

WORLD WIDE SURVEY OF  
FERMENTATION INDUSTRIES 1963

*A Report Prepared for the International Union  
of Pure and Applied Chemistry  
by the  
Fermentation Industries Section*

# APPLIED CHEMISTRY DIVISION

## FERMENTATION INDUSTRIES SECTION†

### WORLD WIDE SURVEY OF FERMENTATION INDUSTRIES 1963

#### INTRODUCTION

At the meeting of the Fermentation Industries Section held in connection with the XXII Conference of the International Union of Pure and Applied Chemistry (IUPAC) in London 1963, it was decided that the Section would undertake a world wide survey of the present status, the trends and future potential of industrial fermentation in the world. In consequence of this, 40 inquiries were sent during 1963–1964 to experts in different countries around the world with requests for statistical data regarding various branches of the fermentation industry and reports regarding production, export and import. Response to this questionnaire form has brought data from 28 countries: Argentina, Austria, Brasil, Bulgaria, Canada, Colombia, Czechoslovakia, England, Finland, France, Holland, Iceland, Israel, Italy, Japan, New Zealand, Norway, Philippines, Peru, South Africa, Spain, States of Malaya, Sweden, Switzerland, United States, Uruguay, West Germany and Yugoslavia. Also other available statistics have been used to supplement the survey. In spite of all efforts, it must be admitted that the report is based on rather limited and varying material so detailed diagrams or tables with numerical values have therefore been omitted. Numbers are presented only as examples of the distribution of production, export and import between different countries. Further, for the above reason, the increase or decrease appearing in the different branches of production is not considered; here only an attempt is made to enumerate the different fields of the fermentation industry in 1963. The statistical data obtained have been transformed as far as possible into the same units, metric tons for weight, hectolitres for volume and U.S. dollars for currency. The data are dealt with and the survey drawn at the Research Laboratories of the Finnish State Alcohol Monopoly (Alko).

At the meeting of the Fermentation Industries Section held in connection with the XXIII Conference of IUPAC in Paris, July 1965, it was agreed that some aspects of the material thus collected would create a base for the further work of the Section.

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**INDUSTRIAL ALCOHOL***Production*

In most of the countries which have fermentation industries, ethyl alcohol is produced by fermentation on a large industrial scale. Alcohol is produced mainly for two purposes: as solvents for industry or as raw material for alcoholic beverages. In countries where beet or cane molasses are abundantly available, alcohol production is generally from these sources of raw material. Some ethyl alcohol is also produced from grain, potatoes or sweet potatoes, and fruits, but the alcohol obtained from these sources is used mainly for the production of flavoured and unflavoured beverages. Alcohol is also produced from the sugars of sulphite waste liquor. Particularly in the northern states of Europe, Sweden, Finland and Norway, where the production of synthetic alcohol is limited, sulphite waste liquor is an important raw material for the production of industrial alcohol.

To what extent industrial alcohol today is produced by fermentation is very hard to estimate, partly because production data cannot be obtained from all countries and partly because only a few countries have provided detailed information as to how much fermentation alcohol is used as industrial alcohol and how much for the production of alcoholic beverages. Except for Iceland and U.S.A., all the countries surveyed reported that they produce industrial alcohol by fermentation and their total production during 1963 was a little over 1.3 million tons of 100 per cent alcohol. The above exceptions arise because Iceland makes only beer, and practically all industrial ethanol in the U.S.A. is produced synthetically while fermentation alcohol is used for manufacture of beverages. For comparison, we see that the total production of ethyl alcohol in the U.S.A. during 1963 exceeded 1.9 million tons<sup>1</sup>. The production of industrial alcohol in Europe was about 1 million tons, of which amount England produced 300,000 tons, France 260,000 tons and Italy 116,000 tons; the two latter countries use molasses as the main raw material. Compared with these quantities, the production of industrial alcohol in other European countries is markedly smaller, with amounts varying from 3000 to 85,000 tons annually. The main raw material is molasses, but in some countries also sulphite spirits and small amounts of grain spirits are produced for industrial purposes. The most important producers of sulphite spirits are Sweden with 49,000 tons/year, and West Germany, Finland and Norway with an annual production each varying between 16,000 and 18,000 tons. Switzerland makes all its industrial alcohol from sulphite waste liquor, the average annual production being 3000 tons. Unfortunately no information has been obtained from the Soviet Union, probably the data from that country would markedly alter the production figures for Europe. It is estimated, for instance, that the annual production of sulphite spirits in the Soviet Union exceeds 100,000 tons<sup>2</sup>. As a result of the heavy increase of synthetic ethanol production in U.S.A., almost no industrial alcohol is made by fermentation. Thus, only 17,000 tons of spirits were produced from sulphite waste liquor in 1963<sup>1</sup>. For comparison, the sulphite spirits production in Canada is about 13,000 tons annually. In Asia the annual production of industrial alcohol is about 53,000 tons, of which Japan accounts for approximately 85 per cent. About 33,000 tons of the Japanese industrial alcohol is produced from molasses and 5000 tons

from sweet potatoes. In South Africa approximately 34,000 tons industrial alcohol are produced annually. In South America, Argentina and Brazil have the largest alcohol industry. The total annual production of South America exceeds 200,000 tons, most of it produced by fermentation.

#### *Export and Import*

The fermentation industry together with the synthetic alcohol industry is well able to satisfy the local needs for industrial alcohol today. For this reason alcohol trade on a large scale is very limited. The import and export values for industrial alcohol reported in collected statistics of 1954–1957<sup>3</sup> seem to vary considerably even in the same country. This is obviously due rather to the fluctuations in quality and price than to eventual changes in production capacity. In 1963, the total European import of industrial alcohol was about 68,000 tons, of which the largest importers were Switzerland (15,800 tons), Sweden (13,800 tons), and Norway (12,500 tons). The quantities imported by England, Italy and West Germany exceeded 5000 tons in each case. Very few data are obtainable regarding the European export in 1963. Finland exported 11,100 tons of sulphite spirits. The amount of industrial alcohol exported by England has been estimated to be about 6400 tons. Quantities less than 1000 tons have been exported by Bulgaria, Holland, Italy and West Germany. In 1962, the export of industrial alcohol from France comprised altogether 74,000 tons from beet molasses and the quantities are presumably of about the same magnitude in 1963. Thus, the total quantities of export for Europe amount to about the same as the imports. The import and export of industrial alcohol made by fermentation seem to be of rather minor importance outside Europe. The export and import of Brazil and Colombia amount to 0.5–2.5 tons, the import of the Philippines is 13.5 tons and that of New Zealand about 1600 tons. Obviously the export and import of industrial alcohol produced by fermentation is kept down by the ever increasing production of synthetic alcohol.

## ALCOHOLIC BEVERAGES

### BEER AND WINE

#### *Production*

While the output of industrial fermentation alcohol decreases, due to the rising production of synthetic alcohol, it is obvious that the quantity of alcoholic beverages produced by fermentation increases. The undistilled beverages produced by fermentation are divided into two groups in this survey: beers and wines, both containing various kinds typical of different countries and continents. According to statistical information of the United Nations<sup>4</sup>, the world's beer production was 435 million hectolitres in 1962 and had been estimated to be 448 million hectolitres in 1963, an increase of a little over 3 per cent. The largest beer producers of Europe are West Germany with a production of 62.1 million hectolitres in 1962 and 66.4 million hectolitres in 1963, and England with 45.7 million hectolitres in 1962 and 46.3 million hectolitres in 1963<sup>4,5</sup>. Belgium had incomparably the highest beer consumption per capita of Europe, 140 litres; Czechoslovakia, West Germany and England came next with a consumption

of about 125, 122 and 89 litres per capita, respectively, during 1963<sup>5</sup>. The beer production in Czechoslovakia was about 18 million hectolitres, in France 17.9 million hectolitres in 1963 and in Japan 17 million hectolitres. The United States had the largest beer production in the world, 114.9 million hectolitres during 1963, or about a fourth of the whole world's output, and about four times as large as the beer production of the Soviet Union<sup>4</sup>.

Although wine production has grown since 1955<sup>4</sup>, the increase has not, however, for natural reasons, been as steadily continuous as that of beer. In 1962, 285 million hectolitres of wine were produced in the whole world<sup>4</sup>, and the wine production for 1963 was estimated at 255 million hectolitres or about 30 million hectolitres less than in the year before<sup>4</sup>. France appears as leading wine producer at the top of world wine statistics with a production exceeding 74 million hectolitres in 1962 and 55 million hectolitres in 1963. Italy comes next with 70 million hectolitres in 1962 and 54 million hectolitres in 1963. Spain and Argentina each produced over 20 million hectolitres wine in 1962 and Algeria, U.S.A., Portugal and the Soviet Union each had an output of over 10 million hectolitres<sup>4</sup>.

### Export and Import

Although beer consumption has increased considerably in several countries, the brewing industry has been able to satisfy the increased demand and with a few exceptions, import and export of beer have been of less importance. The only notable import data are reported for England with an import exceeding 2 million hectolitres, and West Germany and France with annual import quantities around 340,000 hectolitres. West Germany exported the most beer in 1963, over 970,000 hectolitres while Holland exported 790,000, U.S.A. 760,000, France 616,000 and Czechoslovakia 350,000 hectolitres.

Almost all the countries, from which replies to the questionnaire have been obtained, have imported wine. The highest import is reported for Switzerland, 1.5 million hectolitres. U.S.A. has imported 830,000 hectolitres in 1963, England 580,000 hectolitres and Sweden and Holland over 300,000 hectolitres each. France and Italy are the most important wine exporting countries, both exporting more than 2.3 million hectolitres. Spain also exported large quantities of wine, about 2 million hectolitres in 1963, and Bulgaria exported 0.9 million hectolitres including fortified wines.

## DISTILLED ALCOHOLIC BEVERAGES

### Production

The production of distilled alcoholic beverages covers a wide range of products: cognac, brandy, whisky, rum, unflavoured spirits such as vodka, and flavoured liquors. The latter group consists of many different varieties. When surveying the production data given for distilled beverages, striking differences appear as to the concentrations and units reported. In countries using English units the production is generally given as Imperial proof gallons<sup>†</sup>, (100 proof or 100 per cent proof = 57.15 per cent v/v at 60°F

† 1 Imperial gallon = 1.201 U.S. gallons.

1 Imperial proof gallon = 1.201  $\times$   $\frac{57.15}{50}$  = 1.313 U.S. proof gallons.

or 15.56°C) while in the United States the concentration is reported as 100 proof (100 proof = 50 per cent v/v at 60°F). Countries using the metric system also use two ways of calculating the concentration: either as 100 per cent alcohol or as 50 per cent alcohol, and further variations appear in the volume units used. Thus, in this survey the production data have been transformed and are given in hectolitres 100 per cent alcohol. Accordingly, the total world production of distilled alcohol beverages is estimated to about 18 million hectolitres of which Europe produces a total of 7.5 million hectolitres. Greatest European producers are Britain, with 3.6 and West Germany, with 1.6 million hectolitres. The French production exceeds 0.5 million hectolitres, of which, in 1962, cognac alone amounted to 0.34 million hectolitres. The production of the United States is reported to be 3.2 million hectolitres which seems to be a too low estimation when comparing with other countries producing distilled beverages. Canadian production of alcoholic beverages and all kinds of spirits, except industrial alcohol, were estimated to be 440,000 hectolitres for the year 1961<sup>5</sup>. In South America, distilled alcoholic beverages are produced mainly by Brazil, Peru, Colombia and Uruguay, and their total production exceeds 2 million hectolitres. In Asia, the production is approximately 4.3 million hectolitres, of which Japan accounts for 95 per cent. Compared with the above quantities the production of South Africa is very modest, altogether about 290,000 hectolitres. The main South African product is brandy, the output of which in 1964 amounted to about 200,000 hectolitres.

### **Export and Import**

In addition to domestic production some countries import a considerable amount of distilled beverages. The import quantities of U.S.A. exceed 0.5 million hectolitres. France reports an import of 0.18 million hectolitres in 1962, England and West Germany both about 0.11 million hectolitres in 1963. In proportion to its population, only about 7.5 million people, Sweden has a considerable import of distilled beverages, 76,000 hectolitres. The imports of other European countries range from 15,000 to 30,000 hectolitres. The export of distilled alcoholic beverages is rather small in many countries and includes a great many types of drinks. According to our survey, the greatest export countries are U.S.A., with an export in 1963 of 0.87 million hectolitres, and the United Kingdom with an export of 0.83 million hectolitres. The U.K. mainly exports whisky, 0.74 million hectolitres, and to some extent gin and other alcoholic beverages. France exports 0.15 million hectolitres, of which 0.14 million hectolitres is cognac, or about 40 per cent of the entire cognac production in France. Other important export countries are Holland and Italy with shipments of 41,000 and 27,000 hectolitres of distilled beverages, respectively.

## **ORGANIC SOLVENTS**

### **Production**

Today the production of other organic solvents by fermentation is rather small compared to that of industrial alcohol, while the synthetic production gradually increases. The world's total production of other organic solvents

was about 53,000 tons in 1963. Acetone and butanol amounted to 30 per cent, glycerol 25 per cent; the rest, about 45 per cent of the world's production, consists of 1,2-propanediol and other fermentation products. Of the European countries Czechoslovakia manufactures glycerol, acetone and butanol. Of the total output of 9900 tons, 55 per cent is glycerol and 45 per cent is acetone-butanol. West Germany has not reported any notable glycerol production by fermentation since 1954. In the United States the annual acetone-butanol production is about 1000 tons. Argentina in South America reports considerable quantities of acetone-butanol, an output totalling 16,500 tons per year. In Asia, Japan produces about 15,000 tons acetone-butanol and 1,2-propanediol annually.

### **Export and Import**

The export and import quantities of organic solvents reported for Europe, America and Asia are surprisingly like the amounts of production reported for the same continents. Obviously this is due partly to the fact that the production data are not complete, and the data for export and import may even contain some synthetically manufactured products. The total European shipments amount to 56,000 tons exported and 54,000 tons imported per annum. Italy does not, according to the reported data, have this kind of fermentation industry, and yet it reports a quite large export, over 28,000 tons per year of which there are 15,000 tons of acetone. The acetone-butanol quantities together represent 98 per cent of the organic solvents exported by Italy. Organic solvents, mainly acetone and butanol, are also exported from Sweden, about 7700 tons in 1963. Holland reports a considerable export of glycerol, 19,000 tons in 1963, but it is presumed that this is not produced solely by fermentation. France and the Philippines also export glycerol. Several countries both export and import organic solvents. The greatest quantities are brought in by Switzerland: in 1963 a total of 23,400 tons were reported, including 18,700 tons of acetone-butanol. Italy's imports in 1963 totalled about 12,500 tons and Sweden's, 8,400 tons; the acetone-butanol portion of Italian imports was about 90 per cent, and of Swedish imports, about 50 per cent. The imports of organic solvents into South America and Asia are rather small compared with those of Europe.

## **ORGANIC ACIDS AND AMINO ACIDS**

### **Production**

Of the organic acids manufactured by fermentation, most important are acetic and citric acids; and of the amino acids it is chiefly glutamic acid. With a few exceptions, all the surveyed countries produce 10 per cent fermentation vinegar for the food industry and for general consumption. Obviously enough synthetic acetic acid is produced to satisfy the industrial demand of other industrial branches; and, thus, the production of fermentation vinegar is generally not very large. The United States has the largest production, 3.3 million hectolitres. In addition, Spain and Japan annually make more than 1 million hectolitres of fermentation vinegar; and the production of Italy, England and West Germany annually exceed 0.5 million hectolitres per country. According to this survey, the world's total

annual production of 10 per cent fermentation vinegar amounts to 9.5 million hectolitres. The production of citric acid is estimated at about 57,000 tons per year in U.S.A. while the European countries produce about 30,000 tons annually. Brazil reports a production of 500 tons and Japan of about 2000 tons of citric acid per year. According to the survey, glutamic acid is produced in Europe by France, 2500 tons and by Italy, 2000 tons annually. The U.S.A. makes about 24,000 tons and Japan 38,500 tons per year. Thus, the total annual production of glutamic acid in the world reaches about the same quantity as that of citric acid—a little over 60,000 tons. In addition to these, other organic acids and amino acids are produced only by the U.S.A. and Japan. In the U.S.A. about 1250 tons of lactic acid, 1600 tons of gluconic acid, 110 tons of itaconic acid and 230 tons of lysine are produced annually. The total annual production of other acids in Japan is about 400 tons, 40 per cent of which is lactic acid.

### **Export and Import**

The small movement of fermentation vinegar reported by the different countries proves that the fermentation industry is more or less able to satisfy the demand of each country. Only Holland imports noticeable amounts, over 200,000 hectolitres; however, Holland also reports a considerable export of vinegar, 136,000 hectolitres. Italy follows with an export of 86,000 hectolitres, Japan with 36,000 hectolitres, and France with 18,000 hectolitres per year. The total import of citric acid by the European countries amounted to 8500 tons annually; France imports 2300 tons, Italy 1900 tons, and Sweden a little over 1000 tons. In South America, Brazil and Colombia import citric acid; and in the Far East, Japan, the Philippines and New Zealand are citric acid importers. Japan has the largest import, 6000 tons annually. Glutamic acid is imported into Europe only by France, Italy, Norway and Switzerland, in amounts totalling 3500 tons; of this quantity, Switzerland imports 2100 and Italy 1200 tons. The United States annually imports up to 900 tons glutamic acid, and the Philippines obtains 700 tons. France, Italy, the U.S.A. and Japan export glutamic acid; the U.S.A. exports the largest amount, 18,000 tons, and Japan, 10,000 tons. In addition to the acids mentioned above, smaller quantities of lactic, gluconic, fumaric and itaconic acids are imported and exported by several countries. In 1964, Spain reported an import of as much as 40,000 tons of lactic acid with a concentration under 50 per cent and 23 tons lactic acid stronger than 50 per cent. Italy imports 500 tons, and Brazil and Sweden each 200 tons of lactic acid. In Finland, Norway, Switzerland, Colombia and New Zealand lactic acid imports vary from 30 to 75 tons per year. France has the largest export of lactic acid, almost 1000 tons, and Italy reports an export of 180 tons. Gluconic acid is imported by the European countries: Switzerland (1300 tons in 1964), France, Spain and Italy (60–100 tons). Practically no data were obtained as to export of gluconic acid except for Italy which reports a small export of about 100 tons. Notable amounts of other imported acids are reported only by Switzerland, about 6600 tons fumaric and itaconic acids, and Norway, fumaric acid, maleic acid and maleic anhydride, totalling 290 tons. No information on the export of these acids was obtained.



**FOOD AND FEED PRODUCTS****PRESSED BAKER'S YEAST****Production**

The fermentation industry has an important place in food production, particularly in the production of yeast. However, it appears that rather few countries have given statistics on their own yeast production and hence, the total annual production of pressed baker's yeast in Europe, 217,000 tons, is based on information obtained only from Austria, Czechoslovakia, England, Finland, Italy, Sweden, Switzerland, West Germany and Yugoslavia. These countries use mainly beet molasses as raw material for the production of a baker's yeast with a dry matter content of 25-30 per cent. In Europe, West Germany leads production with 79,000 tons made in 23 industrial plants. The annual production of England amounts to 40,000 tons, that of Italy to 30,000 tons, and that of Czechoslovakia to 21,500 tons. Sweden and Yugoslavia both produce over 10,000 tons, and Finland about 8800 tons of baker's yeast per year. In Austria, the total production of the 7 yeast plants amounted to 6800 tons baker's yeast in 1963, Switzerland has an annual production of about 5000 tons. Of the world's total output of pressed baker's yeast, the United States dominates with an annual production of 170,000 tons. In South America, Brazil produces 20,000 tons and Uruguay 2000 tons per year. South Africa reports a production of 7000 tons. From Asia production data have been obtained for Japan only, which manufactures up to 42,000 tons fresh yeast annually.

**Export and Import**

Very few of the countries collaborating in this survey have reported any import or export of pressed baker's yeast. France and Holland, from which no production quantities have been obtained, are, together with Italy, the only countries in Europe which mention an export of pressed yeast. France exports 4500 tons, Holland 6400 tons and Italy 30 tons. Further, the U.S.A. reports export of about 1000 tons per year, a small quantity when compared to its total production. Also New Zealand reports a minor export of about 30 tons. Regarding import, information has been obtained from very few countries, England reports an import of 5000 tons and Italy of 1900 tons pressed baker's yeast. France and Holland, which reported exports of baker's yeast, also have some imports: France, 1400 tons, and Holland, 2500 tons.

**ACTIVE DRIED BAKER'S YEAST****Production**

In recent years active dried yeast has gradually become more and more popular. It is obvious that the increased consumption of dried yeast, at least to some extent, will take place at the expense of fresh yeast. On the basis of reports, the production of dried baker's yeast can be considered important, so far, only in a few countries. In the United States the production has already reached 10,000 tons, in England it is 2500 tons, and in Brazil 2700 tons annually. In 1963, Japan as well as South Africa had three production plants for manufacture of dried yeast with output of 300 tons in Japan and 250 tons in South Africa. Small amounts of dried yeast are also

produced in Sweden, Switzerland and Uruguay (Sweden 10 tons, Switzerland 4 tons and Uruguay 2 tons per year). Some manufacture is known to take place also in Holland, but no production data are given. While estimating the present position of dried yeast it is found that Brazil has relatively the largest production, representing 12 per cent of the whole yeast production. In England and the U.S.A., the dried yeast production amounts to 5-6 per cent of the total yeast output.

### Export and Import

Hitherto, the export of dried yeast has been very modest. The United States annually exports about 3000 tons and England about 1500 tons. Very small amounts have also been imported by some reporting countries, by Italy, 5 tons, by New Zealand, 4 tons, and finally by Norway, 1 ton per year.

## FOOD AND FEED YEAST AND OTHER YEAST PRODUCTS

### Production

In many countries the fermentation industries produce other yeasts beside baker's yeast, mainly fodder yeast for the feeding of cattle. In addition small amounts of food yeast, yeast extract, yeast hydrolysate and yeast autolysate are manufactured. In several countries fodder yeast is produced from molasses, though sulphite waste liquor is also quite generally used as raw material. Sweden and Switzerland, for instance, exclusively use sulphite waste liquor for production of fodder yeast. Japan also uses this raw material for nearly all (93 per cent) of its fodder yeast production, but it is the source for only 25 per cent of the U.S.A. production. Distillery wastes or stillage are also utilized as a source of raw material for the production of fodder yeast. In his survey on the World Output of Microbial Food, H. J. Bunker<sup>6</sup> collected additional data from countries not participating in this survey; such as Belgium, Cuba, East Germany, Hungary, India, Iran, Poland, Formosa (Taiwan) and the Soviet Union. According to the statistics of Bunker, food and fodder yeast were manufactured during 1963 in 20 countries, and the annual output was estimated to be 180,000 tons dry weight. The production of fodder yeast predominates in the Eastern European countries. In the Soviet Union it is 52,000 tons, in East Germany 22,000 tons, in Poland 17,000 tons, and in Czechoslovakia 10,000 tons per annum. The Soviet Union, Poland and Czechoslovakia plan to further increase production. France produces 7250 tons of fodder yeast and 150 tons of food yeast annually; in Italy 6200 tons of fodder yeast are made, and it is reported that the European Economic Community (EEC) countries totally produce about 30,000 tons. Further some production is reported by Romania, Hungary, Switzerland, Sweden and Yugoslavia. The United States has a large production of fodder yeast, 20,000 tons; Cuba makes 11,000 tons, Taiwan 13,000 tons and Japan 7500 tons per year. In South Africa the production has exceeded 2000 tons, but in South America it is still quite modest. Both Brazil and Peru produce less than 1000 tons each. In addition to fodder yeast, Italy manufactures about 450 tons per year of yeast extract, yeast hydrolysate and autolysate for human nutrition, while Sweden makes about 10 tons per year of the same products. The output of these products

is rather large in the U.S.A., 1000 tons, while Japan makes 22 tons and South Africa 200 tons per year.

### Export and Import

Only a very few countries have reported noticeable export and import data for food and feed yeasts. France imports a total of 110 tons, Italy 755 tons, Spain 136 tons, and Norway reports an import of 1400 tons fodder yeast and 24 tons of food yeast. Compared to the import of food yeast, that of yeast extracts has been remarkably small: Italy 1 ton, U.S.A. 900 tons and South Africa 30 tons. Fodder and food yeasts have been exported from France (3900 tons), from U.S.A. (2000 tons) and from Japan (2700 tons). Italy has an export of 670 tons, Norway, which has a plant for fodder yeast production although no production data are presented, reports an export of 218 tons. Other yeast products are exported only by Italy (1 ton) and by New Zealand (400 tons).

## ENZYMES

### Production

The information obtained on enzyme production is rather limited, and thus this activity can be surveyed only with regard to a few countries. In this part of our report the production quantities are expressed as U.S. dollar equivalents, except for England and Japan, which use weight units. In England the main production is  $\alpha$ -amylase enzymes, up to 1500–2000 tons; other unspecified enzymes amount to 100–200 tons. Finland made enzymes in 1964 in four production plants; one produced fungal  $\alpha$ -amylase worth \$15,000 annually and the three others made malt amylase equivalent to about \$35,000. In Sweden \$53,000 worth of proteolytic enzymes are produced and about \$20,000 worth of other enzymes. Switzerland has a rather large enzyme production representing a value of \$580,000. The U.S.A. and Japan are the only countries outside Europe reporting data on enzyme production. In the U.S.A. the output exceeds 9 million dollars and comprises proteases produced by microbial or fungal fermentations (\$4.1 million), glucoamylase or amyloglucosidase (\$3.0 million) and bacterial amylase (\$1.5 million). The production of fungal amylases, other carbohydrate hydrolases (e.g. cellulases and hemicellulases), pectinases and other enzymes varies from \$50,000 to \$300,000. In Japan, altogether 40 production plants made enzymes in 1963, and the production amounted to 20,600 tons, including 17,500 tons (or 85 per cent) bacterial  $\alpha$ -amylase, 1450 tons malt amylase, 690 tons glucoamylase, 540 tons protease, 230 tons fungal  $\alpha$ -amylase, and 120 tons lipase. The Japanese production of cellulase, pectinase and some amylase preparations varies from 12 to 36 tons per year.

### Export and Import

Data on import and export quantities of enzymes are obtained mainly from Europe. France has reported the largest import, chiefly  $\alpha$ -amylase enzymes for \$750,000. Spain follows with an import amounting to \$630,000, then Italy \$590,000 and Switzerland, \$450,000. Of the northern European countries, Sweden has imported enzymes worth \$66,000 and Norway \$28,000. Brazil imports 5.2 tons. The Philippines' import of enzymes is

\$54,000, and New Zealand imports \$29,000 worth of enzymes. Export data for enzymes are available only for Europe. France has the largest export (\$461,000), Switzerland (\$320,000), and Italy (\$177,000). Spain and Sweden have had some export, \$40,000 and \$22,000 worth, respectively.

## ANTIBIOTICS

### Production

The production of antibiotics has increased in Europe during recent years, and today South America and Asia have a considerable production. The largest production, however, in quantity as well as in number of different kinds, occurs in the United States. In 1963 about 10 U.S.A. plants had a total output valued at \$385 million. Penicillin and its salts were valued at \$61.6 million, streptomycin \$25.6 million, neomycin and its salts at \$4.8 million, tetracyclines \$66 million, and other antibiotics at \$227 million. In England the total production of penicillin was 159 tons in 1961 and 1962, but increased during 1963 to 258 tons. In Yugoslavia the output of penicillin in 1963 was also twice the amount produced in 1962, being at present 6.22 tons or  $10,228 \times 10^9$  I.U. Furthermore, this country annually produces about 12.8 tons oxytetracyclines. Bulgaria has a considerable production, about  $10,647 \times 10^9$  I.U. of penicillin and 10.5 tons of tetracyclines annually. Italy makes  $300 \times 10^6$  I.U. of penicillin and its salts as raw products, besides 30 tons of streptomycin and 22 tons of other antibiotic products per year. In Spain 5 factories produced antibiotics in 1963; the total output amounted to  $35.9 \times 10^6$  I.U. penicillin; streptomycin and dihydrostreptomycin manufactures were valued at \$2.7 million and tetracyclines at \$1.8 million. Sweden and Denmark had a considerable production of penicillin and streptomycin and Sweden is one of the leading manufacturers of cycloserine in the world; also Austria, Holland and West Germany produce antibiotics in quantity. In South America, Colombia has reported an antibiotic production, estimated at \$960,000 in 1961, and further, Argentina, Brazil, Chile and Mexico produce their own requirements of antibiotics. In Asia, Japan reports a production of oxytetracycline and chlortetracycline in two factories with a total output of 10 tons; in addition penicillin production in four factories was reported to be  $46,000 \times 10^9$  I.U. in 1963.

### Export and Import

In a survey on the fermentation industries of France, in 1962, L. Genevois<sup>7</sup> has reported import quantities, not only of France but also of some other countries. According to his report, the United States, England and West Germany have the largest import of antibiotics. In reply to our questionnaire, England reports an import of antibiotics, amounting to \$4.7 million in 1963 and \$3.8 million in 1964. From the U.S.A. and West Germany we have not obtained any data of imports. Italy has a considerable import, in total \$7.5 million, while the import of Switzerland amounts to \$1.9 million, of Spain to \$1.4 million, of Holland to \$0.84 million and that of Norway to \$0.52 million. In South America, antibiotics have been imported by Brazil, Colombia and Uruguay, Brazil imported 342 kg penicillin, 2900 kg streptomycin and 3200 kg tetracyclines, Uruguay has imported penicillin worth \$0.65 million, and other antibiotics worth about \$4.0 million. Colombia

reports imports valued at \$5.7 million in 1961. In the Far East, the Philippines and Japan have imported antibiotics and some data have been obtained from New Zealand. In 1963, the Philippines had imported antibiotics valued at about \$1 million; the distribution of imports was 46 per cent penicillin, 35 per cent streptomycin, 2 per cent neomycin, 16 per cent other antibiotics and 0.6 per cent tetracyclines. Japan reported an import of 13 tons hygromycin. New Zealand imports were estimated at a little over \$0.5 million of which penicillin represented 60 per cent. In general, the countries with a large production of antibiotics also have an export trade. England presents the highest export values; in 1964, penicillin worth \$10.8 million was exported with \$19.3 million worth of other antibiotics. The total export of antibiotics from Italy was estimated at \$10.5 million in 1963, while Switzerland's export amounted to a little over \$0.7 million. Even Spain and Norway have had limited exports and Sweden was one of the main suppliers of cycloserine to the world market. In South America, Colombia reports an export amounting to \$14,000 (1961) and in Asia the Philippines' export values are about \$130,000.

## **ANIMAL AND FOOD ADDITIVES AND MISCELLANEOUS PRODUCTS**

### **Production**

The largest and most important branches of fermentation industries have been surveyed above. In addition to these data, some countries have given information regarding fermentation production of animal feed and human food additives and miscellaneous products. Three countries have reported a production of vitamins; in 1963, Spain produced 8 kg vitamin B<sub>12</sub> in one production plant, West Germany, the same year, had a total production of this vitamin to \$60,000 in value and Japan, without specifications as to the kind of vitamins, reported production of \$8.5 million in value. In the U.S.A., 31.8 tons of crude fermentation products containing streptomycin are produced in addition to other earlier mentioned antibiotics.

To the miscellaneous compounds produced by fermentation belong, for instance, gibberellic acid, which England manufactures 120–125 kg and Japan 54 kg annually. West Germany makes ergosterol of an estimated annual production worth \$250,000. Japan produces 80 tons inosinic acid per year.

### **Export and Import**

Very meagre and scattered information is obtained regarding export and import of miscellaneous products. Norway reports an import of crude fermentation products, largely penicillin worth \$94,000 and other antibiotics and vitamins worth \$63,000. Sweden in 1963 imported oxytetracycline worth \$220,000 and \$80,000 worth of aureomycin. Brazil had brought in 332.5 tons of animal food additives while New Zealand had an import valued at \$300,000. Norway reports an export of these products in total amounting to \$565,000 and Brazil has had a small export of 3.5 tons.

A few countries also have had some export and import of other miscellaneous fermentation products. Italy has exported \$1400 worth of ergosterol while importing \$19,100 worth of the same compound. Japan reports an annual export of 5 kg gibberellic acid.

## References

- <sup>1</sup> H. O. Parsons. *Chem. Eng. News* **42**, No. 36, 107 (1964).
- <sup>2</sup> A. Kaukoranta. (Sulphite Spirits Ltd., Helsinki), personal communication.
- <sup>3</sup> F. Brown. *Statistical Year-book of the World Power Conference No. 9*. Percy Lund, Humphries & Co. Ltd., London 1960, pp. 85-93.
- <sup>4</sup> *Statistical Yearbook 1964*. United Nations, New York 1965, pp. 246-248.
- <sup>5</sup> *Hoeveel Alcoholhoudende Dranken Worden er in de Wereld Gedronken?* Produktschap voor Gedistilleerde Dranken, 5e uitgaave, Schiedam, Najaar 1965, p. 2.
- <sup>6</sup> H. J. Bunker. *World Output of Microbial Food*. Report to a sub-committee of the Royal Society, London 1964.
- <sup>7</sup> L. Genevois. *Ind. Aliment. Agr. (Paris)* **81**, 505 (1964).