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1.7 1971 – 30.6 1972

SIK-Rapport No. 311
## Contents

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swedish Institute for Food Preservation Research (SIK), 1971/72</td>
<td>3</td>
</tr>
<tr>
<td>SIK 25th anniversary</td>
<td>3</td>
</tr>
<tr>
<td>Research</td>
<td>5</td>
</tr>
<tr>
<td>Research program 1971/72</td>
<td>5</td>
</tr>
<tr>
<td>Freezing</td>
<td>7</td>
</tr>
<tr>
<td>Heating</td>
<td>9</td>
</tr>
<tr>
<td>Industrially precooked foods</td>
<td>11</td>
</tr>
<tr>
<td>Biochemical catalysis</td>
<td>13</td>
</tr>
<tr>
<td>Microbiology</td>
<td>16</td>
</tr>
<tr>
<td>Flavour</td>
<td>17</td>
</tr>
<tr>
<td>Rheology</td>
<td>21</td>
</tr>
<tr>
<td>Sensory evaluation</td>
<td>23</td>
</tr>
<tr>
<td>Education</td>
<td>25</td>
</tr>
<tr>
<td>Chalmers University of Technology (CTH)</td>
<td>25</td>
</tr>
<tr>
<td>Seminars and courses</td>
<td>25</td>
</tr>
<tr>
<td>Documentation</td>
<td>26</td>
</tr>
<tr>
<td>Papers issued this year</td>
<td>27</td>
</tr>
<tr>
<td>SIK-Publikation</td>
<td>27</td>
</tr>
<tr>
<td>SIK-Rapport</td>
<td>28</td>
</tr>
<tr>
<td>Contract service</td>
<td>29</td>
</tr>
<tr>
<td>Contacts</td>
<td>29</td>
</tr>
<tr>
<td>Governing Board of the Swedish Institute for Food Preservation</td>
<td>32</td>
</tr>
<tr>
<td>Research</td>
<td>32</td>
</tr>
<tr>
<td>Auditors</td>
<td>32</td>
</tr>
<tr>
<td>Members of the Foundation for Swedish Food Preservation</td>
<td>33</td>
</tr>
<tr>
<td>Research</td>
<td>33</td>
</tr>
<tr>
<td>Governing Board of the Foundation for Swedish Food Preservation</td>
<td>34</td>
</tr>
<tr>
<td>Preservation Research</td>
<td>34</td>
</tr>
<tr>
<td>Economy</td>
<td>35</td>
</tr>
<tr>
<td>Buildings and equipment</td>
<td>36</td>
</tr>
<tr>
<td>Organization of SIK</td>
<td>37</td>
</tr>
</tbody>
</table>
Swedish Institute for Food Preservation Research (SIK), 1971/72

1971/72 has been the first year of the new 3 year-period agreement between the Swedish Government and the Foundation for Swedish Food Preservation Research. The Foundation has presently 52 members. Activities at SIK covers research (see page 5), education (see page 25), documentation (see page 26), and contract service (see page 29). SIK has integrated activities with the Department of food chemistry at Chalmers University of Technology (CTH). The Nordic aroma research group, which is supported by Nordforsk, has carried out three research projects and contract service at the Institute.

Lists of the governing board of SIK as well as the members and governing board of the Foundation are found on page 32—34.

Over 80 persons, of which about 15 work for their Ph.D. degrees, work at the Institute. Approximately 20 students from CTH carry out special degree projects at the Institute. Dr. Michael Kent from Torry Research Station, Aberdeen, and Dr. Rimma Golovnja from the Institute of element-organic compounds, Moscow, have worked as visiting scientists at SIK during short periods.

SIK 25th anniversary

The 25th anniversary of SIK, which occurred this year, was celebrated in connection with the information meeting on the 14—15th of October. About 120 guests visited the Institute during these days. During the meeting, SIK had arranged an exhibition, which showed the present activities of the Institute. Demonstrations from the research work were also performed.

The lectures during the meeting comprised not only a review of the past 25 years but also a look into the coming years. Professor S. A. Goldblith, Massachusetts Institute of Technology, USA, lectured
A rebuilding and an extension of the present building at SIK will start at the end of 1972. The new building involves a separate lecture hall and an extension of the present building. On the drawing the new building is marked with dark sections.

on "Food Science and Technology 1946 — 1971 — 1996: Retrospect, prospect, past accomplishments and future challenges". Mr. K. E. Flinck, Nestlé Alimentana S.A., Switzerland, a former member of the governing board of SIK, described in the lecture "SIK 25 years" the activities of SIK during the past years. Finally, Professor E. von Sydow, SIK, outlined the near future of the Institute in a lecture called "SIK and the seventies".
Research

The research program is decided by the governing board of SIK for each year. The present program is regulated by a three-year agreement for the years 1971—1974 between the Swedish Government and the Foundation. Both the three-year program and the annual program are appointed in joint deliberation with private and groups of Foundation members and also with other research institutions in Sweden to make it possible to adapt each others research and development work in the food field.

SIK has carried out 27 research projects, of which 7 are new projects. Most of the projects have been financed through an agreement between the Swedish Government and the Foundation for Swedish Food Preservation Research (see also page 35). The projects concerning quality properties of foods have received special grants from the Swedish Board for Technical Development (STU). Nordforsk has contributed economically to certain aroma research projects.

The projects have been divided into the following fields: processing and technology (freezing, heating, industrially precooked foods), chemical and biological stability (biochemical catalysis, microbiology) and quality properties (flavour, rheology, sensory evaluation). A list of the projects and description of the different project groups follow below.

Research program 1971/72

<table>
<thead>
<tr>
<th>Research group</th>
<th>Project No</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freezing</td>
<td>26</td>
<td>New methods for ultrafast freezing of foods</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>Structural changes in animal products caused by freezing procedures</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>Protein changes in frozen cod muscle tissue</td>
</tr>
<tr>
<td>Category</td>
<td>Page</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Heating</td>
<td>32</td>
<td>High frequency heating of food</td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>Structural changes in vegetable products</td>
</tr>
<tr>
<td>Industrially precooked foods</td>
<td>54</td>
<td>Cooking and reheating of preserved food components</td>
</tr>
<tr>
<td>Biochemical catalysis</td>
<td>65(^1)</td>
<td>Enzymatic control of food qualities</td>
</tr>
<tr>
<td></td>
<td>66(^1)</td>
<td>Effect of processing variables on catalytically active proteins</td>
</tr>
<tr>
<td></td>
<td>67(^1)</td>
<td>Protection against fat oxidation</td>
</tr>
<tr>
<td>Microbiology</td>
<td>37</td>
<td>Germination of bacterial spores</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>Resistance of bacterial spores</td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>Fat-splitting microorganisms</td>
</tr>
<tr>
<td></td>
<td>68(^1)</td>
<td>Lenient biological preservation</td>
</tr>
<tr>
<td></td>
<td>69</td>
<td>Microbiological quality improvements</td>
</tr>
<tr>
<td>Flavour</td>
<td>43(\text{N})</td>
<td>Effect of climatic conditions on the aroma of berries and fruits</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>Aroma of processed berry products</td>
</tr>
<tr>
<td></td>
<td>45(\text{N})</td>
<td>Aroma changes in frozen cod</td>
</tr>
<tr>
<td></td>
<td>46</td>
<td>Aroma formation by heat processing of protein foods</td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>Correlation between physico-chemical and sensory data with computer technique</td>
</tr>
<tr>
<td></td>
<td>70(^1)</td>
<td>Rancidity as a negative quality factor</td>
</tr>
<tr>
<td></td>
<td>71(\text{N})</td>
<td>Odour and taste from packaging materials</td>
</tr>
<tr>
<td>Rheology</td>
<td>49</td>
<td>Psychorheology</td>
</tr>
<tr>
<td></td>
<td>50(^2)</td>
<td>Bibliography of food rheology</td>
</tr>
<tr>
<td></td>
<td>59</td>
<td>Protein rheology</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>Dynamic rheological methods of analysis</td>
</tr>
<tr>
<td>Sensory evaluation</td>
<td>57</td>
<td>Scaling methodology</td>
</tr>
<tr>
<td></td>
<td>58</td>
<td>Methods for selection and control of judges</td>
</tr>
</tbody>
</table>

\(\text{N} = \text{The Nordic aroma research group, Nordforsk}\)

\(1 = \text{New project}\)

\(2 = \text{Finished during the year}\)
During 1972/73 we will start a new project within the group industrially precooked foods: "Qualitative changes in reheating and holding of precooked foods".

Freezing

The main effort within the field of freezing has comprised studies of structural changes during frozen storage of animal products and protein changes in frozen cod muscle tissue. In addition, SIK has cooperated with the University of Agriculture at Alnarp in studies on the influence of freezing rate and freeze-protective agents in freezing of fruits and berries.

The study of structural changes in animal products due to frozen storage has been concerned mainly with cod muscle, partly the fine structure of the intact muscle fibres, partly the structure of muscle proteins extracted from the fibres. In both cases, the conditions before and after frozen storage are compared. The purpose of these investigations is to provide information that, combined with results from biochemical research elsewhere, could explain how, principally, the textural properties of the muscle tissue are impaired by frozen storage and to find suitable means to diminish this effect.

By optical microscopy and electron microscopy we have got a fairly good understanding of the architecture of muscle fibres and of variations therein down to the dimensions of the myofilaments, which are threadlike structures with a diameter of approximately $10^{-3}$ mm. These are composed of protein molecules, which are barely visible with available preparation techniques for electron microscopy.

The reasons for the toughening of muscle tissue and for its decreasing water holding capacity during frozen storage seem to be essentially associated with these protein molecules and their relation to each other. By electron microscopy in progress on replicas produced by freeze-etching technique it is suggested that changes appear in the thicker myofilaments, which are composed of myosin molecules. Using another preparation technique for electron micro-
scopy (negative staining) extracted actomyosin is studied. Actomyosin is a complex formed by myosin and actin. The latter protein makes up most of the thinner type of the myofilaments. The appearance of the extracted actomyosin reflects the decreasing extractability of myosin from the thick myofilaments, presumably due to aggregation of myosin molecules. In model experiments we study how such aggregation is influenced by different ionic strengths of the extraction medium and by added free fatty acids with the purpose to simulate conditions, which are formed spontaneously in the frozen, stored tissue.

Investigations as those mentioned will be continued. Studies on changes after heating and studies of model systems of macerated muscle tissue in combination with other food components will start next year.

The objective of the freezing experiments with fruits and berries has been to investigate if programmed freezing and thawing in conjunction with the use of freeze-protective agents could lead to any noticable texture improvement for strawberries and sliced apples and pears. The experiments were carried out at the Institution of fruit- and berry production at the University of Agriculture (Balsgård) within the scope of a doctor’s degree and with certain help with equipment, supervision and planning from SIK. In freezing experiments with strawberries (Senga) postive effects were found particularly for sliced berries and glucose treatment. This was also the case for apple slices, but glucose treatment of the apples at reduced pressure led to a certain transparency which was judged negatively by some members of the sensory panel. For apples, the influence on variety and maturity in conjunction with freezing rates and additives has also been studied. The experimental part of the project will terminate with the strawberry season of 1972. The final investigations will comprise a study of the importance of freezing rate with regard to selection in fruit breeding of varieties suitable for freezing.

Project Nos. 26: New methods for ultrafast freezing of foods

Assistant Professor N. Bengtsson, and Agr.Eng. A. Teksöz

SIK Annual Report 1971/72
31: Structural changes in animal products caused by freezing procedures
Mr. A. Liljemark, M.Sc., and Mr. L. Jarenbäck, M.Sc.

51: Protein changes in frozen cod muscle tissue
Mr. A. Liljemark, M.Sc., and Mr. L. Jarenbäck, M.Sc.

Heating

Our work within the field of heating of foods comprises two separate projects, fundamental technological studies of dielectric heating with evaluation of the possibilities of industrial application, and microscopical research on the structural changes in plant products.

Thawing, pasteurization, blanching and cooking of foods with dielectric heating have previously been studied. The main objective at present is microwave sterilization of industrially precooked foods at different frequencies.

The work over the past year has comprised continued fundamental studies of the dielectric properties of foods and experiments with computer simulation of temperature profiles in combined conductive and microwave heating. In addition, the influence of time-temperature relationships on quality and yield when sterilizing in thin layers have been studied, components have been tested, and microwave sterilizing equipment for two different frequencies has been developed. The dielectric measurements at 2800 MHz have been extended to temperatures above 100°C and measurements at 900 MHz below 100°C will soon be completed. The application of a one-dimensional computer simulation program for combined conduction and microwave heating has shown good agreement between simulated and experimentally determined temperature profiles.

To obtain an idea of the possible merits to expect from HTST (High Temperature Short Time)-sterilization of foods by microwave heating, the influence of different time-temperature combinations was studied by conventional steam retorting of solid foods.
packed in thin layers in special cans or flexible packaging. Good results were indicated particularly for HTST-treatment of peas and fish pudding.

The influence of different microwave processing parameters is presently studied in pasteurization experiments at atmospheric pressure, and a semi-continuous microwave sterilizer for work at over-pressure under construction. Suitable microwave applicators for the frequencies 2450 and 915 MHz are being tested, primarily of the "Broad-side array" type, which permits direct comparisons between frequencies at equivalent field distribution.

During the coming year, dielectric measurements at 915 and 450 MHz will be completed. The influence of frequency and other processing parameters during microwave sterilization will be studied by computer simulation, while actual heating experiments will be carried out at 2450 MHz as starting point.

In the continued work structural changes during heat treatment of plant products will be studied in cooperation with another SIK project described below. Cooperation is also being maintained with the Department of circuit theory at the Chalmers University of Technology and with Torry Research Station, Aberdeen.

Various microscopy techniques are being used for investigating how food processing procedures affect the structure of plant products and how this is related to their quality.

We have chosen potato and potato products as materials to be studied because of their economic importance and the quality problems connected with the great variation in the texture properties.

This year has been used mainly for preliminary studies on potato tissues and instant mashed potato (potato granules) by means of optical microscopy and scanning electron microscopy. To a great extent this meant also working out techniques for using the new scanning electron microscope. In collaboration with producers of potato products and with institutes for plant breeding and plant cultivation, an intensification of the work has been planned in order to obtain information on the histological basis for the textural properties of potato and potato products by investigating the fine structure in tissue components such as starch, cell walls and intercellular substances. To begin
with we will study tissue structures in relation to their location in the potato tuber and to its maturation state as well as tissue structures in dried products with different textural properties.

Project Nos. 32: High frequency heating of food  
Assistant Professor N. Bengtsson, and Mr. T. Ohlsson, M.Sc.  
52: Structural changes in vegetable products  
Mr. A. Liljemark, M.Sc.

Industrially precooked foods

The rapid market development enjoyed by industrially precooked foods or convenience foods, in conjunction with a rapid increase of the number of meals served outside the home has actualized the need for fundamental research and the development of equipment and methods in this product area. The aim of the work done at SIK is to develop basic knowledge needed for process optimizing by studying heat and mass transfer during heating of foods, and the influence of different raw material and process variables on composition and quality of foods. The intention is also to study qualitative changes and their causes during handling of industrially prepared and preserved food in institutional kitchens, particularly while holding before serving. The long range objective is to create a better basis for development of methods and equipment.

Over the past year, equipment and technique have been further developed to permit careful studies of heat and mass transfer in sliced beef during oven and pan frying. Corresponding profiles for temperature and fat and water content have been determined for different heating times and as a function of different process parameters such as the initial temperature and the cooking temperature. In pan frying, the weight loss was lower when cooking raw meat slices directly from the frozen state than from thawed condition, while the reverse was true for oven cooking of thicker samples.
For calculation of heat penetration in rectangular slabs, the so-called Hottel diagrams are often used, showing a linear relationship between simple functions of factors such as initial- and centre temperature of the sample, the surrounding temperature and time. Experimental values plotted in such diagrams resulted in straight lines even when heating from the frozen state, which permits simple calculation of cooking time to any desired centre temperature, when initial heating conditions are known. This confirms earlier observations reported by Carlheim-Gyllensköld.

Preliminary work with computer simulation of the time-temperature relationships in beef cooking showed surprisingly good correlation with experimentally determined temperature profiles, using empirically chosen values for heat transfer coefficient and simple boundary conditions. It seems possible to further develop such computer simulation programs into important tools for optimizing cooking processes and equipment.

The continued work will comprise comparative studies of heat- and mass transfer in other food materials, for instance with regard to the effects of breading. The influence of degree of cooking prior to freezing, of the nature of the surrounding medium and of programmed heating will be investigated as well as the various factors governing the formation of a surface crust during frying. An attempt will be made to interrelate heat- and mass transfer in improved mathematical models.

A project regarding qualitative changes during handling of pre-cooked foods will start with a close literature search and investigations of practical conditions during institutional heating and holding at serving temperature, after which experimental studies of qualitative and nutritional changes during holding will follow.

The project is being coordinated with work in the same field in progress at the Department of food technology, University of Technology, Lund, and extended cooperation is being planned, especially with regard to research on institutional handling of foods, with participation also from the Department of clinical nutrition, Sahlgrenska Hospital, Göteborg, the Department of food hygiene, Veterinary In-

Project No. 54: Cooking and reheating of preserved food components

Assistant Professor N. Bengtsson, Dr. B. Jakobsson, and Mr. M. Dagerskog, M.Sc.

Biochemical catalysis

Food qualities are influenced advantageously or disadvantageously by biocatalysts during storage and production. A greater knowledge about the biocatalysts, their function and behaviour in unit operations, will enable favouring of positive and preventing of negative quality changes.

In the project group "Biochemical catalysis", biocatalysts like lipase, lipoxigenase, hemoproteins and alcoholdehydrogenase are concerned in order to investigate how formation of flavour from food lipids is effected by environmental variables like pH, temperature and oxygen pressure. Such studies can result in methods to control the aroma by preventing rancidity in a natural way. In certain compositions, flavour compounds of the groups alkanals, alkenals and alkadienals and the corresponding alcohols might contribute to a positive or negative aroma formation.

The enzyme lipoxigenase, which catalyses the oxidation of polyunsaturated fatty acids, has been studied concerning both thermal inactivation and the formation of two isomeric acid hydroperoxides, which give rise to different volatile compounds. The ratio between the two hydroperoxides varied with enzyme source, pH, temperature, and oxygen pressure. This fact might influence the flavour which arises from lipid oxidation reactions. These relations will be studied further during next year. The enzyme lipoxigenase is inactivated, apparently completely, at time-temperature combinations in the order of 80—60°C for 10 seconds to 2 hours. The thermal inactivation was found sensitive
to the presence of the above mentioned linoleic acid hydroperoxides but insensitive to oxygen.

Many of the identified aldehydes, which are produced by oxidation of polyunsaturated fatty acids, can be reduced to alcohols by catalysis of the enzyme alcohol dehydrogenase to corresponding alcohols with 20—100 times higher odour threshold values than those of the aldehydes. The possibility to make use of this knowledge to control the aroma of certain foods will be looked upon.

During heating of hemo-proteins like hemoglobin, myoglobin, peroxidase and catalase, which also catalyse lipid oxidation, a great increase of the catalytic activity occurs at pH above 5.5 in a temperature range of 75—125°C for 2 to 60 minutes. This depends on an unmasking of the heme group due to protein denaturation. At more severe heat treatments the heme group was destroyed, especially in the presence of oxygen, which counteracted the heat activation. We have developed a very sensitive method for heme analysis in order to enable studies of the catalytic reactions in foods which do not become rancid in relation to foods which do. The work will continue with investigations of the occurrence of heme in different food components related to preservation treatment.

Fat oxidation, which leads to rancidity, can thus be catalysed by lipoxygenase, heat activated hemo-proteins or metals. Rancidity is, however, not observed in all food, especially fermented food products seem to be less disposed to rancidity. Besides, certain food components such as peptides and amino acids are known to prevent rancidity, which has been measured in dry systems by an apparatus developed at SIK. Observations from this field have also been collected from a literature survey which was carried out with the aim to find "natural" antioxidants. Milk protein hydrolysates and one spice, e.g. sage will be investigated in this respect.

Project Nos. 65: Enzymatic control of food qualities

Dr. C. Eriksson, and Mrs. K. Leu, M.Sc.

SIK has during this year supplied a microcalorimeter (LKB, batch), which is used to measure heat quantities in e.g. enzyme reactions with great precision. Besides biochemistry work, the calorimeter can also be useful for physical measurements in microbiological and food technological investigations.
66: Effect of processing variables on catalytically active proteins
Dr. C. Eriksson, Mrs. K. Leu, M.Sc., and Mr. S. Svensson, M.Sc.

67: Protection against fat oxidation
Dr. C. Eriksson, Mr. H. Lindner, M.Sc., and Dr. pharm. R. Marcuse

Microbiology

The main efforts within the microbiological research at SIK are carried out on heat sterilized foods and refrigerated foods respectively. The aim is to increase the shelf-life and to maintain a high quality.

A somewhat changed approach towards more lenient preservation methods has been evolved during recent years with the aim to limit quality changes during processing. An increased knowledge of basic physiology of microorganisms may give possibilities to develop better preservation methods. As a consequence of these facts, the mechanism of bacterial spore germination and spore resistance are investigated at SIK.

In spore germination research the work has been concentrated on the connections between germination stimulating amino acids and germination inhibiting compounds like fatty acids and fatty acid amides to give an explanation to the physiology of spore germination.

In the investigation of bacterial spore resistance the efforts have been mainly directed towards a search for the primary connection between heat resistance and water activity ($a_w$). For Bacillus subtilis as well as B. stearothermophilus the results give full evidence that resistance increases with decreasing $a_w$ between 0.9 to about 0.2. At extremely low or high water activities in the presence of e.g. NaCl or glucose a reduced heat resistance is observed when $a_w$ decreases.

The above mentioned projects will in the future be closely related to a new project dealing with biological preservation of foods. We will
mainly study the behaviour of bacterial spores in different fermented food products. The literature in this field has been covered during the year.

In refrigerated foods with high fat content the fat-splitting microflora is of importance for the keeping quality. Research at SIK has given valuable information on the composition of the flora in various foods. At the same time the activity of lipases and the relationships between lipase activity, pH and temperature have been studied. pH-stat-technique and gas chromatography are used to follow and analyse the changes caused by fat-splitting microorganisms. The factors most likely to regulate the effect of the lipolytic microflora in food is the present aim of these studies. The technique and the results of this project are supposed to be directly applicable on a new cooperative project with the Section of chemical structure ("flavour") dealing with microbiological quality improvements.

Project Nos. 37: Germination of bacterial spores
   Dr. B. G. Snygg

38: Resistance of bacterial spores.
   Dr. B. G. Snygg, and Mr. G. Härnåln, M.Sc.

39: Fat-splitting microorganisms
   Dr. B. G. Snygg, and Mr. U. Jonsson, M.Sc.

68: Lenient biological preservation
   Dr. B. G. Snygg, and Mr. G. Härnåln, M.Sc.

69: Microbiological quality improvements
   Dr. B. G. Snygg, Mr. U. Jonsson, M.Sc.,
   Dr. J. Andersson, and Professor E. von Sydow

Flavour

Foods develop flavour properties, desirable or undesirable, as a result of the processing procedures, storage conditions and type of package. In some foods, e.g. fruit and berry products, it is desirable to retain as much as possible of the flavour of the raw material.
A coordinated physico-chemical and sensory analysis of the aroma properties of a food commodity gives a basis for the development of objective aroma evaluation methods. A greater knowledge of the aroma complex and its changes during industrial operations will aid in the design of processes with optimal retention or generation of aroma and suppression of off-aroma and off-flavour.

It is known that the sterilization of meat products induces a specific off-aroma, which deteriorates the quality of the product. The aroma formation in canned beef has been analysed instrumentally and sensorically, with varied recipes and processing conditions. About ninety volatile compounds, including twenty-one sulphur compounds, were identified by mass spectrometry. Differences due to varying processing conditions and recipes were mainly quantitative. Good correlations have been found between the quantities of various volatile compounds and the sensory aroma notes assessed by a trained odour quality panel. The influence of the can material on the aroma properties is being studied in a two-year storage experiment.

Investigations have been started with the aim to develop methods to avoid or suppress the formation of off-flavour in canned meat products. HTST-processing, sterilization in packages with other shapes, e.g. flexible bags, recipe changes and selective chemical reaction of undesirable aroma components are being studied. The influence of the redox potential on the off-flavour formation will also be investigated.

The protein part of a food product cannot easily be replaced by another protein material with regard to aroma and taste. A physico-chemical investigation of the volatile compounds in unheated and heat treated model systems of some unconventional protein materials has been started. So far, soy protein, fish protein and the reference protein casein have been analysed, resulting in the mass spectrometric identification of about one hundred volatile compounds. Differences between the various proteins were mainly quantitative, though some qualitative differences were shown. Single-cell protein will also be included in this investigation. The flavour effect of the addition of unconventional protein materials to meat products will be studied next year.
As a continuation of previous investigations of the aroma of black currants, lingonberries, cranberries and bilberries, the aroma changes in *heat treatment of black currants* are now being studied. Black currant mash is heated at time-temperature conditions prevailing in industrial practice, and the aroma changes are analysed by gas chromatography, mass spectrometry and, sensorically, by an odour quality panel. Odour notes and quantities of the volatile compounds have been correlated by use of computer techniques. Both positive and negative correlations have been found. This project will be finished next year.

The influence of *climatic conditions* on the aroma properties of black currants is also being investigated. Two black currant varieties are grown on three locations in Sweden with widely different climates but under otherwise equal conditions. Berries harvested in 1968, 1969, 1970 and 1971 have been subjected to gas chromatographic and sensory analysis. Chemical and sensory aroma data and climatic data are being analysed for intercorrelation by computer techniques. The project will be finished during next year.

The aroma changes during *storage of frozen cod fillets* at various temperature levels are being investigated, chemically and sensorically, with the ultimate aim to devise objective methods for assessing the aroma quality. The concentrations of volatile components and free fatty acids and the sensory aroma changes have been observed during a 15-month storage experiment. Good correlations have been found, so far, between sensory aroma data and the quantities of various free fatty acids. The investigation will be finished during next year.

The keeping qualities of many food products are limited by the development of *rancidity*. In previous investigations the thiobarbituric acid (TBA) reaction for characterization of rancidity has been investigated. The ultimate aim of a new project is to devise more effective stabilizing treatment for food products prone to rancidity, by using the results of coordinated sensory and instrumental characterization of various types of rancidity. As a first step, possible ways to develop a system of descriptive terms for the sensory characterization of various types of rancidity are being scrutinized.

*Plastic materials used for food packaging* frequently create off-aroma and off-flavour problems. In a new project the influence of odour and
taste from packaging materials on the flavour of packaged foods will be studied, and methods for measuring such influence will be elaborated. Volatile compounds in various polyolefin films have been identified by mass spectrometry in preliminary experiments. The main part of the project will be devoted to sensory and instrumental analysis of odour and taste compounds in polyethylene films and the influence of raw material, additives and manufacturing process on the generation of such compounds.

Models for relationships between sensory and instrumental data are being developed in a special project. Owing to the numerous data to be handled, computer techniques are used for selection and statistical testing of the models. During the past year a computer program has been constructed which carries out multiple linear regression for a number of models of various degrees of complexity and ranks the models according to the goodness of fit. Next year will be devoted to the development of general programs for the fitting of non-linear regression models to sensory data. Programs for multidimensional analysis of sensory similarity and preference data will also be elaborated.

Project Nos. 43 (N): Effect of climatic conditions on the aroma of berries and fruits
Professor E. von Sydow, and Dr. J. Andersson

44: Aroma of processed berry products
Professor E. von Sydow, and Mrs. G. Ekström, M.Sc.

45 (N): Aroma changes in frozen cod
Professor E. von Sydow, Mr. L. Rasmussen, M.Sc., and Dr. J. Andersson

46: Aroma formation by heat processing of protein foods
Professor E. von Sydow, Mr. T. Persson, M.Sc., and Mr. I. Qvist, M.Sc.

56: Correlation between physico-chemical and sensory data by computer techniques
Professor E. von Sydow, Mr. T. Persson, M.Sc., and Dr. C. Å. Åkesson
Rheology

Within the project group "Rheology" consistency and texture of foods are investigated. These properties contribute, often in a decisive way, to the overall impression that one gets from the food consumed. The research is concentrated on finding methods for rheological analysis of unconventional proteins and foods containing such proteins, on analysis of vibration properties of foods with special interest given to crushing, and on sensory analysis of rheological properties.

The studies of rheological analysis of protein are carried out on two main lines: one instrumental and one sensory. Up to now macroscopic, rheological properties have been studied, but the research will be extended to fine structures down to the electron microscopy level.

We have continued the trials reported last year to fit mathematical models to compression relation curves registered by an Instron Universal Testing Machine. In addition to heat-treated textured soy proteins, a microbiological, textured protein has been investigated by this technique. In order to follow the rheological changes occurring during processing raw material into food ready for consumption, we have also minced and heat-treated the rehydrated proteins, after which we analysed them by using a SuR-penetrometer, fitted with an electronic measuring equipment.

A texture profile analysis of extruded, heat-treated soy proteins has been started. This analysis includes sensory evaluation of a series of rheological properties such as hardness, elasticity, chewiness and tensile strength, and also about ten geometrical properties. Differences between proteins treated in different ways have been quantified.
The study of vibrations, which occur during the crushing of food, has been aimed at obtaining knowledge of the characteristics of the crushing properties of various foods. The long-range aim is partly to develop new methods of analysis, and partly to investigate in what way acoustic factors affect the sensory judgement of rheological properties.

The crushing apparatus, which was constructed the previous year, has been fitted with a loadable plunger making it possible to achieve greater reproducibility. Sound analysis data obtained when crushing different types of crisp bread have been correlated with other instrumental and sensory data.

In a psychorheological experiment (determination of texture by the sense of touch) we have compared data from instrumental analysis and data from the corresponding sensory evaluation of crisp bread. The investigation included Instron analyses, instrumental analyses of crushing vibration and sensory evaluation of fracture force, hardness and brittleness. Computer analyses have rendered valuable information about correlations between the different methods of analysis. (For methods of statistical evaluation, see project group "Sensory evaluation").

The work on a bibliography of food rheology is now concentrated on producing part bibliographies in fields where the literature is difficult to survey or to get access to. In this connection great interest has been given to questions of terminology.

Project Nos. 49: Psychorheology

Assistant Professor B. Drake, Dr. C. A. Åkesson, Mr. L. Halldin, M.Sc., and Mr. Y. Andersson, M.Sc.

50: Bibliography of food rheology

Assistant Professor B. Drake

59: Protein rheology

Assistant Professor B. Drake, Mr. Y. Andersson, M.Sc., Mrs. B. Johansson, M.Sc., and Dr. C. A. Åkesson

60: Dynamic rheological methods of analysis

Assistant Professor B. Drake, Mr. L. Halldin, M.Sc., and Dr. C. A. Åkesson
Sensory evaluation

The increasing interest in catering and the increasing awareness of the consumers have contributed to bringing sensory evaluation into focus. To attempt a solution of principal problems in this field the project group "Sensory evaluation" deals with scaling as an analytical technique, and with questions regarding the selection and control of judges. An extensive service is also given to other research groups at SIK.

The studies of scaling aim at solving problems of measuring technique in connection with the evaluation of sensory properties. Examples of such problems are: Can sensory properties be measured at the same metric levels as physical and chemical properties? To what extent are sensory measurements influenced by random and systematic errors? What is the influence of such errors when determining functional relations between instrumental and sensory data?

To solve the mentioned problems, an extensive mathematical-statistical model has been developed for measuring sensory properties. This model has been applied to food model systems and to real foods, e.g., in a study of crisp bread. The results show marked differences in measuring precision between judges, between judged properties and between judged materials. In a separate study of visual perception it was shown that the training of judges may result in a precision gain of 5—30%.

The aim for next year is to generalize the above mentioned model to include multidimensional analysis of sensory data. This will make it possible to study how complex sensory properties depend on simple sensory properties, and well defined physical and chemical properties. The purpose is also to investigate how preference judgements are influenced by different sensory, physical and chemical properties. Similarities between subjective meaning of verbal expressions for aroma qualities will be analysed with multidimensional methods with the aim to evaluate quantitatively such qualitative descriptions.

The mathematical-statistical development work for the scaling project is carried out in collaboration with the Statistical research group at the University of Stockholm, as well as with the Departments
of computer science, mathematics and mathematical statistics at Chalmers University of Technology, Göteborg.

The development of methods for selection of judges has been started with a study of threshold methods i.e., methods to determine the lowest concentration (absolute threshold) or concentration difference (difference threshold) which can be perceived. Results from a previous international study of difference thresholds for salty taste have been further scrutinized. An investigation of absolute thresholds for salty taste, performed together with 13 other test kitchens in Sweden, has been completed.

During the spring of 1972, absolute thresholds for salt were determined according to an American method. The judges were asked to indicate which 4 samples out of 8 contained salt and which 4 were water. The results from these experiments will be compared with results previously obtained by using methods, in which samples were served in ascending, descending or randomized concentration order.

A computer program has been elaborated which permits an automatic calculation and plotting of sigmoid curves for threshold data.

During the coming year, threshold data for individual judges will be compared with the same judges' performance in ordinary sensory evaluation. A formulation of instructions for selection of judges is expected to appear during 1973.

Project Nos. 57: Scaling methodology

Assistant Professor B. Drake, Dr. C. Å. Akesson, and Mrs. B. Johansson, M.Sc.

58: Methods for selection and control of judges

Assistant Professor B. Drake, Mrs. B. Johansson, M.Sc., and Dr. C. Å. Akesson
Education

Per-Olof Fredriksson has taken his Ph.D. degree at the University of Göteborg on work performed at SIK.

Chalmers University of Technology (CTH)

Thirty students participated in the education in biochemistry, food chemistry, microbiology, food technology and nutrition at the Department of food chemistry at CTH, which is located at SIK. The Director, other members of the staff at SIK and Professor Björn Isaksson, Sahlgrenska Hospital in Göteborg have given lessons. Six students finished and 14 have started special degree projects. Owe Bengtsson and Bengt Jakobsson have passed their Ph.D. degrees at CTH.

Summaries of above mentioned degree works are published as SIK-Rapport Nos. 295, 298 and 304.

Seminars and courses

This year has been the first for the new educational section at SIK, which handles all internal and external education except the courses at CTH.

During this year 23 research seminars and eight information seminars have been arranged as a part of the Ph.D. degree education, and the internal education of the staff at SIK. A course in technical English and a course in gas chromatography have each attracted about 10 participants among the staff.

The following courses and seminars have been arranged for the staff from Government research institutions or agencies and Foundation members:

7.10 1971 Preference or acceptance — methods of analysis and application (35 participants)

Course leader: Assistant Professor B. Drake

14—15.10 1971 Information meeting (114 participants)
16—19.11 1971, Course in sensory evaluation (26 and 31 participants respectively)

Course leader: Assistant Professor B. Drake (16—19.11 1971), Mrs. B. Johansson, M.Sc., and Dr. C. A. Åkesson (11—14.4 1972)

2—3. 2 1972 Unit operations in the food field. Theory and calculations (30 participants)

Course leader: Assistant Professor N. Bengtsson

16. 3 1972 Biocatalysts in foods (35 participants)

Course leader: Dr. C. Eriksson

Documentation

In SIK publication series the following number of publications have been issued: SIK-Publikation 11, SIK-Rapport 7, SIK-Information 7 (of which 2 were special editions), SIK Bok-Nytt 2 and SIK:s Service-Serie 31. These publications as well as other information has been sent to the members of the Foundation and Government institutions on 12 different occasions. A list of reports in the SIK-Publikation and SIK-Rapport series, which have been issued during this year, is given below.

The library comprised in June 1972 of 8950 books, 8090 volumes of bound periodicals and 334 current periodicals of which 33 are abstract journals.

SIK has received two food cans, which were produced 1896 for Andrée's expedition to the North Pole. These cans have been donated by the relatives of the late Mr. Curt Armstedt. The Institute has also been given a canned product for military use from 1911 from Mr. Curt Lindgren, Bromma. Specimen from this product has been sent to Karolinska Institutet for investigations of changes in the cadmium concentration in foods. The cans were also shown at the exhibition at the 25th anniversary of SIK and as an attraction at the packaging exhibition "Plåtpack" at Nordiska Museet, Stockholm, in March.
Papers issued this year

SIK-Publikation


<table>
<thead>
<tr>
<th>No</th>
<th>Author(s)</th>
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<tr>
<td></td>
<td></td>
<td>(Summary of dissertation) (Swe., abstr. in English) 41 p. 1971.</td>
</tr>
<tr>
<td>296</td>
<td>Goldblith, S. A.</td>
<td>Food Science and Technology 1946-1971-1996. Retrospect and prospect,</td>
</tr>
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<td></td>
<td></td>
<td>past accomplishments and future challenges. Paper presented in</td>
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<tr>
<td>297</td>
<td>Drake, B., Johansson, B. &amp; Berggren, B.</td>
<td>Absolute thresholds for the taste of sodium chloride. The influence</td>
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<td></td>
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<td>of sample presentation order, presence of extra samples and</td>
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<td>information to the subjects. Investigation at 14 Swedish test</td>
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<tr>
<td></td>
<td></td>
<td>kitchens. (Swe., abstr. in English) 60 p. 1971.</td>
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<tr>
<td>298</td>
<td>Bengtsson, O.</td>
<td>Freeze-drying of raw beef. (Summary of dissertation) (Swe., abstr.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>in English) 33 p. 1972.</td>
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<tr>
<td></td>
<td></td>
<td>in English) 98 p. 1972.</td>
</tr>
<tr>
<td>301</td>
<td>Marcuse, R.</td>
<td>Fat- and food research in USA. Some impressions from a study tour in</td>
</tr>
<tr>
<td>303</td>
<td>Jakobsson, B. &amp; Bengtsson, N.</td>
<td>Freezing of raw and cooked beef. A study of heat- and mass transfer</td>
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<tr>
<td></td>
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<td>during cooking and reheating from frozen and thawed condition. (Swe.,</td>
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<tr>
<td></td>
<td></td>
<td>abstr. in English) 46 p. 1972.</td>
</tr>
<tr>
<td>304</td>
<td>Jakobsson, B.</td>
<td>Freezing and cooking of beef. A study of the influence of raw</td>
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<td></td>
<td></td>
<td>material- and treatment variables on quality and yield and of heat-</td>
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<tr>
<td></td>
<td></td>
<td>and mass transfer during cooking. (Summary of dissertation) (Swe.,</td>
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<tr>
<td></td>
<td></td>
<td>abstr. in English) 46 p. 1972.</td>
</tr>
<tr>
<td>305</td>
<td>Bengtsson, N. E. &amp; Olsson, P.</td>
<td>Benefits available to members of the Foundation for Swedish Food</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Preservation Research. 5 p. 1972.</td>
</tr>
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</table>
Contract service

The volume of the contract service at SIK is shown in the following schedule:

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Volume (Sw. Crs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>5</td>
<td>100,000</td>
</tr>
<tr>
<td>Other experimental work</td>
<td>50</td>
<td>200,000</td>
</tr>
<tr>
<td>Consulting services</td>
<td>28</td>
<td>18,000</td>
</tr>
<tr>
<td>Documentation (large-scale)</td>
<td>8</td>
<td>50,000</td>
</tr>
<tr>
<td>Education etc.</td>
<td>6</td>
<td>7,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>97</strong></td>
<td><strong>375,000</strong></td>
</tr>
</tbody>
</table>

In spite of the market situation the income from the contract service has increased with 34% compared to last year. This is a result from the growing use of the contract service at SIK by the Foundation members as a part of their long range research and development work. Contact discussions with private or groups of members, which were introduced last year, have been continued with good experiences.

An arrangement has been made with the British Food Manufacturing Industries Research Association (BFMIRA), which will make it possible for members of the foundations of the two organizations to place contract work at the other institute via their own institute. The collaboration in this field will start on September 1st, 1972.

Contacts

Besides the connection with the industry through the contract service and educational service, SIK has also excellent contacts with both Swedish and foreign scientists and institutions. The collaboration with the Chalmers University of Technology has already been mentioned, but we also wish to point out the contacts with the University of Göteborg and the University of Technology in Lund.
Several private visitors, and about 15 visiting groups have been to SIK during this year for discussions with the staff and tours of the Institute. The minister of industry Rune Johansson visited SIK on June 5th, as the head of a delegation from his ministry.

The Food and Nutrition Group in Göteborg (CLiNG) is an association of scientists in the Göteborg area, interested in food and nutrition. Today CLiNG has about 100 members. It was formed in order to facilitate the collaboration among scientists of different disciplines and to carry on interdisciplinary research projects. At present the first project is at a planning stage. During the year one seminar on "Attitudes to food" was arranged. Professor Erik von Sydow has been executive member of the governing board and executive committee of CLiNG.

The Nordic aroma research group, supported by Nordforsk's committee for sensory quality of foods, has during the past year been working on three projects at SIK. Contract service, which is the main interest of the group, has increased considerably compared to earlier years. Mr. Leif Rasmussen, M.Sc., Copenhagen, and Miss Marja Vihavainen, M.Sc., Helsingfors, have worked with the group on Nordforsk scholarships.

The members of Scandinavian Forum for Lipid Research and Technology (Lipidforum) is approximately 350. Dr. pharm. Reinhard Marcuse is the secretary of Lipidforum. A seminar on "Metabolism of human adipose tissue" was arranged by Lipidforum on November 12-13th, in Göteborg.

Dr. Marcuse is also Secretary General for the International Society for Fat Research (ISF). SIK participated in the arrangements of "The 11th World Congress of the International Society for Fat Research", which was held in Göteborg on June 18-22nd. A brochure, which was distributed during the congress, on "What is done where in Scandinavian Lipid Research and Technology" was worked out under the management of Lipidforum with economical help from Nordforsk.

The secretariat of the International Union of Food Science & Technology (IUFoST) is located at SIK. Professor Erik von Sydow is Secretary General and Treasurer of the Union. The purpose of
IUFoST is to work for international cooperation in the exchange of scientific and technical information among scientists and specialists of member nations, to advance technology in the processing, manufacture, presentation and distribution of food products, and to stimulate education and training in food science and technology. To achieve this IUFoST operates through committees and working groups. At present, national groups from 25 nations are adhering bodies of IUFoST. During the year 1971/72 three symposia were arranged in England, Japan and Switzerland respectively.
Governing Board of the Swedish Institute for Food Preservation Research

*Members appointed by the Swedish Government:*

- Director Carl Lindskog, Viken, Chairman
- Professor Erich Adler, Göteborg
- Director General Gösta Björkman, Lidingö
- Laboratory Director Marit Neymark, Stocksund
- Professor Örjan Ouchterlony, Kungälv
- Professor Karl Erik Thomé, Lund

*Members appointed by the Foundation for Swedish Food Preservation Research:*

- Assistant Professor Ingmar Bosund, Helsingborg
- Lic. Agr. Jacob Ekman, Uppsala
- Director Finn Jakobsen, Malmö
- Chief Engineer Erling Jannesson, Staffanstorps (from 1/5 1972)
- Director Kjell Nihlberg, Lund (until 30/4 1972)
- Director Åke Stenberg, Kungsbacka

The governing board has met on October 13th, 1971, January 27th, and May 25th, 1972.

**Auditors**

Chief Accountant Gunnar Helin, Stockholm (appointed by the Swedish Board for Technical Development)

Auth. Public Accountant Rolf Leander (appointed by the Foundation for Swedish Food Preservation Research)
Members of the Foundation for Swedish Food Preservation Research

Abba AB, Stockholm
AGA Aktiebolag, Lidingö
Alfa-Laval AB, Tumba
Astra Nutrition AB, Mölndal
Axel Broström & Son, Göteborg
Cold Stores-gruppen/Västsvenska Kyllhus AB, Göteborg
CPC-Produkter AB, Kristianstad
Gunnar Dafgård AB, Källby
Ekströms Livsmedels Producenter AB, Örebro
Extraco AB, Stockholm
AB Findus, Bjuv
KB Food Control AB & Co, Malmö
Frigoscandia AB, Helsingborg
AB Fructus Fabriker, Bromma
Glace-Bolaget AB, Stockholm
Göteborgs Kexfabriks AB, Kungälv
Husqvarna AB, Huskvarna
ICA, Inköpscentralernas AB, Stockholm
International Flavors & Fragrances, IFF (Sweden) AB, Stockholm
AB Iggesunds Bruk, Iggesund
AB Indra Food, Helsingborg
Kooperativa Förbundet ek. för., Stockholm
Kungsörnen AB, Stockholm
Köttbranschens Riksförbund, Johanneshov
Lantbrukarnas Riksförbund, Stockholm
AB Lithells, Kumla
AB Liva Fabriker, Lidingö
Lival & Co. AB, Göteborg

The Lord Rank Research Centre,
High Wycombe, England
AB Marabou, Sundbyberg
Margarinbolaget AB, Stockholm
AS Norsk Jernverk, Norsk Blíkkvalseverk, Norway
Novia Livsmedels Industri AB, Kristianstad
AB Pellerin/Zenith, Helsingborg
AB Platmanufaktur, Malmö
Fripp-Bryggerierna AB, Bromma
Semper AB, Stockholm
Sewico AB, Göteborg
Svensk Fisk ek. för., Göteborg
Svenska Chokladfabriks AB, Ljungbro
Svenska Elopak AB, Helsingborg
Svenska Extraktionsföreningen ek. för., Karlshamn
Svenska Mejeriernas Riksforening, Stockholm
Svenska Sockerföreningen AB, Malmö
Svenska Ågghandelnsförbundet, Johanneshov
Sveriges Centrala Restaurang AB, Stockholm
Sveriges Hotell- och Restaurangförbund, Stockholm
Sveriges Slakteriförening, Johanneshov
AB Topfryr, Brålanda
Västkustfiskarnas Serviceförening ek. för., Göteborg
AB Åkerlund & Rausing, Lund
Governing Board of the Foundation for Swedish Food Preservation Research

**Ordinary**

Director Olof Söderström (Chairman), Pripp-Bryggerierna AB, Bromma  
Director Christian Ameln (Vice Chairman), Abba AB, Stockholm  
Director Bengt Brynell, AB Plåtmanufaktur, Malmö  
Director Bengt Dieden, Svenska Sockerfabriks AB, Malmö  
Director Ingvar Jonsson, Svenska Unilever AB, Stockholm  
Director Lennart Lilliehöök, Skanek, Malmö  
Director Kurt Lindfors, Kooperativa Förbundet, Stockholm  
Director Börje Lindgren, Stockholms Prosper-Konsult AB, Stockholm  
Director Gunnar Lund, Sveriges Slakteriförbund, Johanneshov  
Director Sven Månsson, AB Felix, Eslöv  
Director Ulf Sundberg, AB Findus, Bjuv  
Director Bertil Turesson, AB Åkerlund & Rausing, Lund

**Deputies**

Director Gösta Brennerfors, AB Lithells, Kumla  
Director Bernt Emblad, Sewico AB, Göteborg  
Director Lennart Hanserud, AB Plåtmanufaktur, Surte  
Director Olof Hultman, Kooperativa Förbundet, Stockholm  
Director Evert Hännestrand, Västsvenska Kylhus AB, Göteborg  
Director Bertil Jonason, Lival & Co. AB, Göteborg  
Lecturer Torsten Nilsson, Frigoscandia AB, Helsingborg  
Vet. Med. Dr. Sten Pagmar, Stockholm  
Dr. Agr. Jaan Teär, Alfa-Laval AB, Tumba  
Director Oscar Westerlind, Lantbrukarnas Riksförbund, Stockholm

**Secretary**

Director Harry Hasselgren, Lantbrukarnas Riksförbund, Stockholm
### Economy

#### Income

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<thead>
<tr>
<th>Description</th>
<th>Amount (in thousand Sw.Crs.)</th>
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<tr>
<td>General program, STU</td>
<td>1,300</td>
</tr>
<tr>
<td>&quot; &quot; the Foundation</td>
<td>1,300</td>
</tr>
<tr>
<td>Projects &quot;quality properties&quot;, STU</td>
<td>1,700</td>
</tr>
<tr>
<td>Project grants</td>
<td>342</td>
</tr>
<tr>
<td>Contract service</td>
<td>374</td>
</tr>
<tr>
<td>Other</td>
<td>283</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,299</strong></td>
</tr>
</tbody>
</table>

#### Expenses

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<th>Description</th>
<th>Amount (in thousand Sw.Crs.)</th>
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</thead>
<tbody>
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<td>Research</td>
<td></td>
</tr>
<tr>
<td>Processes and technology</td>
<td>1,111</td>
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<tr>
<td>Chemical and biological stability</td>
<td>1,389</td>
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<tr>
<td>Quality properties</td>
<td>2,223</td>
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<tr>
<td>Information and education</td>
<td>172</td>
</tr>
<tr>
<td>Contract service</td>
<td>404</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,299</strong></td>
</tr>
</tbody>
</table>
Buildings and equipment

The Swedish Riksdag (Parliament) has on May 18th, approved a bill (No. 1972:54) for the rebuilding and an extension of the present building at SIK. The floor area of the new building will cover some 1225 square meters and the costs are in April 1971 estimated to 4.6 million Sw.Crs. The building work will start at the end of 1972 and will be completed in 1974. The new building involves a separate lecture hall and an extension of the laboratory building. Work for a new lunchroom has been completed.

Among recent acquisitions for research work at SIK the following may be mentioned: spectrofluorometer (Turner model 430), microcalorimeter (LKB, batch), fine distillation apparatus (Fischer-Büshi) completed with control equipment, gas chromatograph (Perkin-Elmer 990), temperature regulator made at SIK and a recorder (HP 7200A Graphic Plotter) to the data terminal at SIK.
Organization of SIK

Director
Secretary
Technical Secretary

Professor Erik von Sydow
Mrs. Anita Klöppel
Mrs. Jorun Kahl, M.Sc.

Research Sections

Biochemistry
Chemical structure (flavour)
Food structure
Food technology
Microbiology
Rheology
Sensory evaluation

Dr. Caj Eriksson
Professor Erik von Sydow
Dr. Jonas Andersson
Mr. Arne Liljemark, M.Sc.
Assistant Professor Nils Bengtsson
Dr. Benkt Göran Snygg
Assistant Professor Birger Drake
Assistant Professor Birger Drake
Mrs. Birgit Johansson, M.Sc.
Dr. Caj Åke Åkesson

Service Sections

Library and information
Contract service
Office
Maintenance
Education

Mr. Alf Erichsen, Graduate Engineer
Assistant Professor Nils Bengtsson
Mr. Pär Olsson, M.Sc.
Mr. Bertil Zetherström, M.Sc.
Mr. Fredrik Schoultz, Office Manager
Assistant Professor Nils Bengtsson
Dr. pharm. Reinhard Marcuse