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Pilot technology and equipment to produce baking yeast in shorter multiplication cycle

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Abstract

The paper presents an optimized technology for baking yeast producing. The specific feature of the proposed technology is the multiplication of baking yeast cells in intensive system using the dynamic aeration in reduced multiplication cycle. The yeast multiplication is performed in three steps, in a pilot installation designed in order to process molasses as raw material.

The designed pilot process of baking yeast producing consists in a gradual multiplication of yeast in volumes bigger and bigger, in order to obtain a concentration in cell per unit of volume as much as possible. For every technological multiplication stage a specific hourly feeding diagram was applied for molasses and nutritive salts solutions.

Keywords: baking yeast, multiplication stages, fermentation vessels, molasses.

1. Introduction

The baking yeast represents a cell biomass of *Saccharomyces cerevisiae*, a high fermentation yeast, able to produce (determine) the dough's sugars fermentation, forming ethanol and CO_2, which play an important role in bread formation. The baking yeast belongs to *Saccharomyces cerevisiae* specie, according to Hansen classification, from 1904, and is exclusively a culture yeast [3].

The main aim of backing yeast technology is to produce maximum biomass quantity with a minimum consumption of raw materials and utilities.For being appropriate for delivery to the backing companies and for commercialization, the backing yeast must meet some quality conditions, regarding the sensorial, physical-chemical and biological properties. The main property which determines the quality of the baking yeast is the dough time, which, according to the Romanian standards, must be maximum 90 minutes.

The technological operations used in the production of compressed backing yeast can be groped as follows:

- the preparation of the nourishment molasses and of the nourishing solution;
- the multiplication of the yeast cells in successive (sequential) generations;
- the separation of the yeast from the dough, forming and obtaining the compressed baking yeast [1,2].

The fermentation vessels used for the yeast production must ensure the following conditions:

- intense aeration and homogenisation in the culture medium, which lead to a fast transfer speed of the oxygen in the gas-liquid-cell system and also standardise the temperature and the composition of the fermentation medium;
- low hydraulic resistance for aeration;
- efficient cooling of the dough;
- easy operation and efficient cleaning [1].

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One of the main conditions for the development and multiplication of the yeast is the aeration of the nourishing medium. The air is the oxygen source necessary for vital processes in the cell and contributes to the yeast multiplication, because it takes out from the medium the carbon dioxide and other volatile products. The aeration also produces the stirring of the culture medium.

Under this circumstances, the yeast cell is in permanent contact with the nourishing substances from the medium: sugars, amino acids, inorganic elements (phosphorus, potassium, magnesium), and also with the oxygen from the air. The raw material and the nourishing substances are supplied after a well established programme, though flowmeters.

All the technology existing for the production of backing yeast, used at this moment, is stipulating a continuous accumulation of biomass. The yeast cultivated in the pure culture station (stand) is multiplied in 2-4 steps, in the factory, according to the technology and the equipment. The obtained yields differ depending on the raw materials characteristics, the yeast culture used and the technologies applied.

In the backing yeast industry, several yeast obtaining systems are used, differentiated by criteria as:
- technological procedure applied – discontinuous, semicontinuos, continuous;
- usage of the raw material – diluted mash or concentrated mash;
- number of multiplication (steps) stages: three – five stages of yeast's multiplication [3].

The technological schemes existing at the moment are based on the same multiplication methods, the producers of baking yeast including their specific differences in technology, or by the mean of the equipment used. The main difference in between the technologies used for baking yeast production is obvious at the level of the group of operations used for the multiplication of the yeast. The most used procedure worldwide is the discontinuous technology, with diluted mashes [1,2].

2. Material and methods

The specific feature of the proposed technology is the multiplication of baking yeast cells in intensive system using the dynamic aeration in reduced multiplication cycle. The yeast multiplication is performed in three steps. The technology and pilot fermentation vessels for yeast multiplication were design at pilot scale and the technological process comprises two main steps [4]:

- producing of baking yeast biomass;
- recovering and concentration of baking yeast biomass.

The main equipments of the pilot installation where the experiments were performed are three fermentation vessels for yeast multiplication, having different total volumes. The main components of the installation are the following:
- fermentation vessels for yeast multiplication having different volumes: 20 litres total volume fermentation vessel for the first fermentation stage; 70 litres total volume fermentation vessel for the second fermentation stage;140 litres total volume fermentation vessel for the third fermentation stage;
- autoclave for sterilization of diluted and acidified molasses;
- centrifuge for biomass recovery from fermented mashes;
- filtration installation composed from a Büchner funnel, extraction vessel and vacuum pump.

The aerobe fermentation vessels are endowed with continuous oxygen diffuser system and with defoamer device. For stirring and air diffusing a Vogelbush dispersion device was used. This kind of device is able to carry on a fine dispersion of oxygen into the biomass, this allowing the process of more concentrated mashes and lead to the increase of total yield of installation and decrease of oxygen consumption.

The technological operations that can be performed in the pilot installation are the following:

- yeast multiplication;
- preparation of nutritive medium for yeast multiplication with molasses as substrate;
- sterilisation and cooling of nutritive medium;
- inside cleaning and sterilisation through steam injection.

The proposed and experimented technology at pilot level comprises three main groups of technological operations:

- preparation of molasses used as nutritive substrate;
- yeast multiplication in three successive stages in order to accumulate yeast biomass;
- recovering of yeast biomass from the fermentation medium, followed by washing and concentration of

baking yeast biomass through filtration to ca. 30% d.m.

The preparation of molasses used as nutritive substrate comprises the following groups of technological operations:
- dilution of molasses with potable water till a concentration of ca. 40% d.m.;
- acidification of molasses using concentrated sulphuric acid (pH final 4.5 – 4.8);
- sterilisation of molasses;
- clarification of diluted and sterilized molasses through decantation and filtration.

There were performed pilot tests using different molasses and different diagrams for the supply of fermentation vessels with nutritive substrate. There were produced baking yeast experimental batches and their physical-chemical indicators were analysed.

The yeast pure culture was prepared based on the culture from a stock test tube. The culture medium is a liquid medium containing malt finished wort 12% d.m. The pure culture preparation was performed in two stages:
- yeast was reactivated through seeding of the solid nutritive medium (malt wort 8% d.m. + 2% agar);
- the yeast grown on the solid medium was dispersed in 10 ml sterile distilled water and then introduced into a laboratory vessel containing 500 ml malt finished wort 12% d.m. After 24 hours of multiplication at 30^0C, the yeast culture was inoculated into the first multiplication stage fermentation vessel [4].

The yeast multiplication was performed in three stages for a gradual increase in yeast biomass and in the last stage the "for sale baking yeast" is obtained, in order to make a comparison with industrial process.

For every technological multiplication stage a specific hourly feeding diagram was applied for molasses and nutritive salts solutions. As nutritive salts ammonium sulphate and super-phosphate extract were used.
The technological quality characteristics for molasses – raw material for baking yeast are the following [5]:
- dry matter – min. 78%;
- total sugar content – min. 50%;
- directly reducing sugar content – max. 1%;
- ash – max. 12% ;
- calcium oxide – max. 0.6%;
- pH – 6.5 – 7.5;
- colloids – max. 9%;
- caramel – max. 1%;
- total nitrogen – min. 1.4% ;
- free nitrogen – min 0.4% ;
- nitrites – 0.

Three series of experiments were performed using the same feeding diagram and different batches of molasses, under similar pilot conditions. The fresh mash for every multiplication stages has the following composition:

- the first stage – 10 litres mash
  - potable water – 5 litres
  - molasses – 4 litres molasses 40% d.m. (equivalent with 2.13 kg molasses standardized at 75% d.m.);
  - 330 ml solution of ammonium sulphate (30% concentration);
  - 670 ml solution of super-phosphate extract (16% concentration).

- the second stage – 40 litres mash
  - potable water – 20 litres
  - molasses – 16 litres molasses 40% d.m. (equivalent with 8.53 kg molasses standardized at 75% d.m.);
  - 1.32 litres solution of ammonium sulphate (30% concentration);
  - 2.68 litres solution of super-phosphate extract (16% concentration).

- the third stage – 100 litres mash
  - potable water – 50 litres
  - molasses – 40 litres molasses 40% d.m. (equivalent with 21.3 kg molasses standardized at 75% d.m.);
  - 3.30 litres solution of ammonium sulphate (30% concentration);
  - 6.70 litres solution of super-phosphate extract (16% concentration).

The specific parameters for every multiplication stage are presented in table 1. The next step after multiplication is the separation of yeast biomass from the mash. This operation was performed using a laboratory centrifuge with 250 ml tubes. The yeast biomass was centrifuged for 20 minutes at 4000 rpm. The biomass was concentrated using the filtration installation composed from a Büchner funnel, extraction vessel and vacuum pump.

Table 1. The specific parameters for every multiplication stage of baking yeast

Multiplication stage	Duration, h	pH	Temperature, ^{0}C	Air throughput, litres/litres/min.
I	17	4.5	30^{o}C	0.6
II	17	4.5 – 5	30^{o}C – 32^{o}C	0.6
III	17	4.8 – 5.4	32^{o}C – 34^{o}C	0.7

3. Results and discussion

The designed pilot and industrial process of baking yeast producing consists in a gradual multiplication of yeast in volumes bigger and bigger, in order to obtain a concentration in cell per unit of volume as much as possible.

The sequence of process designed and experimented in a pilot installation was the following: during the first stage a small quantity of biomass is obtained. Part of it is used as inoculum, for seeding the second fermentation vessel, when a bigger biomass quantity is produced. Part of biomass obtained in the second multiplication stage is then used as inoculum for the third multiplication fermentation vessel, when a bigger biomass quantity in comparison with the second stage is produced. The duration of every separate stage of yeast multiplication is 17 hours [4]. For every multiplication stage in fermentation vessels are introduced inoculum, potable water and nutrients: molasses, ammonium sulphate and super-phosphate extract. The inoculum and potable water are introduced from the beginning in the fermentation vessel, but the nutrients are introduced almost during all multiplication stage (during first 16 hours). The feeding with nutrients is not constant all along the feeding process and is scheduled to be performed using feeding diagrams. This paper has not as objective to study the comparative analyse of feeding diagrams, taking into consideration a 17 hours diagram and studying the behaviour and evolution of some technological parameters depending on just of the quality of molasses.

The quality characteristics determined for the centrifuged and washed biomass of baking yeast produced experimentally in a pilot installation were the following:
- dry matter content;
- nitrogen content (expressed as protein);
- phosphorous content (expressed as P_2O_5);
- dough time development.

The quality parameters of baking yeast at the end of multiplication and concentration are presented in table 2.

Table 2. Quality parameters of baking yeast

Experiment no.	Dry matter, %	Crude protein, (N x 6,25), % d.m.	P as P_2O_5, %	Dough time, minutes
1	31.80	51.41	2.34	56
2	32.16	52.19	2.42	59
3	35.61	56.26	1.83	53

Figure 1 presents the evolution of biomass of baking yeast (standardized for 30% d.m.) for all three series of experiments, for all of three multiplication stage.

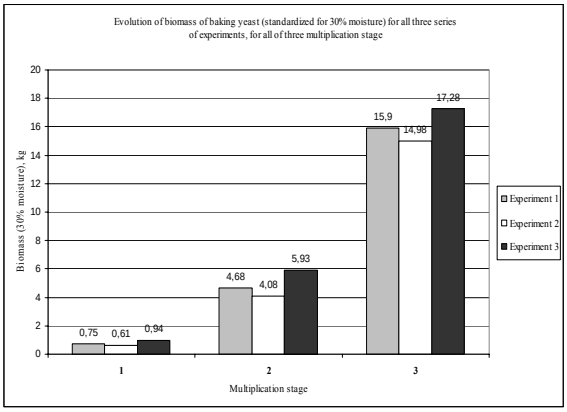

Figure 1. Evolution of biomass of baking yeast (standardized for 30% d.m.) for all three series of experiments, for all of three multiplication stage

At the end of multiplication process, the molasses consumption and biomass of baking yeast obtained through the proposed technology are presented in table 3.

Table 3. Molasses consumption and biomass of baking yeast, for all three series of experiments

Experiment no.	Molasses consumption, kg molasses (standardized for 40% d.m.)	Biomass (30% d.m.), kg
Experiment 1	31.96	21.33
Experiment 2	31.96	19.67
Experiment 3	31.96	24.15

As regards the specific consumption and technological yields calculated depending on the quality parameters of molasses – raw material, the results are presented in table 4

Table 4. Specific consumption and technological yield at baking yeast technological process, depending on the molasses characteristics

Experiment no.	Molasses characteristics		Technological yield in biomass, %	Molasses specific consumption, kg molasses (standardised at 40% d.m.) / 1 kg biomass (30% d.m.)
	Total sugar, (%)	Dry matter, %		
1	50.04	76.8	81.70	1.498
2	50.18	77.2	85.76	1.625
3	52.30	80.1	90.34	1.323

4. Conclusion

The technological yield and specific consumptions depend on the total sugar content and dry matter content of molasses.The correlation total sugar content - dry matter content of molasses has a considerable influence on technological yield and specific consumptions.
For the experiments performed the best results were noticed for experiment no. 3. In this case, the molasses was characterized by a high content in dry matter and a relative good content in total sugar.

We consider that a new technological term for molasses designed for baking yeast industry could be established, namely *molasses processing capacity*. This term is an illustration of technological quality and behaviour of molasses to be processed into the yeast biomass. As a consequence, the molasses should be strictly selected upon technological principles, in order to be processed in baking yeast industry.

The feeding diagram applied in gradual system at pilot level allowed to produce baking yeast biomass with acceptable technological yields and specific consumptions.

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Abbreviations. d.m. – dry matter

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