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ENGLISH

INFORMATION PACKAGE^a
ON
PRODUCTION OF BAKER'S YEAST

Prepared by
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^a The following report gives the names of some of the firms which are known to manufacture yeast in this category, but the list should not be regarded as exhaustive. Inclusion in the list does not imply any recognition by UNCTAD. The data are compiled from information in the files of the Commission for the Development of the Middle East and the Middle East Development Centre, UNCTAD.

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1. Introduction

Yeast are single celled microorganisms of widespread occurrence in nature but only a few are used industrially, such as *Saccharomyces carlsbergensis* for brewing, *Candida utilis* for feed production and *Saccharomyces cerevisiae* for alcohol production and in bread making. (see also table I)

Purpose of use in the bread production is to obtain a leavened dough and a more digestible bread.

For bread production about 2 - 5% of yeast is applied.

There are two types of bakers yeast. The wet yeast (30% total solids) and the active dry yeast (92% total solids). Wet yeast or fresh yeast can only be stored in coldstorage rooms and be transported in air conditioned cars; therefore it is used mainly in cold climate countries or where cold storage facilities are available.

Active dry yeast keeps its activity under normal storage conditions (20°C) over one year, it is easy to transport and to store and therefore it is nowadays mostly used in tropical countries.

The world yeast production is not known with great accuracy, but it is estimated in the order of 500,000 tonnes/year based on dry weight, excluding the Soviet Union. (see table II)

Table I:

Principal Industrial Yeasts and their usage

<u>Yeast species</u>	<u>Products/applications</u>
<i>Saccharomyces cerevisiae</i>	Bread-type products, beer brewing, wine making, distilled beverages, ethanol, cider, food yeast, feed yeast, yeast-derived products, (autolysates, hydrolysates, protein, biochemicals), invertase
<i>Saccharomyces uvarum</i> (syn. <i>S. carlsbergensis</i>)	Beer brewing
<i>Saccharomyces sake</i>	Sake brewing
<i>Saccharomyces bayanus</i>	Sparkling wines
<i>Saccharomyces lactis</i>	Lactase
<i>Kluyveromyces fragilis</i> (syn. <i>S. fragilis</i>)	Food yeast, feed yeast, ethanol
<i>Candida utilis</i>	Food yeast, nucleic acids, feed yeast
<i>Candida tropicalis</i>	Food yeast, feed yeast
<i>Candida pseudotropicalis</i>	Food yeast, feed yeast
<i>Candida lipolytica</i>	Feed yeast

Table II:

Estimated annual yeast production, 1977 (dry tons)

<u>Location</u>	<u>Bakers' yeast</u>	<u>Dried yeast*</u>
Europe	74,000	160,000
North America	73,000	53,000
The Orient	15,000	25,000
United Kingdom	15,500	**
South America	7,500	2,000
Africa	2,700	2,500

Production figures for USSR not reported

*) Dried yeast includes food and fodder yeasts; data for petroleum-grown yeasts are not available.

***) None reported

2. Yeast technology

2.1. General remarks

Bakers' yeast is obtained by fermenting a sugar solution with a selected yeast strain. In order to stimulate the yeast growth air (oxygen) and nutrients must be added, without them yeast would ferment the carbon source (sugar) into alcohol and not assimilate it for growth.

In order to obtain bakers' yeast in the required quality (see Annex 1, quality parameters of bakers' yeast) and with economically reasonable (yield) raw materials, nutrients and air have to be specially prepared and added following a detailed programme called internationally "Zulauf". The conditions of fermentation (pH, temperature, etc.) are also controlled continuously.

The equipment and machinery must be suitable to match the requirements of the process and also be adapted to the locally available raw materials, chemicals and utilities. The generally required raw material and utility standards are given in the Annex 2 and 3.

Normally a bakers' yeast production facility is divided into several departments.

- Preparation of molasses
- Fermentation and centrifugation
- Yeast cream storage and pressing
- Yeast drying
- Utility supply
- Storage and infrastructure facilities

2.2. Preparation of molasses and nutrients

The purpose of the preparation is to transform the substances, which are necessary for the yeast growth into a form and concentration, which can be assimilated by the yeast. (solid into a low concentration liquid.)

Furthermore, toxic substances which impede yeast growth and reduce quality, must be eliminated.

Molasses preparation

The principal raw material is molasses (cane or beet molasses). Normally molasses are diluted in a tank with hot water, sterilized with steam, cooled and finally the sludge is sedimented. This can be done batch-wise (cooking tank, sedimentation tank) or continuously using a jet cooler for pasteurisation of molasses and a centrifuge for the sedimentation. A plate heat exchanger is used for cooling. In cases of a very "fine" sludge, molasses can also be filtered through a disk filter.

Nutrient preparation

As nitrogen source, ammonia, urea and diaminonsulfate or diaminonphosphate can be used. There is used generally a combination of two products. As phosphate source, diaminonphosphate or phosphoric acid should be used. The nutrients are diluted with hot water, the sludge is sedimented (in some cases washed) and the clear liquid is used in the fermentation. When chemicals with high purity are used, they can be added to the fermentation without dilution. The pH of the fermentation is controlled with sulfuric acid, which should always be diluted to approximately 10%.

2.3. Fermentation and centrifugation

The yeast is grown in various stages, (pure culture, prefermentation, seed yeast and mainfermentation) in several fermentation tanks. The fermentors are equipped with a highly efficient aeration system, a cooling system and a dosification and instrumentation system.

Normally bakers' yeast is grown at a temperature of 30°C, while the raw materials and nutrients are dosified automatically in accordance with yeast growth. Bakers' yeast is fermented batch-wise. After the batch has been completed, the yeast cells are separated from the mash by centrifuges. The result is yeast cream which is washed with water and again passed through the centrifuge.

2.4. Yeast cream storage and pressing

The yeast cream, which contains about 16-18% total solids is stored at +7°C. It is dehydrated to 28-30% total solids for easier transportation and handling. A continuous vacuum filter is used for capacities over 12 tonnes/day, a batch-wise working filter for lower capacities.

Now the pressed yeast can be either packed and delivered as fresh bakers' yeast to the bakeries, or dried to obtain Active Dry Yeast (ADY). In some countries where big bakeries are close to the yeast factory, yeast cream can also be used. It is delivered daily to the bakery and added directly to the dough.

2.5. Active dry yeast production

The fermentation process is similar to that of the fresh yeast production. After filtration, the yeast is granulated and carefully dried in a continuous or discontinuous process. The dried yeast granulate, i.e. the active dry yeast is then packed under vacuum or protective gas and can be stored up to one year without a substantial loss in activity. The instant character of the active dry yeast is obtained by certain additions (emulgators) as well as by a special drying process. Compared to the conventional active dry yeast, the instant dry yeast has the advantage that it can be worked directly into the dough without any previous water addition.

The drying of the yeast is carried out in a fluid bed dryer. The drying conditions depend on the process applied, however the dryer should be equipped with a device for air conditioning (temperature and humidity control) and another to regulate the air quantity. By regulating the air quantity and the air conditioner, the yeast is dried under sensitive conditions in order to maintain high activity (raising power).

2.6. Utility supply

- Steam:

Steam supply at a maximum of 8 bar is required.

- Water:

Water of drinking quality is required for the process and cooling water with max. 24°C for cooling of the fermentation tanks. Where cooling water is not available, a cooling tower must be installed.

- Electricity:

Availability of electricity at local available voltage must be guaranteed for 24 hours/day.

2.7. Waste water

Large amounts of waste water result from bakers' yeast production (12m³ for 1 ton of fresh yeast). Waste water can be either concentrated through evaporation and used as animal feed stuff or treated by anaerobic digestion, by which methane gas is produced.

3. Economic considerations

Several factors influence the economics of the yeast production such as availability and costs of raw materials, chemicals, utilities, manpower and waste water treatment. One very important fact is the size of the plant.

The industrial scale is more "economical" than a small scale unit, but taking into account the "transportation" aspect, a small size production can be more economical for the customer (bakery). Therefore both plant sizes, the small scale and the industrial scale, will be described and indications given concerning, the technological characteristics and economic impact.

4. Small scale bakers' yeast production

4.1. Technical details

A small scale production unit consists of the same basic equipment for molasses preparation, fermentation, centrifugation, filtration, storage and drying. It demands regular utility supply and a waste water treatment. Normally it is designed in such a way that some equipment and machinery can be used for different purposes for example:

- the yeast propagator as yeast acidification tank
- the main fermenter, as seed yeast fermenter and prefermenter
- one centrifuge for separation and yeast washing
- pumps, which are movable for different applications
- other equipment, such as dryer may also be used for other related industries, such as pharmaceutical or fruit production.

A small scale unit for the production of 500 tonnes fresh yeast/year, or 100 tonnes of ADY/year normally consists of:

- molasses tanks for storage, diluting and cooling
- fermentation equipment with one 2m³ propagator and one 25m³ main fermenter
- one or two centrifuges and one filter press (300 kg fresh/batch)
- 3 yeast cream tanks (5m³ each)
- yeast dryer for 30 kg ADY/hour

- utility supply including boiler, cooling tower or cooling machine, air conditioning equipment, storage for chemicals
- laboratory equipment
- simple instrumentation

The installation of the equipment can be done locally. Some companies also offer equipment which is ready installed in containers, which can be easily set up together with the production unit on the site.

The quality of the final product depends on the local conditions, but is normally 10% less than in sophisticated industrial scale units. (see also table III)

Table III:

Quality standard of fresh bakers' yeast in small scale plant

total solids	28 - 30%
P ₂ O ₅	2.4 - 2.8%
protein	42 - 46%
colour	light
raising power	1200ml CO ₂
stability *	750ml CO ₂

Quality standard of active dry yeast in small scale plant

total solids	min. 92%
P ₂ O ₅	2.2 - 2.4%
protein	40 - 44%
colour	light
raising power	1000ml CO ₂
stability *	650ml CO ₂

*) After 24 hours storage at 35°C

The consumption figures are given in table IV.

Table IV:

Consumption figures for a small scale plant

	fresh yeast (30%)	ADY (92%)
molasses	1300kg	4700kg
urea	20kg	60kg
diaminonphosphate	15kg	50kg
antifoam agent	1.5kg	5kg
sulfuric acid	15kg	50kg
electric energy *	260kWh	2100kWh
process water	25m ³	80m ³
cooling water (24°C)	300m ³	950m ³
steam 2.5bar	250kg	900kg
steam 7.0bar	--	4500kg

*) only for the production line

4.2. Estimation of investment costs

Investment costs depend on local conditions such climate, transportation, ready available infrastructure etc. and can be estimated as follows:

- molasses preparation	USD	25,000.-
- fermentation	USD	110,000.-
- separation/filtration	USD	130,000.-
- yeast storage	USD	30,000.-
- yeast drying	USD	150,000.-
- chemical preparation	USD	15,000.-
- laboratory equipment	USD	30,000.-
- utility machinery *		
(compressor, cooling machine)	USD	60,000.-
- boiler water treatment *	USD	60,000.-
- installation material and		
installation	USD	<u>200,000.-</u>
	USD	810,000.-

	USD	810,000.-
- assistance for design, engineering	USD	<u>300,000.-</u>
	USD	1,110,000.- **

*) may be partly or totally available locally

**) no costs for financing included.

The total investment cost for 1kg ADY produced/year is USD 7.4
(1,110,000 : 150,000)

The total investment cost for 1kg fresh yeast produced/year
is USD 1.6
(800,000 : 500,000)

5. Industrial scale production

5.1. Technical details

Yeast production is considered on industrial scale, when the installed capacity is more than 20 tonnes fresh yeast/day. The basic stages of production are the same as in the small scale plant, however there is normally a higher grade of automatisisation and process control and a better energy and utility economy.

Industrial scale yeast factories are installed in traditional bread consuming countries with a good transportation infrastructure. Depending on the climate and the transportation facilities, ADY production can also be considered.

A factory with a capacity of 20 tonnes/day (6,000 tonnes/year) can produce about 5 tonnes of ADY/day or 1,500 tonnes/year.

The main equipment is the following:

- Raw molasses storage plant
- Molasses treatment plant comprising 2 molasses boiling tanks each 15m³, 1 molasses centrifuge and pumps
- Propagation plant 1 tank 1,000l, 1 tank 15m³, pump
- Yeast fermentation plant with 2 fermenters, each 100m³ with cooling jackets and pumps.
- Yeast cream plant with 3 yeast separators each 50m³/h, 1 plate cooler, 4 yeast cream tanks, 1 acid treatment tank 3m³, pumps.
- Chemical treatment plant with 1 solution tank 12m³, 1 soda tank 12m³, 1 urea tank 12m³, 2 superphosphate tanks each 12m³, 1 sulphuric acid tank 10m³, 1 emulgator tank 1m³, pumps.
- Filtering plant with 1 rotary vacuum filter 8m².
- Plant for continuous production of instant active dry yeast (IADY), 3 fluid-bed dryer 100kg IADY/h and packing plant.
- Pipes, pipe holders, fittings and valves in stainless steel.
- Instrument plant with process control equipment for controlling the fermentation process in the yeast fermentation tanks and with various panels for remote control of pumps and valves.
- Cooling plant based on ammonia as coolant. Cooling of fermenters, yeast cream, fresh air for IADY drying, cold store.
- Air processing plant with 2 x 5,000Nm³/h and 1 x 400Nm³/h rotary blowers with air filter.
- Laboratory equipment
- Boiler plant with 2 steam boilers each 2,000kg/h steam. Softening plant, de-aerator, steel pipes, pumps.
- Cold water and water treatment plant.
- Hot water plant
- Electrical installation with switchboard and cables, lighting installation, 2 emergency diesel generators each 700 kVA.

The installation of the equipment is done locally under the supervision of the equipment manufacturers and the contracted engineering company.

The yeast quality is indicated in table V.

Table V:

Quality standard of fresh bakers' yeast in an industrial scale plant

total solids	28 - 30%
P ₂ O ₅	2.4 - 2.8%
protein	42 - 46%
colour	light (almost white)
raising power	1,500ml
stability	900 - 1,000ml

Quality standard of active dry yeast in an industrial scale plant

total solids	min. 92%
P ₂ O ₅	2.2 - 2.4%
protein	40 - 44%
colour	light
raising power	1,300ml
stability	900ml

The consumption figures are indicated in the following table.

Table VI:

Consumption figures for an industrial scale plant

	fresh yeast (30%)	ADY (92%)
molasses	1,200kg	4,400kg
electric energy *	240kWh	1,900kWh
cooling water (24°C)	--	900m ³
steam 2.5bar	200kg	800kg
steam 7.0bar	--	4,000kg

*) only for the production line

5.2. Estimation of investment costs

- molasses preparation	USD	200,000.-
- fermentation	USD	900,000.-
- separation/filtration	USD	700,000.-
- yeast storage	USD	60,000.-
- yeast drying	USD	1,100,000.-
- chemical preparation	USD	100,000.-
- laboratory equipment	USD	250,000.-
- utility (machinery)	USD	500,000.-
- boiler, water treatment	USD	300,000.-
- installation material	USD	<u>600,000.-</u>
	USD	4,710,000.-

assistance for design, engineering
and start up

USD 1,000,000.-
USD 5,710,000.-

Total investment cost for 1kg ADY produced/year is USD 3.81
(5,710,000 : 1,500,000)

Total investment cost for 1kg fresh yeast produced/year is USD 0.83
(5,000,000 : 6,000,000)

6. Conclusion

It has been shown that the investment costs for the production of 1kg yeast are two times higher in the small scale plant than on the industrial scale. It seems that big industry is more economical than small scale. However, industrial production requires also a big market demand and availability of good transportation infrastructure. There is no demand for yeast on the export market at the moment, so yeast production should only be designed to a capacity which meets the local demand. In many cases, where yeast is imported and raw materials (molasses) and utilities are locally available, a small scale production unit might be feasible, especially when considered from the socio-economic point of view.

7. List of equipment suppliers and engineering companies:

Becker - Andritz GmbH
Andritz
8045 Graz
Austria

Vogelbusch GmbH
Blechturm-gasse 11
A- 1050 Vienna
Austria

Alfa - Laval AB
Box 500
S- 14700 Tumba
Sweden

VOEST - Alpine AG
P.O. Box 2
A- 4010 Linz
Austria

Westfalia Separator AG
P.O. Box 3720
4740 Oelde 1

Westphal Ing KG.
Bahnhofstr. 47
D- 6050 Offenbach/Main
F.R.G.

Levalco APS
10, Raffinaderivey
DK- 2300 Copenhagen
Denmark

National Filter Coop.
147, West 22nd Street
New York 11
USA

The Pfandler Comp.
1000 West Avenue
Rochester 3, N.Y.
USA

Starcosa GmbH
Am Alten Bahnhof 5
D- 3300 Braunschweig
F.R.G

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The Yeasts, Volume 3
Yeast Technology
Academic Press, London 1970

Technical Inquiry Service
Office of Technical Services
U.S. Dept. of Commerce, Washington, D.C., USA

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(ACP-EEC Convention of Lome)
Brussels, Belgium

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Publishing Co. Inc., 1960

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New York, 1958

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Kautzman et a.
Die Hefen,
Hans Carl Nürnberg F.R.G, 1962

H. Kretschmar,
Hefe und Alkohol,
Springer, Berlin, 1955

J. White,
Yeast Technology,
Chapmann and Hall, London 1954

Annex 1

Requirements on molasses

total solids	80 - 90° Bx
total sugar	45 - 60%
not fermentable sugar	max 6%
nitrogen	min 0.3%
P ₂ O ₅	min 0.1%
ash	max 10%
sludge	max 4%
pH	5.0 - 6.5
volatile acids	0.5%
alcohol yield	min 29%

Annex 2

Requirements on utilities

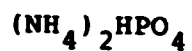
Process water should be of drinking quality

temperature	max. 18°C
total hardness	max. 15°dH (150mg CaO/l)
iron	max. 0.1mg/l
KMNO ₄ -demand	max. 10mg/l
Cl	max. 250mg/l
NO ₃	max. 50mg/l
SO ₄	max. 500mg/l

Annex 3

Requirements on chemicals

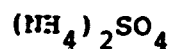
Diammoniumphosphate:



technical quality:

P_2O_5	min. 50%
N_2	min. 20%
As	max. 0.0001%
Fe	max. 0.01%
Pb	max. 0.01%
water	max. 1.0%

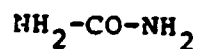
Diammonsulfate:



technical quality:

N_2	min. 20%
$(\text{NH}_4)_2\text{SO}_4$	98.8 - 99.7%
CaO	max. 0.1%
ash	max. 0.25%
water	max. 0.5%
As	max. 0.0001%
Pb	max. 0.01%

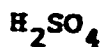
Urea:



technical quality:

N_2	min. 45%
humidity	max. 1.0%
(NH_3)	max. 0.015%
Pb	0.01%
As	0.0001%
biuret reaction	max. 0.1%

Sulfuric acid:



concentration	min. 94.0%
Pb	max. 0.01%
As	max. 0.0001%

Antifoam agent:

A synthetic antifoam agent is recommended, e.g.:
glanapon 2000 FKW

Desinfectant:

NaOCl (solution)	
spec. gravity	1.190
active chlor	min. 10%
NaCl	max. 8.2%
NaOH	max. 2.5%
Na_2CO_3	max. 1.3%
HCHO (solution)	
HCHO	min. 40%