SASKATOON INDUSTRIAL FERMENTATION COMPLEX: A SURVEY

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Saskatoon Industrial Fermentation Complex

A Survey to Identify Industrial Fermentation Products or Processes for Commercial Application in the Saskatoon Industrial Fermentation Complex

for

The Government of Canada
Department of Regional Economic Expansion
814 Bessborough Tower
601 Spadina Crescent East
Saskatoon, Saskatchewan, Canada

by

Agrisearch Investment Analysis Limited
#124 Heritage Hill Professional Centre
6 Heritage Drive S.E.
Calgary, Alberta, Canada

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HIGHLIGHTS

1. The products/processes identified as having an apparent potential for profitable commercial application in the Saskatoon Industrial Fermentation Complex are:

   Citric Acid;
   Xanthan Gum;
   Pullulan;
   Xylitol;
   Modification of Rapeseed Meal.

2. The following trends were identified as being of special interest for the development of new products/processes by industrial fermentation:

   a) biodegradeable and/or ecologically oriented materials;

   b) a shift to the use of carbohydrates as fermentation substrates replacing petroleum derivatives;

   c) the use of immobilized microbial cells and cell cultures in the production of products by fermentation;

   d) the modification of carbohydrates, proteins and lipids through fermentation techniques.

INTRODUCTION

The Saskatoon Industrial Fermentation Complex is intended to contain viable commercial enterprises which will produce products through the process of fermentation and will utilize, for the most part, renewable resources in Saskatchewan such as grains, wood, and so on, as the fermentation substrates. Earlier studies have identified bakers yeast, antibiotics, industrial ethanol, industrial enzymes, single cell protein and potable alcohol as having potential for profitable commercial application in the Saskatoon Industrial Fermentation Complex. A number of other fermentation processes are known to yield valuable metabolites. The objective of the survey was to identify such other products or processes of fermentation that have an apparent potential for profitable commercial application in the Saskatoon Industrial Fermentation Complex.

PRODUCTS PRODUCED BY FERMENTATION

Substances that are being produced using fermentation processes, except for antiobiotics, enzymes, ethanol, bakers yeast and single cell proteins, are as follows:

Products	Countries
Organic Acids	
Citric acid	West Germany, Belgium, U.S.A., France, Taiwan, England
Comenic acid	U.S.A.
Erythorbic acid	Japan
Gluconic acid	West Germany, U.S.A., Japan, Taiwan
Itaconic acid	U.S.A., France
2-Keto-D-gluconic acid	Japan, West Germany, U.S.A.
Alfa-Ketoglutaric acid	Japan
Lactic acid	West Germany, U.S.A., England, France
Malic acid	Japan
Urocanic acid	Japan
Solvents	
2,3-Butanediol	Holland
Vitamins and Growth Factors	
Gibberellins	U.S.A., England, Japan, Italy
Riboflavin	U.S.A.
Vitamin B_{12}	India, Hungary, Italy, England, U.S.A., France
Zearalanol	U.S.A.
Nucleosides and Nucleotides	
5'-Ribonucleotides and nucleosides	Japan
Orotic acid	Japan
Ara-A-(beta-D-arabinofuranosyl)	U.S.A.
6 - Azauridine	Japan

Amino Acids

L-Alanine	Japan
L-Arginine	Japan
L-Aspartic acid	Japan, Italy, France
L-Citrulline	Japan
L-Glutamic acid	Japan, South Korea, France, U.S.A., Taiwan
L-Glutamine	Japan
L-Glutathione	Japan
L-Histidine	Japan
L-Homoserine	Japan
L-Isoleucine	Japan
L-Leucine	Japan
L-Lysine	Japan, France
L-Methionine	Japan
L-Ornithine	Japan
L-Phenylalanine	Japan
L-Proline	Japan
L-Serine	Japan
L-Threonine	Japan
L-Tryptophan	Japan
L-Tyrosine	Japan
L-Valine	Japan

Miscellaneous Products and Processes

Acetoin	Holland
Acyloin	West Germany, U.S.A.
Anka-pigment (red)	Taiwan
Blue Cheese flavor	U.S.A.
Desferrioxamine	Italy
Dihydroxyacetone	West Germany, U.S.A., France Japan
Dextran	Sweden, Hungary, Japan, Denmark
Diacetyl (from acetoin)	Holland
Ergocornine	Austria, Italy, Hungary, Switzerland
Ergocristine	Austria, Italy, Switzerland

Ergocryptine	Austria, Italy, Hungary, Switzerland
Ergometrine	Hungary
Ergotamine	Italy, Hungary
Bacillus thuringiensis insecticide	U.S.A., Japan, France
Lysergic acid	Italy
Paspalic acid	Austria, Switzerland
Picibanil	Japan
Ribose	Japan
Scleroglucan	France
Sorbose (from sorbitol)	U.S.A., Switzerland, West Germany, Taiwan, Japan
Starter cultures	U.S.A.
Sterol oxidations	Holland, Japan, West Germany, U.S.A.
Steroid oxidations	Italy, Holland, England, West Germany, France, Hungary, U.S.A.
Xanthan	Hungary, West Germany, U.S.A., France, Taiwan, England

PRODUCTS/PROCESSES OF COMMERCIAL INTEREST

A number of products and processes of fermentation have been identified as having an apparent potential for profitable commercial application in the Saskatoon Industrial Fermentation Complex. The products and processes recommended for consideration are: citric acid; xanthan gum; pullulan; xylitol; and the modification of rapeseed meal.

Citric Acid

Citric acid, sodium citrate and calcium citrate are very widely used chemicals in the soft drink, food and other industries. It has been reported that over 200 million pounds was produced in 1976 by the following nine companies in six countries.

- Joh. A. Benckhiser GmbH,
  Ludwigshafen/Rhein, West Germany
- C.H. Boehringer Sohn
  Ingelheim/Rhein, West Germany
- Citrique Belge,
  Tienen, Belgium
- Miles Laboratories, Inc.
  Elkhart, Indiana, U.S.A.
- Pfizer, Inc.,
  New York, New York, U.S.A.
- Rhone-Poulenc S.A.,
  Paris, France
- San Fu Chemical Company Ltd.,
  Taipei, Taiwan (Republic of China)
- John and E. Sturge Ltd.,
  Birmingham, England
- Tai Nan Fermentation Industrial Company Ltd.,
  Taipei, Taiwan (Republic of China)

The Canadian market is purportedly supplied by Pfizer, Inc. and Miles Laboratories, Inc. of the U.S.A. The importation of citric acid into Canada is not reported separately by Statistics Canada. It has been reported that citric acid production through fermentation was evaluated recently by John Labatt Limited.

Further, it has been reported that the production of citric acid through a fermentation utilizing rapeseed oil may offer some unique advantages. The use of lower grade rapeseed oils would have the benefit of providing a market for such oils in Saskatchewan and allow rapeseed crushers to purchase the lower grades of rapeseed from the farmers to produce such oils. At the present time, damaged, frosted or immature rapeseed is heavily discounted when purchased by the rapeseed processors for use in edible oil production. This results in farmers receiving a very low return for low grade rapeseed.

Further, it has been reported that a new process for the isolation of pea and bean protein through precipitation with citric acid has been developed recently in Canada. Owing to the research and development ongoing with field peas, as a viable field crop in Saskatchewan, the development of processes for the isolation and further processing of pea proteins with citric acid appears to relate both to a viable pea processing industry and to the possible production of citric acid in the Saskatoon Industrial Fermentation Complex.

Xanthan Gum

Xanthan gum is used as a viscosity agent in the food and oil industries. The technology with respect to the production and use of xanthan gum was developed at the U.S.D.A. Northern Regional Research Laboratory, Peoria, Illinois. The process was commercialized in the United States by the Kelco Division, Merck and Company, Inc. The first Kelco plant is in San Diego, California, and a new plant has been added recently at Okmulgee, Oklahoma. Kelco was purported to have captured nearly all the United States market for Xanthan gum.

On a worldwide basis, xanthan gum production has been reported by the following eight companies in six countries:

- Biogal,
  Debrecen, Hungary
- Lohmann and Company AG,
  Cuxhaven, West Germany
- Merck and Company, Inc.,
  Rahway, New Jersey, U.S.A.
- Orsan, S.A.
  Paris, France
- Pfizer, Inc.,
  New York, New York, U.S.A.
- Rhone-Poulenc S.A.,
  Paris France
- Taiwan Sugar Corporation,
  Taipei, Taiwan, (Republic of China)
- Tate and Lyle Ltd.,
  Yorkshire, England

General Mills Chemicals, Inc., Minneapolis, Minnesota, U.S.A., carried out extensive feasibility studies on the production of xanthan gum in the United States recently.

Xanthan gum may be utilized in the tertiary recovery of oil through a flood recovery technique. It has been reported that the tertiary recovery of oil by this technique will become feasible when the price of oil reaches $15.00 per barrel. The use of xanthan gum in the petroleum industry in Western Canada may offer significant markets in the near future as the recovery of oil from the depleting oil fields becomes more difficult or impossible by primary or secondary techniques.

The importation of xanthan gum into Canada is not reported separately by Statistics Canada, hence the food and industrial uses are not well described. Xanthan gum is widely used in the food industry, for example, in ketchup, ice cream, salad dressing, gravies, and so on.

Pullulan

Pullulan, a viscous polysaccharide, is produced extracellularly by growing a fungus-like yeast on starch syrups. The yeast, commonly called "black yeast", was named Pullularia Pullulans or Aureobasidium pullulans. Pullulan can be used as a film for coating and packaging foodstuffs and as a low calorie ingredient in foods. In addition, it can be made into an adhesive, laminates or nylon-like fibres and fabrics.

Pullulan films, fibres, and fabrics are purported to be fully biodegradable and safe in the environment versus the comparable plastic products made from petroleum derivatives.

Xylitol

There is great interest in xylitol as a sweetener for human foods, and other uses, owing to the "anti-tooth decay" claims that have recently been made in Scandanavia. Xylitol is derived from the pentose sugar xylose. At present it is being produced in Finland from the pentosans of the birch tree. Undoubtedly research is ongoing to locate sources of pentosans with a high yield of xylose. In this respect, wheat, barley and oat hull and bran are being evaluated as sources of xylose derivatives.

The production of xylitol from natural pentosans involves high-cost purification procedures in the extraction process. It is likely that intensive searches are now underway to produce xylitol by fermentation with micro-organisms in an attempt to lower costs and eliminate some of the current extraction problems and processes.

Modification of Rapeseed Meal

A process is described by Dr. T.J. Staron, Institut National de la Recherche Agronomique, Paris, France, in U.S. Patent 3,803,328, April 9, 1974, for improving the value of cakes of vegetable origin, e.g. rapeseed meal. The crude rapeseed meal is macerated in an aqueous medium with strains of micro-organisms, notably the yeast Geotrichum candidum. The rapeseed meal is thus freed from the sulfur-containing impurities which contaminate it and limit its use at present. The yeast acts in at least two ways: on one hand, hydrolysis of thioglycosides with breakdown of the isothiocyanates formed and, on the other hand, a freeing, followed by destruction, of toxic hetero-protein compounds. The cakes obtained have an improved nutritive value.

New, pure proteins can be isolated from the maceration liquids by precipitation to the isoelectric pH or in the presence of saline solution. It is claimed that, by continuing fermentation, complete solubilization of the rapeseed protein is observed, which can be leached out by conventional chemical methods. The fractions thus obtained contain between 65 and 80 percent protein and are suitable for texturization. The purified protein products are edible and are purported to have higher nutritive values and a functionality that enhances their use in nutritive supplements, texturized proteins, and other food applications.

The above described process for the modification of rapeseed meal through fermentation may have special application to the rapeseed crushing industry in Saskatchewan. The meals from varieties of rapeseed grown for erucic acid are very high in the toxic thioglucosides and present a problem to the crushers in terms of market outlets and prices received. Further, it is unlikely that rapeseed protein will be permitted in the human diet unless a process can be developed to completely remove such undesirable components in rapeseed. The fermentation of rapeseed meal to modify the protein and destroy the thioglycosides, and other undesirable components, appears to offer a unique process for the upgrading of Saskatchewan rapeseed meal.

AREAS OF SPECIAL INTEREST

New opportunities for the production of products by fermentation appear to be opening up as a consequence of increasing prices and shortages of petroleum and natural gas. For example, the production of industrial grade ethanol from carbohydrates may soon be competitive with that made from ethylene. Fermentative production of organic chemicals from carbohydrate - such as acetone, butanol, acetic acid, lactic acid, 2,3-butylene glycol, furfural, and so on -- could become feasible if the projected price increases for petroleum are borne out.

The fermentative utilization of carbohydrates to produce products which are alternatives to petroleum products, or conserve petroleum products, are now the subject of a number of applied research projects. In addition, products produced by fermentation are "ecologically oriented materials" versus many products derived from petroleum.

The trends in the production of fine chemicals and pharaceuticals by fermentation over the past four years have included the introduction of about 25 new fermentation products, an expansion of fermentation capacity in existing manufacturing facilities, construction of several new manufacturing plants, and a shift back to the use of carbohydrates as fermentation substrates replacing products of the petrochemical industries.

An area of special new importance is the use of immobilized microbial cells instead of growing microbial cultures for the production of certain products. Improvements in technology of cell culture in the past five years have led to successful operations in this field, including: the conversion of fumaric acid to aspartic acid and to malic acid; conversion of glucose to fructose; conversion of arginine to citrulline; conversion of histidine to urocanic acid; conversion of indole to tryptophan.

It is likely that the use of immobilized cells and cell culture will increase in the future as the technology is improved and their economic advantages are demonstrated.

Another area of special opportunity is the modification by fermentation of carbohydrates, proteins, lipids, and so on, to develop new or improved characteristics of greater value and/or for specific uses. For example: the solubilization of protein; the altering of protein functionality; the nutritive up-grading of proteins and carbohydrates; the destruction of toxic or inhibiting compounds or complexes; the utilization of inedible wastes for the production of edible products; the conversion of isomers from the non-biological to the biologically available form; and so on.

SOURCES OF INFORMATION

1.	Dr. John Holme Director	Food Research Institute Agriculture Canada Ottawa, Ontario
2.	Mr. S. Suzuki Manager	Ajinomoto U.S.A., Inc. New York, New York, U.S.A.
3.	Mr. Van Miller President	Brookside Farms Ltd. Mississauga, Ontario
4.	Mr. Robert J. Gillespie President Mr. William T. Craig Vice President Mr. James Currie Business Manager	The Canada Starch Company Ltd. Montreal, Quebec
5.	Dr. G.N. Irvine Director	Grain Research Laboratory Canadian Grain Commission Winnipeg, Manitoba
6.	Mr. Anthony R. Tweed Baking Technologist	Canadian International Grains Institute Winnipeg, Manitoba
7.	Mr. J.C. Brown Director Dr. Maher M. Abou Guendia Program Supervisor	Market Development Canadian Wheat Board Winnipeg, Manitoba
8.	Dr. C.R. Russell Chief	Cereal Products Laboratory Northern Regional Research Center, U.S.D.A., Peoria, Illinois
9.	Mr. Kyd D. Brenner Director of Public Affairs	Corn Refiners Association, Inc. Washington, D.C.
10.	Dr. John B. Hall Director, Food Marketing Dr. G.V. Rao Asst. Director Research	FAR-MAR-CO, Inc. Hutchinson, Kansas

11. Mr. Jerry Kersten
Commercial Development

Ken Magnuson
Technical Group Leader
Food Ingredients

Dr. F. William Tuominen
Manager,
Research and Development

Mr. T.J. Bradley
Sales Manager
Food Ingredients

General Mills Chemicals, Inc.
Minneapolis, Minnesota

12. Mr. John R. Nugent
Warehousing Manager

Gilbey Canada Ltd.
Toronto, Ontario

13. Mr. Arlen R. Elliott
Manager
Industrial Products Sales

Mr. Robert G. Rohwer
Vice President

Grain Processing Corporation
Muscatine, Iowa

14. Dr. Fred Comer
Cereal Chemist

Mr. Randolph M. Friesen
Technical Marketing

The Griffith Laboratories Limited
Scarborough, Ontario

15. Mr. H.W. Berry
Vice President

M. Gurvey & Berry Co., Inc.
Toronto, Ontario

16. Mr. John D. Bodrug
President

Mr. R.G. Greven
Vice President
Manufacturing & Technology

Industrial Grain Products Ltd.
Montreal, Quebec

17. Mr. T.J. Staron
Directeur

Laboratoire des Antibiotiques
Institut National de la Recherche Agronomique,
Paris, France

18. Dr. Paul Melnychyn
Consultant

Paul Melnychyn Consultant
Hudson, Quebec

19. Mr. Real Roy
President

Miracle Feeds
Montreal, Quebec

20.	Dr. John R. Vose Prairie Regional Laboratory	National Research Council Saskatoon, Saskatchewan
21.	Dr. C.T. Bishop Associate Director Dr. Ian McDonald	Division of Biological Sciences National Research Council Ottawa, Ontario
22.	Mr. Edward Phillipchuk Industrial and Engineering Services	Research Council Government of Alberta Edmonton, Alberta
23.	Mr. H. Hanson Director	Production Development Asia & Pacific Area Joseph E. Seagram & Sons Ltd. New York, New York, U.S.A.
24.	Dr. H. Jackson Professor and Head	Department of Food Science University of Alberta Edmonton, Alberta
25.	Dr. P. Townsley Professor	Department of Food Science University of British Columbia Vancouver, B.C.
26.	Mr. Joseph J. Warthesen Assistant Professor Food Chemistry	University of Minnesota St. Paul, Minnesota
27.	Dr. D. Perlman Professor	School of Pharmacy University of Wisconsin Madison, Wisconsin
28.		Statistics Canada Edmonton, Alberta