

CLEAN-UP TECHNOLOGIES FOR MALT AND BREWING INDUSTRY

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Abstract. The problem of by-products and waste collection, storage and recycling is one of the main objects discussed in the present paper. In Romania there is no appropriate technology for treatment of the by-products and wastes resulted from beer production. The theme proposed in the paper represents an absolute novelty for Romania and is intended to achieve a proper management of wastes and by-products from malt and beer production.

Keywords: malt, beer, by-products utilisation, waste management.

NATIONAL AND INTERNATIONAL CONDITIONS

Technology impact on the environment by industrial processing is one of the main issues of the environment. The essence of this issue is described in the long-lasting development concept. Long-term development may be severely affected by the environmental degradation. It is well-known that pollution has an impact on resource quality (water, air, soil) and organisms, as well.

In Romania, mainly before 1989, there was observed an intense industrialisation that was not accompanied by adequate provision for environment protection. In other words, likewise in other ex-socialist countries, this trend may be characterised as the reverse of the long-term development. An existing concept is that pollution prevention is more efficient by technological provisions within the basic production.

Our country is integrated into the international system of countries concern regarding environment presentation and protection. Long-term industrial development involves an economic development providing environment and natural capital protection by a proper treatment of wastes and by-products got for recycling.

Now, in our country, malt and beer factories are to face the issues related to by-products and waste collection, storage and recycling. There is no adequate technology for it. The main by-products and wastes resulted from beer produc-

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tion, malt spent grains and brewing yeast, respectively, are not industrially capitalised but they are delivered in a non-planned and non-rhythmic ways to different private beneficiaries or they are drained by sewerage system together with waste waters resulting in a severe environment pollution. This results in factory blocking because of an impossible by-product and waste supply, of blocking that can stop production and not complying with the regulations in force regarding environment protection, as well.

Initiation of a specific base for by-product and waste quantity diminution is taken into account by technical and technological requirement formulation related to raw material and utility consumption reduction contributing to ecological protection of the environment.

Costs afferent to ecological treatment and protection as well as investments for ecological protection objectives are considered.

Preliminary analysis carried out at beer factories in the country, mainly in the domestic production, resulted in the following needs:

- Main issue is malt spent grains and beer yeast capitalisation that requires special conditioning in view of a minimum 12 month preservation;
- Achievement of drained aqueous waste treatment plans also performing chemical (neutralisation being included) treatment as well as biological treatment and, if it is possible, according to the economic achievements of every commercial agent, to introduce new high performance methods as ultrafiltration and reverse osmosis.

Particular concern within beer industry regarding this project, is related to two aspects, namely:

- The factories have not their own treatment plants, drained waste water quality (containing most of resulted by-products and wastes) does not meet the limits stated by NTPA 002/ 2001.
- In the near future, activity in this field is to be conditioned by drained waste water quality: economic agents who will not get quality conditions consonant to the regulations in force, are to cease function.

Although some of beer factories took over the technology from the European Union countries, this did not cover by-product capitalisation and waste water treatment, too.

Taking into account the development of beer industry worldwide during the last 25 years (beer being known as a popular drink, a food drink generally tax-free) there were approached and solved all the issues concerning:

- Material and energy consumption diminution in order to make production and ecological protection profitable;
- Protection realised by building waste water treatment plants so that a beer factory built in the EU or satellite countries will not generate pollution issues.

The approach of the research takes into account the following:

- Material balance necessary for malt and beer production for every factory resulting in productive yield of beer factories analysed (5 beer factories) as well as a balance representing total waste and by-product output of beer production of the country (for brewing professional association) is to be drawn up;

- Research on nutritive value expressed as nutritive units for the by-products got from malt production as well as malt spent grains resulted from beer production, is formulated to be set up for different animal (poultry and polygastric animals);

- Technologies enabling optimum capitalisation of by-products resulted by their economic recycling, are to be formulated;

- Ecological protection realised by building up suitable treatment plants.

In this case, there are taken into account the following:

- Formulation of the technology of drying malt spent grains, a product that being wet, as it can be noticed during the process, is perishable. Due to the fact that concerning wet malt spent grains, beer factories have minimum requirements, spent grains buffer storage may result in the temporary ceasing of factory activity or spent grains drainage by the sewage system generating severe pollution issues for the environment, by drying, spent grains may be kept for a year under determined air temperature and relative humidity and used for foddering polygastric animals, mainly sheep during winter period. Applying this procedure the issue for malt spent grains of all beer factories in the country can be solved.

- The yeast resulted from malt wort fermentation will be collected and processed by technologies that are to be formulated within this project to procedure:

- a protein and vitamin concentrate intended for poultry feeding, mainly chickens and other categories of newly bred feathery in our country as for example, quails and ostriches;

- yeast tablets intended for food for special social groups as: old-aged people, children, sportsmen, soldiers.

In case of this product, reduction of yeast nucleic acid content to comparative values of nucleic acid contents of other foods, as for example: meat, will be aimed at.

- In order to turn protein deposit from wort cooling into good account, is taken into consideration the following:

- reuse of protein deposit for a new mashing in view of extraction yield increase, hop consumption decrease and wort quality improvement;

- recovery of protein deposit wort and its reuse for beer production and solid coarse part is to be dried after being mixed with spent grains;

- use of protein deposit for other purposes as for example: food grade alcohol production.

- In order to capitalise spent hop, two possibilities are taken into account:

- reuse of spent hop for another boiling in view of a further extraction of bitter substances from spent hop. In this case, spent hop will be added to the first step of hop rate for the bitterness;

- drying of spent hop after being mixed with wort spent grains and its use for foddering.

- In order to capitalise malt rootlets, the following is taken into account:

- biofactors obtained can be used in biotechnologies as stimulators to produce microorganisms (*Saccharomyces* yeasts for baking yeasts and single-cell biomass) and *Aspergillus niger* strains used for molasses citric acid production;

- foddering of polygastric animals, mainly horned cattle.

Finally, according to all the works carried out, technical and technological requirements will be formulated in order to decrease raw materials and utility consumption in view of:

- diminution of manufacture costs;

- diminution of by-products and waste quantities that can be produced under the specific conditions of the Romanian brewing industry;

- processes are turned to be ecological.

In light of the theme proposed, a total solution of existing issues related to the administration of wastes and by-products resulted and not properly capitalised as well as process turned ecological, is aimed at. High performing technologies obtained used for by-products processing capitalisation and waste water treatment to protect all the environment factors for a long-term development of this activity division having a large share in food industry of Romania, are anticipated.

The following objectives are taken into consideration by applying the research results:

- storage of wastes under ecological conditions;

- waste treatment technologies in view of recycling;

- new methods and technologies of reusable material recovery;

- methods and technologies of industrial product recycling at the end of their utilisation.

NOVELTY AND COMPLEXITY LEVEL

By-products and wastes resulted from brewing industry can be grouped, as follows:

- by-products and wastes resulted from malt production, as for example cereal wastes: foreign grains, broken grains, malt rootlets;

– by-products and wastes resulted from proper beer production as: malt spent grains, spent hops, protein deposit, yeast and CO₂.

Experimental research carried out previously resulted in the following basic data regarding by-products and wastes from malt and beer production.

CEREAL WASTES

They result from barley dehulling, sifting and wetting as well as malt degermination and polish. Wastes from barley dehulling and sifting are broken grains, husk, little barley grains and foreign matters as dust, sand, soil, etc. These wastes can be seen when sorting and sifting and they represent up to 1.5% of initial barley.

After barley sifting, then remains only barley grains of third and fourth quality (< 2.5 mm in size) that represent up to 30% of initial barley amount.

After barley wetting, light barley grains, chaff, straws and other foreign matters can be separated. All these are known as floating barley and it represents 0.1-2% of wet barley.

After malt drying, degermination and polish, there are malt rootlets that separate representing 3-6% of wet barley. Husk and dust removed after malt polish represent 0.2-1% of total malt.

Malt rootlets are obtained from dried malt degermination. This operation partially starts in malt drier and goes on in degermination machine. Malt rootlets removal is carried out soon after drying as being very dry, rootlets separate quite easily by grain rubbing one from another and their knocking against the machine walls.

Malt rootlets also contain:

- vitamins of B group,
- vitamins of E group,
- provitamins A and D,
- P-phosphorus,
- Ca,
- carotene.

Malt spent grains is a waste resulting in the largest amount in brewing factories and it is obtained after malt wort filtration in the boiling vessels.

Spent hop resulted from hop wort boiling. After boiling, it is pumped into hop separator that keeps hop catkins away. After wort drainage, spent hop remained on sieves is washed for complete exhaustion of catkins in extract.

Protein deposit (sludge) appears in beer wort after boiling with hop and it is found again in the cooling step. Practically, during the first step, the sludge is separated under hot conditions, i.e. protein deposit formed during wort cooling up to 80°C in rotapool.

Cooler sludge, formed while wort cools on up to the fermentation temperature of 6-10°C, is separated later. The quality of warm sludge or coarse sludge produced falls within the range of 20-80 g of dry substance / hl or 150-400 g of substance as such / hl. Coarse sludge grain size falls within the range of 30-80 µm.

Cooler sludge or cold sludge contains particles of 0.5-1 µm and represents 5-30 g dry substance / l of wort or 25 – 35% of coarse sludge quantity.

Brewing yeast represents a waste resulted from beer production from both primary fermentation vessels and secondary fermentation and maturation tanks.

Yeast yield as compressed yeast (about 25% dry substance) varies between 0.2-1 kg / hl of beer in accordance with yeast species and technological processes applied.

Due to its complex composition, brewing yeast is recognised as an important factor for nutrition and it is used for this purpose as:

- it is considered one of the most complex vitamin concentrate;
- protein substances contained have an intermediate position between the vegetable and animal ones. Most essential aminoacids, among which lysine represents about 10%, are found in their composition;
- it is one of the richest source of lecithin (3-4.5%) that justifies the significant ratio of phosphorus it contains and which as P_2O_5 reaches 52% of total minerals it contains.

Carbon dioxide CO_2 is produced during malt wort fermentation in a quantity of 3.7 kg for 1 hl of fermented wort. If CO_2 (dissolved in beer) losses or it is released by air during the first step of secondary fermentation, it means that 1 hl of fermented wort can trap and capitalise 2.8 kg of CO_2 .

By-products resulted from malt and beer production are turned into good account in order to formulate, test and turn into practice complex fodder recipes taking into consideration specific nutritional requirements of different species, mainly polygastric animals. An important base of soaking agents for soft drinks and sparkling water can be created by CO_2 recovery, purification, liquefaction and packaging.

Proper conditions are created to promote technologies for optimum capitalisation of specific by-products as economic agents in the country, malt and beer producers by carrying out this project and experimenting under production conditions. It can be also promoted to be exported the following:

- technologies formulated to capitalise valuable by-products as: malt spent grains, protein deposit and yeast resulted from fermentation;
- technologies referring to the capitalisation of other by-products and wastes resulted from beer production: cellulose – basis filtering plates, asbestos, cellulose acetate and pulverulent filtering materials (e.g. kieselgur, expanded perlite and even volcanic tuff);

- food – and fodder – grade products, nutritive, fortifying and vitamin products.

Technologies involve the application of a complex know-how in the field of food technologies, biotechnologies and waste water cleaning and we anticipate the performing of original resolutions consisting in:

- formulation of technologies allowing the optimum capitalisation of by-products obtained and their reintroduction into the economic cycle, will set up framework fodder recipes for different groups of animals (poultry and polygasttric animals);

- ecology protection carried out by building up adequate treatment plants that comply with the limits regulated by the environment protection;

- food – and fodder – grade products, nutritive, fortifying and vitamin products as well as sources of soil fertilisation, materials used for building.

The theme represents an absolute novelty for our country as up to now the problem of by-products and wastes obtained from malt and beer production in order to be turned into good account and provide environmental protection for a long-term development of this branch of food industry has not been tackled and shows a high complexity level due to multidisciplinary character of approaching the theme proposed. The achievement of a viable technology of by-products processing and treatment of waste waters from beer production involves the following specialities into the project solution:

- chemical engineering,
- technological engineering,
- sanitary engineering,
- industrial microbiology,
- ecology,
- chemistry,
- building,
- management, marketing.

THEME RELEVANCE FOR FOOD INDUSTRY AND HOW IT HARMONISES WITH THE NATIONAL POLICY OF ROMANIA

The solution of the issues related to domestic waste storage under ecological conditions is regulated by Law of Environment No 137/1995 that states: 'Local public administrative authorities should take the steps to prevent and limit the impact of any nature substances and wastes on the environment.' NTPA 002/2001 regulates drainage conditions for waste waters into sewerage system. The requirements imposed by the European Union, that have to be taken into account within the accession process of our country, aim at being in line with the European standards first by complying with the law of environment.

The theme is approached in order to achieve a proper management of wastes and by-products resulted from malt and beer production by turning them from environment pollutants into highly nutritive and non-perishable fodder for polygastric animals. By-product processing is intended for the production not only of food – and fodder – grade products, nutritive, fortifying and vitamin products but also sources of soil fertilisation, eventually building materials. Thus, ecological protection of the environmental factors is carried out by making optimum treatment solutions for aqueous wastes drained from factories under new conditions of high by-product and waste processing.

Up to now, this is a different issue even if an efficient brewery, that does not provide a high processing of by-products and wastes resulted, from this activity and waste water treatment, is imported.

Technologies proposed within this project and carried out together with industry partners found solutions for environmental protection providing competitive prices much closer to the economic potential of the country and equally high performance treatment as the imported ones.

RESULTS – FORESEEN BENEFITS, ESTIMATED PROFIT, PROFITABILITY

Final results of the project will be theoretical ones and technique has practical applicability.

Effects of theoretical results will complete knowledge in the field and substantiate the technologies of processing by-products of brewing production and waste water treatment.

Technical effects of the results will be emphasised by technological transfer as a final step. Project result application allows the following results/profit to be obtained:

- food – and fodder – grade products, nutritive, fortifying and vitamin products and sources of soil fertilisation, eventually building materials from processing of by-products and wastes of malt and beer production;
- creation of a new activity division meant to provide a long-term development of beer that has recently bloomed;
- achievement of a high treatment technology in a field where the issue of waste water treatment has not been solved yet;
- harmonisation with technical norms of water protection, NTPA 002/2001;
- diminution of expenses/penalties for water pollution;
- enhancement of experts' competence in waste water treatment.

Project application at industrial beneficiaries will give the following results:

- increase of jobs number for a new activity making the process flow of the existing breweries complete;

- enhancement of the outlet for food – and fodder – grade products, nutritive, fortifying and vitamin products as a consequence of processing by-products and wastes resulted from malt and beer production;
- increase of the economic agents' incomes applying the respective technologies;
- insurance of environment protection;
- initiation of an alternative source for fodder stuffs having a nutritive value similar to the classical ones that allows the high capitalisation of cereals production by agricultural techniques.

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