Tropical Products Institute

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An industrial profile of yeast production

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Contents

	Page
NOTE	iv
ACKNOWLEDGEMENTS	iv
SUMMARIES	
Summary	1
Résumé	1
Resumen	2
INTRODUCTION	3
RAW MATERIALS	3
WORLD PRODUCTION AND USES	3
DESCRIPTION OF THE PROCESS	4
SIZE OF PLANT	5
MACHINERY AND EQUIPMENT	5
CAPITAL REQUIREMENT	5
PHYSICAL INPUTS	6
PERSONNEL REQUIREMENTS	6
FEASIBILITY STUDIES	6
FIGURE 1	
Flow chart of baker's yeast production systems	7

NOTE

The Tropical Products Institute has published a number of studies of industries designed to facilitate investment decisions in developing countries. These usually deal in considerable detail with costs as well as physical inputs. This study is limited to the presentation of basic information about industrial processes such as a description of the process, machinery and equipment requirements, raw materials, power, labour requirements, an estimate of capital costs etc. The information provided is not sufficient to enable investment decisions to be taken. This can only be done in relation to the conditions pertaining to a particular geographical location and requires further investigation, taking into account local costs and conditions. The study should enable potential investors, in the private or public sectors, to decide if further investigation in the form of a feasibility study, is warranted. Further information can be obtained from the Tropical Products Institute which may be able to carry out feasibility studies, on contract or under Technical Co-operation terms.

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Summaries

SUMMARY

This profile provides a brief introduction to the yeast production industry with particular emphasis on the production of baker's yeast. Yeast can be obtained either as the primary product of a process, as in the case of baker's yeast, or as a secondary or by-product from alcoholic fermentations. Secondary yeast is usually preferred to primary yeast for use as animal feed for reasons of economy.

Carbohydrates in the form of molasses or hydrolysed starches are the most commonly used substrates for yeast growth. Carbohydrate-containing waste streams from other processes and n-paraffins from oil have also been exploited for the production of feed yeast.

Processes for the production of primary yeast vary but basically consist of materials preparation, seed yeast production, fermentation, yeast separation and pressing or drying steps, depending on the type of yeast required. About half a million tonnes are thought to be produced annually, slightly under half as baker's yeast.

The size of plant can vary from half a tonne per day upwards. Plants have been built for n-paraffin feed yeast with capacities of 100,000 tonnes per year. The cost of a basic plant to produce 7.5 tonnes of active dried baker's yeast (10% moisture) per day would be about £3.5 million f.o.b. UK in July 1980. Additional plant, necessary in many locations, would increase the cost. Yeast plants are not labour intensive; this scale of operation would provide 21–24 jobs.

Detailed feasibility studies should be undertaken to follow up this introduction where it is felt circumstances might be favourable.

RÉSUMÉ

Cet exposé donne un bref aperçu de l'industrie de la production de levure en insistant particulièrement sur la production de levure de boulangerie. La levure peut être obtenue soit comme le produit primaire d'un traitement, comme dans le cas de la levure de boulangerie, soit comme un produit secondaire ou sous-produit à partir de fermentations alcooliques. Pour l'alimentation animale, on préfère habituellement la levure secondaire à la levure primaire pour des raisons d'économie.

Les hydrates de carbone sous forme de mélasses ou d'amidons hydrolysés sont les substrats le plus couramment utilisés pour la croissance des levures. Les effluents contenant des hydrates de carbone provenant d'autres transformations et les n-paraffines provenant de l'huile ont également été exploités pour la production de levure pour l'alimentation animale.

Les procédés de production de la levure primaire sont variables, mais en principe ils consistent en préparation des matériaux, production de levure d'ensemencement, fermentation, séparation de la levure et stades de compression ou de séchage suivant le type désiré de levure. On estime la production annuelle à près d'un demi million de tonnes, dont un peu moins de la moitié comme levure de boulangerie.

La taille d'une usine peut être d'une demie tonne par jour et plus. Des usines ont été construites pour la production de levure pour l'alimentation animale à partir de n-paraffines avec des capacités de 100.000 tonnes par an. Le prix d'une usine de base pour la production de 7,5 tonnes de levure de boulangerie sèche active (10% d'humidité) par jour serait d'environ £. 3,5 millions f.o.b. Royaume-Uni en juillet 1980. Matériel supplémentaire, nécessaire dans de nombruses régions, augmenterait le prix. Dans les usines de production de levure, la main d'oeuvre n'est pas intense; une opération à cette échelle fournirait 21 à 24 emplois.

Des études détaillées des possibilités de réalisation doivent être entreprises pour faire suite à cet aperçu là où l'on estime que les conditions pourraient être favorables.

RESUMEN

En este artículo se introduce de modo breve la industria de la producción de levadura, empleada en panadería. La levadura puede obtenerse como producto primario de un proceso, como es el caso de la levadura empleada en panadería, o bien como subproducto o producto secundario procedente de fermentaciones alcohólicas. La levadura secundaria es preferida normalmente a la primaria para su uso en piensos animales, debido a su economía.

Los hidratos de carbono en la forma de melazas o los almidones hidrolizados son los substratos más ampliamente utilizados en la producción de levadura. Los desperdicios fluidos que contienen hidratos de carbono procedentes de otros procesos, así como las parafinas-n procedentes del petróleo, han sido también explotados en la producción de levadura para piensos.

Los procesos para la producción de levadura primaria varían, pero básicamente consisten en la preparación de materiales, la germinación de la producción de la levadura, la fermentación, la separación de la levadura y el prensado o las etapas de secado, dependiendo del tipo de levadura requerido. Se cree que la producción anual es de medio millón de toneladas aproximadamente, de cuya cifra un poco menos de la mitad corresponde a levadura empleada en panadería.

El tamaño de la instalación puede variar desde media a una tonelada de producción diaria como mínimo. Se han construido instalaciones para la producción de levadura para piensos procedente de parafina-n con capacidades máximas de 100.000 toneladas anuales. El costo de una instalación básica que produjera 7,5 toneladas de levadura deshidratada activa para uso panadero (10% de humedad) al día sería de unos 3,5 millones de libras esterlinas f.o.b. en el Reino Unido en julio de 1980. La maquinaria adicional, necesaria en muchas ubicaciones, incrementaría el costo. Las instalaciones de producción de levadura no usan gran cantidad de mano de obra; esta escala de producción crearía de 21 a 24 puestos de trabajo.

Deberán llevarse a cabo estudios de posibilidad de realización detallados como continuación a esta introducción, cuando se piense que las circunstancias pudieran ser favorables.

An industrial profile of yeast production

INTRODUCTION

Yeasts are single-celled micro-organisms of widespread occurrence in nature though only a few species are important industrially. Strains of the species *Saccharomyces cerevisiae* are used in breadmaking and the production of wines, beers and potable spirits while *Candida utilis, Saccharomyces fragilis* and *Candida lipolytica* are used for the production of food and feed yeast from various sources.

Yeast is available either as the primary product of a process or as a by-product of alcoholic fermentations where its sale provides an addition to revenue from the main product. By-product or secondary yeast is not suitable for baking purposes due to its low activity and the presence of other undesirable components, for example, hop residues. For use as a food or feed ingredient, however, where live cells are not required, secondary yeast is usually cheaper to produce than the purpose-grown, primary product. This profile concentrates on the production of baker's yeast.

RAW MATERIALS

Baker's yeast is usually grown on a molasses-based medium which provides carbohydrate in a form readily assimilated by the yeast. Starchy raw materials such as grain, cassava, potatoes and yams could also be used, but additional cost is involved as the starch must first be degraded into fermentable sugars. This is normally achieved by heating the material to gelatinize the starch and treating it with starch degrading enzymes in the form of malted grains or preparations produced commercially from micro-organisms.

Primary yeast for use in food and feeding stuffs is occasionally produced from substrates such as ethanol or molasses. The use of low-, or even zero-, cost raw materials such as the effluent streams from various processes has, however, received more attention due to the relatively low value of the product. For example *C. utilis,* which can utilise a wider range of carbon sources than *S. cerevisiae,* is grown on waste sulphite liquor from paper making and the high strength effluent from confectionery production. Starch-containing waste streams from potato processing have been used in the production of feed yeast by a mixed culture of *Endomycopsis fibuligera* and *C. utilis,* and cheese whey is used to produce the food yeast *S. fragilis.* Non-renewable resources such as gas oil and purified n-paraffins have also been used in the production of *C. lipolytica* for use as an animal feed ingredient.

WORLD PRODUCTION AND USES

World yeast production is not known with great accuracy but is probably of the order of half a million (dry) tonnes per year (excluding production in the Soviet Union), slightly less than half this total being baker's yeast.

Baker's yeast is produced in two forms, pressed yeast containing around 30% solids, and active, dried yeast which contains about 90% solids.

Fresh, pressed baker's yeast is more active than the active, dried variety (about 1.5 times on a dry matter basis) and is cheaper to produce. It does, however, require refrigerated storage and has a shorter shelf life. Tropical countries contemplating producing baker's yeast would have to weigh carefully the relative merits of a smaller capacity plant to produce pressed yeast and the superior keeping and handling properties of the active, dried material.

Feed yeast is usually dried for ease of handling and storage although it can be used in fresh state provided there is a convenient local market where it can be used quickly.

Some yeasts, both primary and secondary, are used in the production of yeast extract and various biochemicals required by the food and pharmaceuticals industries.

DESCRIPTION OF THE PROCESS

Figure 1 outlines the process for the production of baker's yeast from cane molasses.

Molasses often contains substantial amounts of suspended colloidal material which interferes with the process and must be removed by precipitation and centrifugation in a preliminary clarification step. It is then diluted to its working concentration with water, and nutrients such as ammonium phosphate, ammonium sulphate and sometimes vitamins are added. The medium is sterilized to remove contaminating micro-organisms by passing it through a heat exchanger.

The yeast inoculum is grown up from a laboratory stock culture through a series of increasingly large fermenters, the product from one serving as inoculum for the next. In the production fermenter the yeast is propagated by a fed-batch process in which medium is added to the inoculum at an increasing rate until the fermenter is full; the contents are then left for a period of up to 2 hours to ripen before harvesting.

The fermenters used are well aerated with sterile filtered air, the pH maintained at a constant value (usually between 4 and 6) and foam formation restricted by mechanical breakdown or the addition of anti-foam chemicals. Cooling coils or a similar arrangement are fitted to remove the large amounts of heat liberated during the fermentation and maintain the temperature at a level between 25° C and 35° C. The total time for the production stage is 9—15 hours.

Yeast cells are separated from the medium, washed and concentrated in a series of centrifuges. The yeast cream produced, which contains about 20% weight by volume yeast solids is kept in a refrigerated holding tank prior to filtration on a rotary vacuum filter. At this stage yeast is in the form of a cake containing 28—30% weight by weight yeast solids.

Pressed baker's yeast is then mixed with small quantities of emulsifiers and vegetable oils, extruded through a nozzle and cut to size. Active, dried yeast is extruded through a screw press to produce a granular product which is then air-dried at 40—50° C in a fluidized bed air dryer or some other low temperature drying system. Low temperature drying to preserve viability is unnecessary in the production of feed yeast which is dried at high temperatures in a drum dryer.

Pressed yeast is packed in waxed paper and stored at 4° C. Active, dried yeast can be packed in small polythene lined packets or gas-tight tins and stored in a cool place until distribution.

SIZE OF PLANT

Very small quantities of yeast can be produced at the kitchen level by procedures such as the sour dough technique occasionally used in breadmaking. The capacity of commercial plants can be upwards from half a tonne per day, the most common size in demand being in the 5—10 tonnes-per-day range. Size is influenced by the usual range of factors such as location, raw material sources, market size, availability of capital, etc. Economies of scale may be particularly important when primary feed yeast is produced as it is subject to competition from other high protein feedstuffs such as soya- and fish-meal. Commercial plants for this purpose using n-paraffins have capacities as large as 100,000 tonnes per year.

MACHINERY AND EQUIPMENT

The plant described here will produce 7.5 tonnes per day of active, dried baker's yeast with a 10% moisture content using molasses as carbon source. It requires the following basic machinery and equipment:

Molasses storage tanks
Molasses clarification, dilution, sterilisation and nutrient addition plant
4-stage aerobic fermentation system with heat exchangers and control equipment
Yeast centrifuging and washing system
Yeast cream chilling and storage plant
Rotary vacuum filter
Fluidized bed dryer for yeast drying with associated equipment for conveying and breaking up the yeast
Yeast bagging equipment
In-place cleaning equipment
Interconnecting process and service pipework
Instrumentation and control equipment
Electrical and control field wiring
Main services, i.e. steam boiler, refrigeration plant, cooling towers, air compressor

In addition to the above the following may also be needed in some locations:

Electricity generators
Weighing equipment
Laboratory equipment
Office fittings
Water and effluent treatment plant
Spares

CAPITAL REQUIREMENT

The cost of this plant in July 1980 including installation, commissioning and engineering design but excluding carriage, insurance and freight is given as £3.5 million sterling. Any or all of the possible additional requirements listed would of course add to this cost.

Machinery and equipment costs are, however, only one of the components of capital requirement. Provision must also be made for land costs, buildings, civil engineering, transport of machinery and equipment to site, installation and commissioning (if not included in prices), training of personnel, and working capital. These components can vary enormously from one location to another and their calculation therefore is more appropriately in the province of feasibility studies.

PHYSICAL INPUTS

The following approximate inputs are given for the above plant (n/a = not available):

Steam	1.6 tonne/h
Process water	n/a
Cooling water	200 m^3 /h
Electricity	400 kW
Compressed air	30,000 m^3 /h
Feedstock, molasses (50% sugar)	30 tonne/day
Nutrients	100 kg/tonne
Antifoam, acid, and alkali	Small quantities

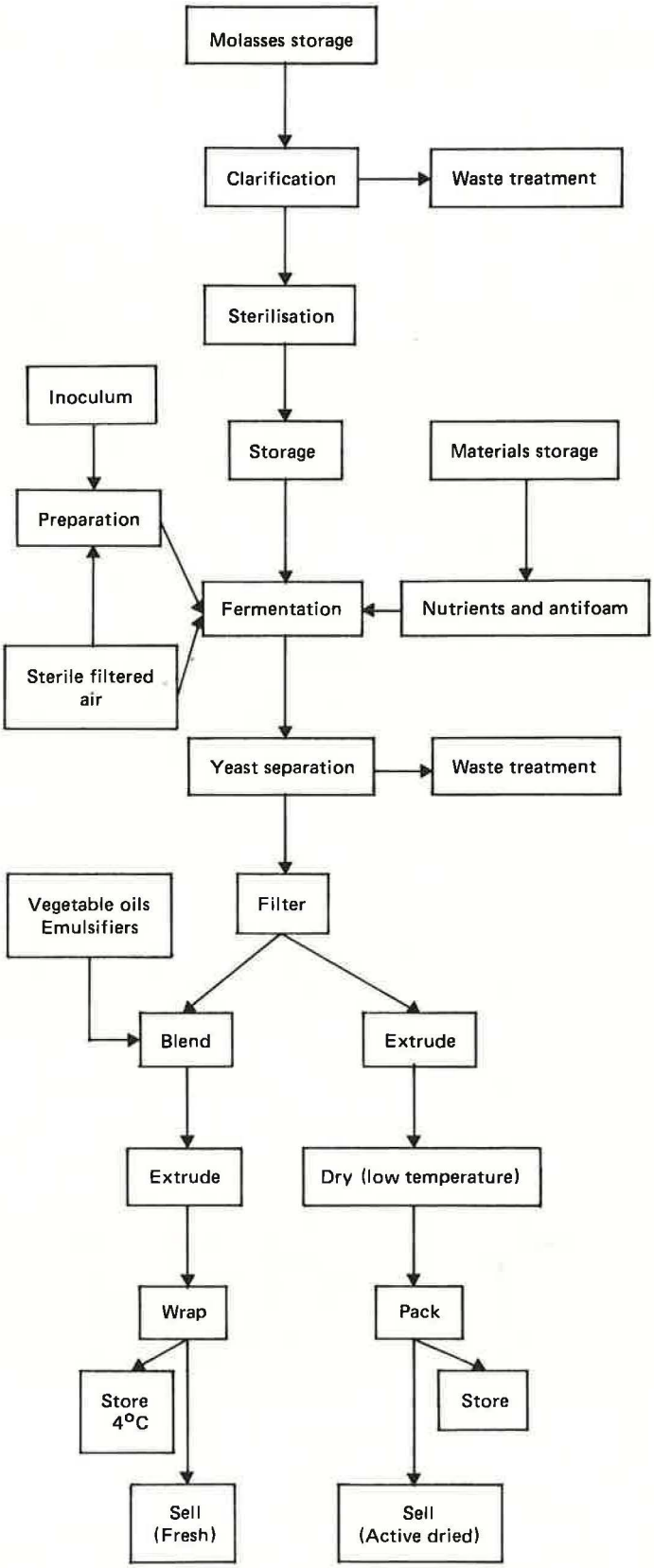
PERSONNEL REQUIREMENTS

Aside from the usual manager-secretary-clerk type of management structure, the personnel should include at least one professional technologist and one skilled maintenance fitter per shift operated, for any size of plant. Yeast production plants are not labour intensive, especially when instrument controlled. The addition of two or three other operators per shift is probably sufficient for the plant outlined. Drying, packing and storage may require two additional people bringing the total shift requirements of six or seven and the total personnel requirement to some twenty-one to twenty-four people. Operation without instrumental control would increase employment by two or three people but this could result in a severe loss in both quantity and quality of product.

FEASIBILITY STUDIES

The information supplied here is intended for initial guidance only. For decision making a feasibility study would be required to assess accurately the capital requirement, costs of raw materials and other physical and labour inputs. Careful assessment of markets and product choice would also be necessary as well as the important question of location.

Figure 1
Flow chart of baker's yeast production systems



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