protein without adverse effect on growth performance, carcass characteristics and internal organs of broiler chickens (Chollom et al., 2017). Also, dietary SBY had shown beneficial effects on egg laying performance, egg quality, nutrient digestibility, and excreta microflora in laying hens (Park J.et al., 2020). SBY in combination with other brewer's by-products, namely brewer's spent grain with hot sludge and protein sludge from press liquor, were found suitable for the preparation of protein-rich feed for laying hens (Levic, et al, 2010). In another study (Gondwe, Mtimuni, and Safalaoh (1999) showed that the substitution of vitamin premix with sun-dried SBY in broiler finisher diets exerted significant positive effects in terms of weight gains and live weights.

Aqua Feed: The spent yeast increases digestibility when included in fish feed, as it has a lower intestinal absorption rate than the typically used fishmeal. SBY had good digestibility and could potentially be used as a fishmeal alternative in aqua feeds (Martin, 2020). Also its use has been shown to improve digestive capacities of white seabream and meagre fish species (Castro et al., 2013), and the potential of SBY as a fish meal alternative in diets for giant freshwater prawn has been shown. Results showed that up to 60% of fishmeal protein in the diet of the prawn can be substituted by SBY (Nguyen et al., 2019). Rreplacement of 30–40% fishmeal with SBY in the diet of the carp Labeo rohita can promote better growth and enhance protein content.

Pigs: Fresh brewer's yeast is an excellent source of high quality, highly digestible protein. It also contains enzymes and co-factors which benefit pig health and performance. When fed in large quantities to pigs, a mineral mixture rich in calcium and with a low phosphorus content must be used, and a supplement of vitamin B12 should be included. It also contains enzymes and co-factors which benefit pig health and performance (Granier, R. J. 1988). SBY can also replace fish meal as a protein source and can be supplemented in pig diets up to 6% without detrimental effects on performance (Kabugo et al., 2014). The incorporation of SBY in pig diet resulted in significantly decreased total cholesterol and blood urea nitrogen in pigs and has been shown to have a significant enhancement in apparent magnesium (Mg) availability with SBY incorporation (Sreeparvathy et al., 2018).

Rabbits: brewer's yeast can partially or even completely replace soybean meal in rabbit diets, and inclusion rates can be as high as 20% of the diet without alteration of growth, slaughter performance or health status. This equivalence between the proteins of brewer's yeast and soybean meal is mainly explained by their high digestibility and their quite similar amino acids profile.

5.5 Environmental aspects

The main SBY characteristics that could be danger for the environment are:

a) Fast bio-degradation: the quick growth of microorganisms can restrict the use (limited lifespan).

b) High moisture content (> 90 %), dumping of humid products leads to e.g. more bacterial and fungal growth on rubbish dumps.

c) If not utilized, it should be treated together with wastewater, waste beer, etc. in a treatment plant.

In Ethiopia most often SBY, is directly used by farmers usually mixed with spent brewer's grain, deposited in the fields, or burned (Karlović, 2020). It is important to note that incineration alone causes greater environmental damage than just disposal in the fields. SBY as a byproduct of brewery industries can become an environmental hazard if dumped in the environment, leading to solid waste and air pollution. Solid waste of SBY in the environment can lead to a place for dangerous fungal and bacterial growth.

6 Economic Analysis[4]

As spent brewer's yeast (SBY) is produced locally and is currently available free of charge, using it as an alternative source of protein in animal feed could alleviate some pressures from the ingredient market. The supply of SBY throughout the year is very reliable, with only short periods of time (in the order of a week, see 4.4) in which the supply may stop due to maintenance works at the breweries.

There is the possibility of drying the SBY, which would eliminate many problems in terms of storage and use. However, due to its high water content, this process has a very high cost that cannot be justified, when used as an ingredient in animal feed.

Use of liquid by-products, instead of first drying, has several advantages. First of all with regards to energy use. Calculations from the Netherlands (Makkink, 2008) show that on average transporting liquid (10 – 20 % DM) products uses 80 MJ per tonne. Drying of such liquid products takes 2400 MJ per tonne and the transport of the remaining dried material costs 5 MJ per tonne. Therefore, the slightly higher energy requirements of transporting liquid products, are compensated by avoiding the energy requirements for drying. Therefore, wet SBY only needs 1/30th of the energy compared to using it in dried form. Furthermore, the CO_2 emissions of producing and using the dried products are almost 25 times as high as the emissions from the wet product. On top of this, using ingredients such as SBY in liquid from improves utilization of its nutrients and minerals, compared to feeding it in dried form (Makkink, 2008).

That is why the pilot in Ethiopia analysed whether it is possible to use SBY as a liquid ingredient directly mixed with animal feed at Alema Koudijs Feed Plc location in Debre Zeit (Bishoftu), Ethiopia. The case study is based on a weekly use of 35-40 tonnes of fresh SBY, with an inclusion rate of 2 % on the total feed formulation. The inclusion of 2 % is based on nutritionist's advice and the maximum amount of liquid that can be included without affecting the texture and composition of the feed.

Figure 5 *Location of Alema Koudijs factory in Ethiopia. Source: Google Maps.*

The product itself is currently freely available from the breweries, but the costs of transport are for the user and are an important limiting factor to consider.

[4] All calculations are based on prices of July 2021.

In the present case, the breweries are spread throughout the country and at various distances of up to 800 kilometers from the location of Alema Koudijs Feed Plc in Debre Zeit (Bishoftu), East Shewa Zone, Oromia (table 5).

Table 5 *Distance from breweries to Alema Koudijs Feed Plc*

Brewery	**Distance to Feed plant**	**SBY (wet)**
	(Km)	(Tonnes)
Factory 1	500	400
Factory 2	600	1200
Factory 3	30	4800
Factory 4	40	3000
Factory 5	250	3000
Factory 6	440	1560
Factory 7	170	700
Factory 8	650	1600
Factory 9	65	1083
Factory 10	800	1418
Factory 11	170	1400
Factory 12	30	1000

The reasoning to be followed for the selection of breweries as potential yeast suppliers would be: i) distance, ii) transportation time, iii) safety and state of the routes, iv) credibility of the supplier in relation to quantity and quality of the product v) status of yeast at the brewery, especially with regard to inactivation and hygiene.

Factories 1, 2, 5, 6, 8, 10 are all located at more than 250 km from the feed plant and are therefore not viable options to consider due to distance and transportation time.

Breweries 3, 4, 9, and 12 are all located within a radius of less than 70 kilometers from the plant. Therefore, they look like the best options from a distance and transportation time point of view.

Brewery 3 appears to be the best option. With brewery 4 as second alternative, since they are the nearest big producers to the feed plant.

Breweries 12 and 9 could be considered from the transport point of view but their production capacity is low.

Factories 7 and 11, located 170 km from the feed plant, are accessible options that can be analyzed if it is possible to combine loads with other breweries located on the same road (i.e., brewery 7 with 9, or brewery 11 with 3 or 4)

Since there are different arrangements made in Ethiopia for the distribution and transportation of waste, it is very difficult to have a singular cost per kilometer: there are no standards tariffs per km or per tonne, since prices are determined by case by case negotiations.

Transporting SBY will take place using a complete tanker truck, with a capacity of 43,000 L. The quoted transport price is around 15,000 ETB for a 30 km distance and 33,000 ETB for a 170 km distance to the location of Alema Koudijs Feed Plc in Debre Zeit (Bishoftu).

When applying the cost of 15,000 ETB to the breweries 3, 4, 9, and 12 and 33,000 ETB to the breweries 7 and 11, the cost per tonne would be approximately 390 ETB/T and 858 ETB/T for each group respectively (table 6).

Table 6 *Summary SBY transport cost for breweries close to the feed plant*

Brewery	Distance to feed plant	SBY production	SBY pro-duction	Transport costs	SBY Price wet	SBY price dry	SBY price per protein unit
	Km	Tonnes wet/year	Tonnes wet/week	Tanker, 43.000 liters	ETB/tonne	ETB/tonne	ETB/unit of protein)
3	30	4800	92	15000	390	3545	0.072
4	40	3000	58	20000	480	4400	0.094
7	170	700	13	33000	858	7800	0.159
9	65	1083	21	15000	390	3545	0.072
11	170	1400	27	33000	858	7800	0.159
12	30	1400	19	15000	390	3545	0.072

The estimated weekly quantity required by the feed plant, based on an inclusion rate of 2% (fresh weight), is around 38.46 tonnes of wet SBY per week. With a safety margin of assuming 10% losses, the feed plant would need approximately 43 tonnes per week. With a density of 1 : 1.1, 43 tonnes of SBY is approx. 39,000 liters of SBY. With this information, we can assume that a full tank truck, with a capacity of 39,000 L will be stored weekly. The production of breweries 7, 9, 11 and 12 is lower than this amount, so if transport cannot be combined, costs will be higher, as will be overall emissions.

If this quantity is transported from nearby factories, the transport cost will be between 390 and 480 ETB/T fresh product, 3545 to 4400 ETB/T DM, and the cost per tonne of protein around 72 to 94 ETB. Looking at the cost of protein, compared to other protein sources commonly used in Ethiopia (table 1), whose value exceeds 1000 ETB per tonne of protein, SBY is a highly attractive alternative protein source.

Alema Koudijs feed plant's annual use would be 2.000 T/year of SBY, this amount would be equivalent to 200 tonnes of soybean meal that could be substituted with the SBY.

One tonne of SBY, with 10 % DM and 50 % protein in the DM contains 50 kg protein. One tonne of soy cake with 50 % protein contains 500 kg of protein.

Due to the limited shelf life of the product and to avoid potential supply or sanitation issues, it is strongly recommended to use a fresh product and avoid storage for more than one week.

Based on these recommendations, the plant would need a storage capacity of twice the expected weekly amount. Therefore, if the full load of a tanker truck is expected to be 43 T, the total storage capacity should be 86 T organized in a way that allows the plant to have storage capacity for two complete batches of 43 T of SBY. The plant will dose the spent liquid beer yeast into the feed mixer directly from the storage tank. The storage tanks will need to have a homogenizing system that, prior to pumping the product to the mixer, allows the yeast to homogenize while maintaining the solid part of it in suspension during the pumping to the mixer.

The estimated investment needed including storage and dosing line would be 150,000 Euro (quote October 2021), including installation costs.

Annual depreciation and maintenance costs are 15 % (22,500 Euro).

The estimated transport cost of 2000 T of SBY averages 440 ETB/Ton (average between 390 and 480), thus totalling to 880,000 ETB

At an exchange rate of 54 ETB/Euro, the total investments are 8,100,000 ETB and annual depreciation and maintenance cost of 1,215,000 ETB.

The cost of 200 tonnes of soybean meal, at the current price (45.000 ETB/T, November 2021), would be 9.000.000 ETB.

This leads to an approximate savings of 6,905,000 ETB/year (€135,000) for the capacity of the Alema Koudijs feed plant (table7).

Table 7 *Potential substitution of soybean meal by SBY in Alema Koudijs feed plant on an annual basis.*

Yearly feed pro-duction	**Inclusion rate**	**SBY use**	**Trans-port costsper tonne**	**Total transport costs**	**Depreciation and main-tenance costs**	**Totalcosts of SBY supply**	**Soy-meal equivalent**	**Soy-meal price**	**Soymeal total costs**	**Savings**
Tonnes	%	Tonnes	ETB/tonne	ETB	ETB	ETB	Tonnes	ETB/Tonne	ETB	ETB
100,000	2%	2000	440	880,000	1,215,000	2,095,000	200	45,000	9,000,000	6,905,000

At the national level, the total capacity of SBY in Ethiopia is 21.161,33 tonnes which could theoretically replace 2.116,133 T/year of soy cake.

7 Plant Establishment

To use SBY in liquid form, piloting equipment to test the use of liquid SBY has been installed at Alema Koudijs Feed Plc in Debre Zeit.

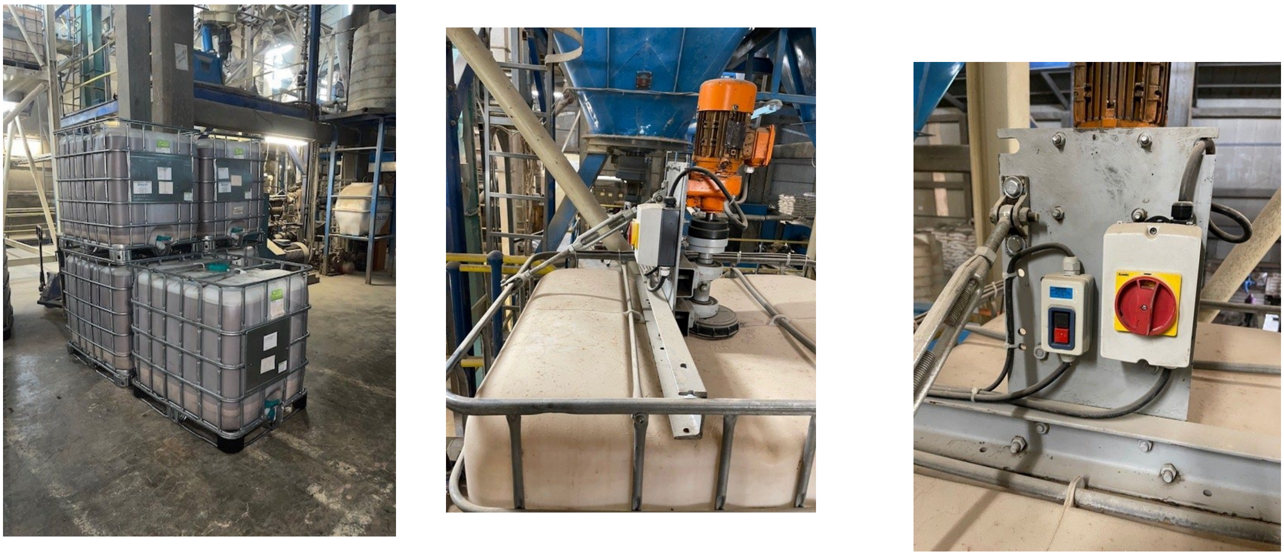

Figure 6 *Impression of the pilot installation, storage and pumping of the SBY.*

Liquid SBY will be dosed into the molasses mixer. In the first pilot stage it was done directly from the intermediate bulk container. The pipelines would be very simple and with very low budget. If this works then an option would be to install 2 (or more) 50 m^3 tanks.

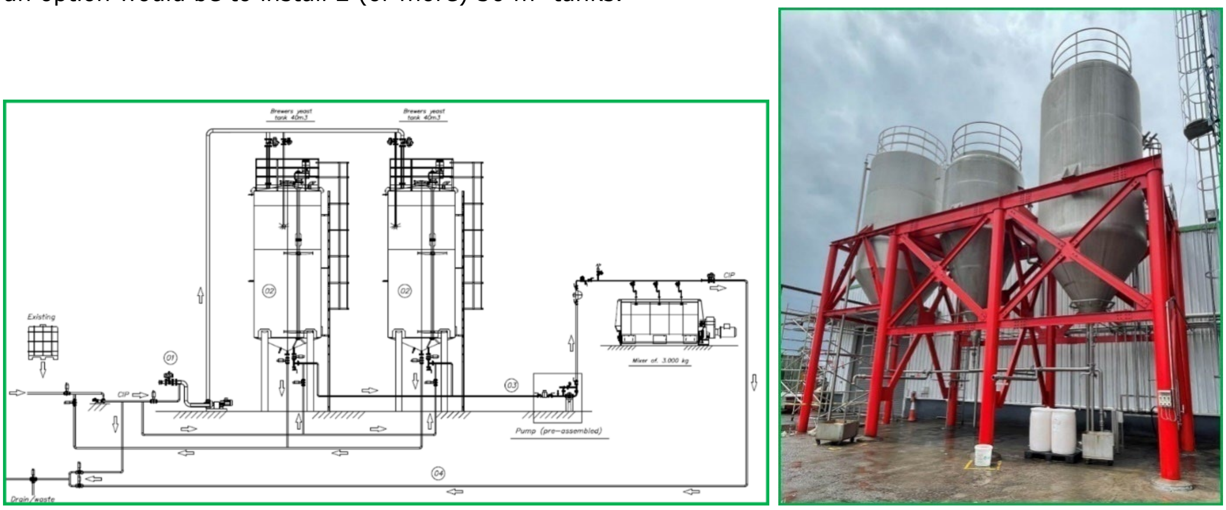

Figure 7 *Proposed Plant Structure and example of comparable tanks next to Koudijs factory Debre Zeit.*

8 Conclusions

It can be concluded from the study that Ethiopian brewery industry is booming and has a substantial availability of SBY, which is now strongly underutilized. With only low seasonal variation in production, enough capacity and a high nutritive value, SBY would be a good source to help cover Ethiopian feed protein demand-supply gap. Although the total production of Ethiopian SBY is enormous and it is a viable product, the huge transport distances will likely not make it realistic to collect SBY from all the brewery factories to a central location. Transportation costs associated with collecting SBY, its short shelf life and its tedious processing are the challenges associated with the usage of SBY in animal feed. Logistic is the main variables enhancing factor.
For good use of SBY, a reliable storage and feed injection system needs to be established at the feed plant. Supply to the processing plant will likely need to be supplied by breweries located in the same region.
This approach will not only improve the use of by-products from Ethiopia's breweries, such as SBY, in the form of animal feed, thus creating a new source of animal feed protein. But will also be helpful in minimizing environmental contamination by beer industries.

Figure 8 *Samples of beer yeast, showing sedentation (see also 5.1).*

References

Bediye Seyoum, Gemechu Nemi, and Harinder Makkar (2018). Ethiopian feed industry: current status, challenges and opportunities. Feedipedia. https://www.feedipedia.org/content/ethiopian-feed-industry-current-status-challenges-and-opportunities .

Bednarski, W., Leman, J., & Poznanski, S. (1983). Osmoactive preservation of brewer's yeasts. Agricultural Wastes, 8(3), 143–153. https://doi.org/10.1016/0141-4607(83) 90113-0.

Braun K, de Lange K (2004). Liquid Swine feed Ingredients: Nutritional Quality and contaminants. ANAC Eastern Nutrition Conference May 11-12, 2004. Ontario, Canada

Castro, C., Pérez-Jiménez, A., Coutinho, F., Pousão-Ferreira, P., Brandão, T. M., Oliva- Teles, A., & Peres, H. (2013). Digestive enzymes of meagre (Argyrosomus regius) and white seabream (Diplodus sargus). Effects of dietary brewer’s spent yeast supplementation. Aquaculture, 416–417, 322–327. https://doi.org/10.1016/j.aquaculture. 2013.09.042.

Chollom PF, Okojokwu OJ, Egbere OJ, Ikeji FN, Yisa AG, Doma UD, Agbo EB (2017). Use of Spent Brewer’s Yeast (Saccharomyces cerevisiae) in Feeds to Replace Soya Bean on Performance, Carcass Characteristics and Internal Organs of Broiler Chickens. Researcher 2017;9(6):40-44]. ISSN 1553-9865 (print); ISSN 2163-8950 (online). http://www.sciencepub.net/researcher. 7. doi:10.7537/marsrsj090617.07.

Demissie Chanie, Veerle Fievez (2017). Review on Preservation and Utilization of Wet Brewer’s Spent Grains Concentrate Replacement Feed for Lactating Dairy Cows. DOI: 10.14737/journal.jahp/2017/5.1.10.13.

El_Shafey, E., Gameiro, M., Correia, P., de Carvalho, J, 2004; Dewatering of Brewer’s spent grain using a membrane filter press: A pilot plant study. Separation Science and Technology, Volume 39, 2004 – Issue 14.

FAOStat, 2018 https://www.fao.org/faostat/en/#data/QV

Feedipedia, Animal feed resources information system. Feedipedia.org

Freitas, D. R.; Campos, J. M. S.; Marcondes, M. I.; Valadares, S. C.; Franco, M. O.; Martins, E. C.; Rodrigues, B. M. C.; Oliveira, A. S., 2015. Dry yeast for lactating dairy cows. Arq. Bras. Med. Vet. Zootec., 67 (1): 211-220.

Gondwe, T., Mtimuni, J., Safalaoh, A, 1999: Evaluation of brewery by-products replacing vitamin premix in broiler diets. Indian Journal of Animal Sciences 69 (5): 347-349

Granier, R. J. (1988). Utilisation de la levure de bière liquide pour le porc charcutier. Journées Rech.

Harlow, B. E., Bryant, R. W., Cohen, S. D., O’connell, S. P., & Flythe, M. D. (2016). Degradation of spent craft brewer’s yeast by caprine rumen hyper ammonia-producing bacteria. Letters in Applied Microbiology, 63(4), 307–312. https://doi.org/10.1111/lam.12623.

Hertrampf, J. W., & Piedad-Pascual, F. (2003). Handbook on ingredients for aquaculture feeds. Springer Science & Business Media.

Huige, N. J., 2006. Brewery byproducts and effluents. In: Priest, F. G.; Stewart, G. G., Handbook of Brewing, CRC Press, Second edition, ISBN 978082472657

Kabugo, S., Mutetikka, D., Mwesigwa, R., Beyihayo, G. A., & Kugonza, D. R. (2014). Utilization of spent brewer’s yeast as a protein substitute for fish meal in diets of growing pigs. African Journal of Agricultural Science and Technology (AJAST), 2(5), 116–121.

Karlović, Andrea & Jurić, Anita & Ćorić, Nevena & Habschied, Kristina & Krstanović, Vinko & Mastanjević, Krešimir. (2020). By-Products in the Malting and Brewing Industries—Re-Usage Possibilities. Fermentation. 6. 82. 10.3390/fermentation6030082.

Levic, J., Djuragic, O., & Sredanovic, S. (2010). Use of new feed from brewery by-products for breeding layers. Romanian Biotechnological Letters, 15(5), 5559–5565.

Makkink, C., 2008: Duurzaam en Verantwoord. De Molenaar nr 3., February 2008. https://edepot.wur.nl/68233

Martin, D. (2020). Brewer’s Spent Yeast and Grain Protein Hydrolysates as Second-Generation Feedstuff for Aquaculture Feed. Waste biomass.

Mathias dos Santos Thiago Rocha. Pedro Paulo Moretzsohn de Mello. Pedro Paulo Moretzsohn de Mello. (2014) Solid wastes in brewing process: A review." Journal of Brewing and Distilling 5, no. 1 (2014): 1-9.

Mohammed, Dawud; Degu Addis; Tinsae Berhanu; and Adriaan Vernooij, 2019. Mapping of spent brewer’s grain supply chain in Ethiopia. Wageningen Livestock Research, Report 1210.

Muema, V. (2018, April 27). Importance of chachu (Brewer's Yeast). Retrieved from Happy Feeds Limited: www.happyfeeds.co.ke

Nguyen, N. H., Trinh, L. T., Chau, D. T., Baruah, K., Lundh, T., & Kiessling, A. (2019). Spent brewer’s yeast as a replacement for fishmeal in diets for giant freshwater prawn (Macrobrachium rosenbergii), reared in either clear water or a biofloc environment. Aquaculture Nutrition, 25(4), 970–979. https://doi.org/10.1111/anu.12915.

Nursoy, H.; Baytok, E., 2003. The effects of baker's yeast (Saccharomyces cerevisiae) in dairy cow diets on milk yield, some rumen fluid parameters and blood metabolites of dairy cow diets. Turk. J. Vet. Anim. Sci., 27 (1): 7-13

Oliveira, R. L., Oliveira, R. J. F., Bezerra, L. R., Nascimento, T. V. C., de Pellegrini, C. B., de Freitas Neto, M. D., do Nascimento Júnior, N. G., & de Souza, W. F. (2016). Substitution of corn meal with dry brewer´s yeast in the diet of sheep. Revista Colombiana De Ciencias Pecuarias, 29(2), 99–107. Retrieved from https://revistas.udea.edu.co/index.php/rccp/article/view/324969

Park Jae Hong, Shanmugam Sureshkumar & In Ho Kim (2020) Egg production, egg quality, nutrient digestibility, and excreta microflora of laying hens fed with a diet containing brewer’s yeast hydrolysate, Journal of Applied Animal Research, 48:1, 492-498, DOI: 10.1080/09712119.2020.1825446.

Peter Alphonce Obuong Alaru, Alfred Anakalo Shitandi, Symon Maina Mahungu (2018). Effect of Handling Practices of Liquid Brewer’s Yeast on Microbial Growth During Storage and Risk Unit Suitability as Feed Supplement in Smallholder Dairy Farms. Journal of Animal and Veterinary Sciences. Vol. 5, No. 4, 2018, pp. 26-30.

Rijnders, B. J., Van Wijngaerden, E., Verwaest, C., & Peetermans, W. E. (2000). Saccharomyces fungemia complicating Saccharomyces boulardii treatment in a non-immunocompromised host. Journal of Intensive Care Medicine, 26(6), 825-825.

Rufino, L. D. A.; Pereira, O. G.; Ribeiro, K. G.; Valadares Filho, S. C.; Cavali, J.; Paulino, P. V. R., 2013. Effect of substitution of soybean meal for inactive dry yeast on diet digestibility, lamb's growth and meat quality. Small Rumin. Res., 111 (1-3): 56-62.

Shotipruk, A., Kittianong, P., Suphantharika, M., & Muangnapoh, C. (2005). Application of rotary microfiltration in debittering process of spent brewer’s yeast. Bioresource Technology, 96(17), 1851–1859. https://doi.org/10.1016/j.biortech.2005.01.035.

Sreeparvathy, M., & Anuraj, K. S. (2018). Effect of feeding spent brewer’s yeast on plasma biochemical parameters on cross bred pigs. Indian Veterinary Journal, 95(4), 26–29.

Steckley, J. D., D. G. Grieve, G. K. Macleod and E. T. Moran. 1979. Brewer’s yeast slurry. II. A source of supplementary protein for lactating dairy cattle. J. Dairy Sci. 62:947-953.

Westendorf, M. L., & Wohlt, J. E. (2002). Brewing by-products: their use as animal feeds. Veterinary Clinics of North America: Food Animal Practice, 18(2), 233-252.

Appendix 1 Questionnaire to collect data on spent brewer's yeast Capacity of Ethiopia per Factory

Objectives: To analyses storage and utilization of spent brewer's yeast on brewery factory location in Ethiopia.

1. Name of the factory……………………………………………………..
2. Location…………………………………………………………………….
3. Brewery capacity of the factory (Hectoliters)……………………………………………………………
4. Spent Brewer's Grain Production capacity…………………………………………
5. Spent Brewer's Yeast production capacity…………………………………………
6. If Storage, then what is the storage capacity for SBG & SBY…………………………………………………
7. Any Seasonal variations, which effect SPY Production.
   - Season/time of year, Increase in production…………………………Reasons…………………………….
   - Season/time of year, decrease in production…………………….Reasons………………………………..
8. Current uses of SBY at factory ………………………………………………………………………………………………
9. Current uses of SPY By farmer………………………………………………………………………………………………
10. If SBY are disposed by the factory then how do they do it
    a. Dumping……
    b. Through as such on soil…………………………………………………………………………………………
    c. Through it in rivers/water……………………………………………………………………………………
    d. Mixing with spent brewer's grains…………………………………………………………………………..
    e. Others……
11. If storage of SBY then What is the Distance of storage from factory…………………………………………
12. Who are the responsible persons at factory from which SBY should be received………………………….
13. Who are Retailers and end users of SBY at the location………………………………………………………………
14. What are the transportation system available to transfer SBY from the factory to storage Location and from storage to the farmers…………………………………………………………………………….
15. Per month Housing Cost of an average storage facility ……………………………………………
16. How much is the cost of transportation per kilometer distance in Ethiopia …………………………
17. What preservative use by the factory For SBY storage……………………………………………………………
18. Labor cost and availability
    - Daily labor wage at the location……………………………
    - Persons/labor required transferring SBY from factory to storage…………….
19. Other equipment has required for temporary storage delivery to end user……………………………

20. If Factory sells process spent brewer's yeast then what is the unit price……………………………………

21. Any abnormalities notice in animals after using SBG with SBY……………………………………………………..

22. Any abnormities notice in animals after using SBY separately…………………………………………………

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