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MODERNIZATION OF FOOD STORAGE THROUGH FREEZE-DRYING TECHNOLOGY

SI/DRK/86/881

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

Technical report: Assessment/analysis of the national food storage capacities and possibilities of their further development *

Prepared for the Government of
the Democratic People's Republic of Korea
by the United Nations Industrial Development Organization,
acting as Executing Agency for the
United Nations Development Programme

Based on the work of Vladimir P. Latishev,
expert in freeze-drying technology for food (meat and fish) storage

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United Nations Industrial Development Organization

Vienna

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EXPLANATORY NOTES

DPRK - Democratic People's Republic of Korea

PMPP - Pyongyang (Ryongsong) Meat Processing Plant

CLIC - Chemical and Light Industry Committee of the DPRK

PFIA - Pyong yang Food Industry Association of the CLIC

$\tilde{w}$ - mass fraction of water in product

$\tilde{f}$ - mass fraction of fat in product

ω - fraction of frozen out water in product

The value of one won (local currency) was equal to $ 0.4587 during the period of the mission.

TABLE OF CONTENTS

ABSTRACT

Modernization of food storage through freeze-drying technology
SI/DRK/86/881/11-01/ J 13103
FOOD, REFRIGERATION, STORAGE, FREEZE-DRYING, KOREA.
Immediate objective:

- To improve the technological processes used in the Pyongyang food processing plant through strengthening the facilities of the laboratory food processing and testing units, including installation of experimental freeze-drying machinery.

- To train national specialists in modern meat and fish storage technologies.

Development objective - to increase of the food industry output and to produce high quality foodstuffs which can easily be stored and distributed. Duration of the activity is equal to 2.5 man-months.

A refrigeration equipment of Pyongyang Meat Processing plant is the long used one. It does not provide the proper refrigerating capacity and the temperature level. Therefore food loses its quality during the cold storage. There are specialists of high qualification at the Pyongyang Meat Processing Plant. The food storage should be modernized. The modernization is preferable through both industrial vacuum freeze-drying technology, and industrial atmospheric freeze-drying technology.

INTRODUCTION

UNIDO expert attived in Pyongyang of the DPRK in July 6,1987. PMPP of the CLIC was the main duty station of the expert. The work was carried out in the close contact and the cooperation with the senior counterpart staff of the DPRK (Annex 1) and the UNDP office in Pyongyang. The expert works in correspondence with the approved work plan (Annex 2). The expert mission duration was equal to 2.5 months including the briefing and debriefing time.

Original immeadiate objective:

- To improve the technological processes used in the PMPP through strengthening the facilities of the laboratory food processing and testing units, including installation of experimental freeze-drying machinery.

- To train national specialists in modern meat and fish storage technologies.

Original development objective:

- To improve the performance of the food industry in order to increase its output and to produce high quality foodstuffs which can easily be stored and distributed.

Experimental laboratory freeze-drying installation was recommended in sheduled time but was not delivered during the expert mission. The original immediate objective was completely attained.

Laboratory equipment, purchased by UNIDO, and national specialists, trained in the DPRK and in Denmark, allow to accelerate the development of the industrial freeze-drying of food and attainement of the development objective.

RECOMMENDATIONS

1. By means of the UNIDO Chemical and Light Industry Committee of DPRK ought to acquire an industrial vacuum freeze-drying installation for the initial modernization of the national food storage at the PMPP through utilization of the industrial freeze-drying technology.
2. Chemical and Light Industry Committee of DPRK ought to equip the Pyongyang meat processing plant with the modern refrigerating installations for freezing of food before freeze-drying and for the enlargement of the cold utilization during the technological processes.
3. Management of the Pyongyang meat processing plant is to include the development of the freeze-drying food assortment and the freeze-drying technology of it with the usage of experimental vacuum freeze-drying installation into a work plan of the plant.
4. For improvement of the national freeze-drying of fish with respect to the increasing of the output of dry fish and to the rising of dry fish quality administration of the PFIA is to include designing and the manufacturing of the atmospheric freeze-drying installations with an open air circulation system and a closed air circulation system into a work plan of the association.
5. The Pyongyang meat processing plant management is to authorize specialists, trained in Denmark, to teach a staff for service of the industrial vacuum freeze-drying installation and of the experimental atmospheric freeze-drying installations.
6. The Pyongyang meat processing plant management ought to equip the ammonia refrigerationg machines with the monometers and the thermometers of proper accuracy for the support of the work regime.
7. The engineers - technologists ought ot go over the more low temperature level in order to preserve the food quality and to intensify the refrigerating treatment.
8. The engineers-technologists ought to stow the food inside the storage chambers with the creation of channals for cold air circulation and the best preservation of the food quality.
9. For the saving of energy the food enterprises of light industry ought to utilize the heat, produced the refrigerating machines, solar energy and surrounding cold air on the largest

scale.

10. Engineers for the new machinery ought to install the refrigerating air dryers in the technological corridors of the mold stores for the prevention of the moisture condensation on the walls and the floor.
11. The Pyongyang meat processing plant management ought to introduce the electrostimulation of carcasses before its freezing in order to preserve the quality of meat.
12. For saving of energy the management of meat and fish processing plants should utilize the heat pumps, especially for atmospheric freeze-drying.
13. Administration of food processing plants should introduce the utilization of ice shields for lowering of mass losses during the refrigerating storage.
14. Chemical and Light Industry Committee ought to organize the periodical training and refresher courses for engineers and technologists to acquaint them with the achievements in engineering, the refrigerating systems, the refrigerating and freeze-drying technology, the effective methods of work.
15. Administration of the Pyongyang meat processing plant should equip the plant with the freezer chest (temperature from -60 to -80°C, volume not less 250 litres) for freezing and storage of raw endocrine materials.
16. Management of food processing plants ought to enlarge the utilization of the light proof and moisture proof packing for freeze-dryed food.
17. Pyongyang meat processing plant administration should begin a restoration of insulating properties of refrigerating store walls without interruption of the functioning of the refrigerating store.
18. UNIDO is expected to assist in purchasing the equipment for the vacuum packing of the freeze-dryed products and for laboratory investigating of the full range of dairy products (e.g. Milko-Scan, Foss Electric, Denmark) for the Pyongyang meat processing plant as further action which might be taken.

1. ACTIVITIES AND OUTPUT

A. Main duties

In close collaboration with the CLIC of the DPRK with the management of the PMPP, with senior counterpart staff and with the UNDP office in Pyongyang the expert carries out the following duties:

- Study and analyze the food processing capacities and the applied technology and introduce freeze-drying processing of meat, fish and other foodstuffs;
- Assist in setting up plant laboratory with the testing and demonstration freeze-drying equipment; supervise its installation and put it into operation;
- Work out a training programme for Korean engineers (study tour to Denmark) and for the local technicians to be trained on the spot;
- Assess the complete organization and management system, qualification of staff, their functions and responsibility;
- Prepare a final report with detailed recommendations for the Government of the DPRK.

UNIDO short term consultant should work out a programme for the modernization of food processing and quality control of the factory.

B. Objectives of the activity

Development objective - to improve the performance of the food industry in order to increase its output and to produce high quality foodstuffs which can easily be stored and distributed.

Immediate objective - to improve the technological processes used in the PMPP through strengthening the facilities of the laboratory food processing and testing units, including installation of experimental freeze-drying machinery;

- to train national specialists in modern meat and fish storage technology.

C. Substance of the technical activity

The development of the food industry of the DPRK ranks as a major priority in the national economy since it is the main component in the improvement of the living standard of the population. The food industry in the DPRK is one of the most important branches of the national economy. The DPRK is increasing the production of food products for local consumption and for overseas markets in general and of fish and meat products in particular.

The 3rd seven-year plan of the development of the national economy of the DPRK during 1987 through 1993 outlines the rise of the industrial production output as much as 1,9 times, and the use of the agricultural production output as much as 1,4 times.

Food storage technology plays a major role in the country's food industry as the harvesting, the slaughter, the fisheries are seasonal. Thus the main part of fruit and vegetables is collected in July through October, the most intensive slaughter are in September through December, the fisheries are in December through February.

Practically all kinds of food should store the lasting term, during which the food loses its mass and deteriorates. The quantity and quality losses of products depend upon the perfection of the utilized storage technology.

The refrigerating storage of fruit, vegetables, fish and meat is practiced in the DPRK. The storage of dryed meat, fish, spices and fruit is used also. The meat is dryed under natural conditions or in general heat installations. The drying of fish is based on the national kind of freeze-drying technology in winter. The plants are dryed with a heat drying as a rule. The freshness of the processed product is not fully kept because of the lack of storage facilities and technologies.

Presently the storage facilities are not adequate from the technical and technological point of view and due to this reason approximately up to 15% of these products are being lost during transportation and storage.

The special attention is being paid to the preservation of the ptoduct quality and in particular the flavour, colour, shape, texture and contents of vitamins, fats and proteins.

It demands the introduction of new progressive technological processes and the improvement of the traditional ones.

The PMPP has 3 buildings with the storage chambers capacity, equals $50 \cdot 10^6$ kg of products. The buildings were put in the explcitation in the period from 1955 to 1969. The considerable modernization of the buildings, the refrigerating and technological equipment has not been done up to the present time.

The PMPP processes up to $30 \cdot 10^6$ kg of beef and pork, up to $10 \cdot 10^6$ kg of poultry, up to $10 \cdot 10^5$ kg of dairy products, up to $3 \cdot 10^6$ kg of fruit and vegetables, up to $3 \cdot 10^6$ kg of fish year in year out. Up to $1,3 \cdot 10^6$ kg of fruit, up to $0,5 \cdot 10^6$ kg of

vegetables, up to $1 \cdot 10^6$ kg of meat and up to $0,9 \cdot 10^6$ kg of fish are in a lasting term storage year in, year out.

Refrigerating equipment and technology

There are the ammonia reciprocating piston compressors, the heat exchange battery, cooled with the brine or with the liquid ammonia, boiled inside the tubes at the PMPP. The PMPP has 3 compressor compartments and the several decentralized refrigerating units.

First compressor compartment. The total refrigerating capacity is up to 1073 kWt. There are the two stage refrigerating units, proved the boiling temperature of ammonia inside tubes at the level of -33 ÷ -28°C and the one-stage refrigerating units with the boiling temperature of ammonia at the level -20°C and with the brine cooling batteries inside the refrigerating chambers.

Second compressor compartment. The total refrigerating capacity is up to 87 kWt. The refrigerating units can work with the one or two-stage compression. The batteries are cooled with ammonia, boiled inside the tubes at temperatures -18°C and -12°C.

Third compressor compartment. The total refrigerating capacity is up to 174 kWt. The re are the one-stage and two stage refrigerating units. The batteries are cooled with ammonia which is boiling inside the tubes at temperatures -23°C, -15°C, -13°C, -12°C.

The milk processing shop has the refrigerating units with total capacity up to 31kWt and the brine cooling apparatuses.

The bone processing shop has the refrigerated air dryer with the capacity of refrigerating unit up to 2,3 kWt.

There is the two-stage halocarbon refrigerant refrigerating unit with the capacity up to 25,5 kWt and with boiling temperature up to -45°C at the PMPP.

In a result of the investigation of the compressor compartments, of the conversation with the management and with the attendants we can draw a conclusion, that the refrigerating units are long used ones and do not correspond the up to date demands. There are no thermometers for the measurement at important places. The accuracy of many manometer is worse then 2,5% [11] (Annex 3).

The attendants are high qualifyed with an extensive practical experience. This allows them to support the long used refrigerating equipment in the operating state. The engineers and techni-

cians of the PMPP are able to exploit the modern ammonia refrigerating equipment with the screw compressors and the refrigerating units of the freeze-drying installations.

The refrigerated stores of the PMPP are multistorey with the low rise chambers. The bare pipe batteries are mounted on walls, sometimes they are mounted in the middle of the chamber as a separating wall. All the batteries are the gravity air flow cooling heat exchangers. The defrosting of the batteries is manual off-cycle by means of the chamber air.

The measurement of temperatures in the cold chambers is centralized in the compressor compartment. The temperature values are daily signed in the registration book. There are the instruments for the measurement of the air relative humidity inside some cold chambers.

In the freezing chambers the air temperature is supported at the level -12°C ÷ -18°C, in the storage chambers - at the level -6°C ÷ -8°C for meat and fish, and at the level +7°C ÷ +10°C for fruit.

The difference of the factual values of air temperature and the designed values of air temperature inside the storage chambers can be explained both the refrigerating capacity decreasing of the compressors, the heat exchange apparatuses and the increasing the heat conductivity of the thermal insulation. The moisture stains on the outside walls of the fruit and fish refrigerating store building proves the fact of a change for the worse of the waterproof thermal wall insulation.

There are the condensation of water vapour on the walls and the floor of the technological corridors of this refrigerating store in July-August. The exess moisture destroys both the insulating materials and the construction.

There are the bulk freezing and storage of vegetables and fruit at the PMPP. Packed poultry is freezed in the containers, installed with gaps between them.

The duration of freezing is the most lasting which does not prove the best preservation of the product quality.

There is a low loss storage at the PMPP as a result of the utilization of the natural convection cooling. For example, the mass losses of beef during freezing and storage does not exceed 3%.

At the PMPP the manual handling is practiced. It takes lasting

time, during which the product becomes warm and loses its quality. Besides it demands an additional expences of cold during the refrigerating storage.

On the whole the PMPP has enough of the refrigerating chambers for the cold storage. Yet, in the time of harvesting (July-October), the intensive fishery (December-February) there is a lack of the refrigerating chamber capacity.

The apparatus for production of meat dumplings was examined. Its capacity is equal to 300 kg of meat dumplings in a shift. This apparatus does not operate in summer because there is a lack of the low temperature commercial refrigerating facilities and of the refrigerated vehicles.

Thermal equipment and technology

The equipment of the milk processing shop, of the canning shop, of the bone processing shop, of the fish processing shop, of the poultry processing shop was examined at the PMPP. The milk at ambient temperature, received from farms is collected in tanks, where it is cooled by means of refrigerating units and stored until the processing. The milk processing shop produces sterilized milk, cow butter, jogurt, concentrated milk, dry milk. There are the vacuum vaporization apparatuses and the spray dryers at the milk processing shop. The capacity of these apparatuses is rather small.

At the bone processing shop the bone boullion is concentrated in the vacuum-vaporization apparatuses and is dryed in the spray-dryers up to a powder. The pure powder or its mixture with other powder components (for example, pepper, salt, spices) is packed in water vapour proof package. In order to exclude the humidization of the powder the refrigerating air dryer are installed in the packing room. The process cooling is not practiced at the poultry processing shop, and at the fish processing shop. A freezing is used for the packed product at the end of the process. There are canned pork, fruit, berries (water melon), vegetables (salted cucumber) at the canning shop.

The high air temperature and the high relative air humidity are typical for many processing shops in July-August.

Atmospheric drying of products

Atmospheric drying of products is not utilized at the PMPP. However, atmospheric winter freeze-drying of fish are in a large scale usage on the coast. Up to 6,5% of "Mintaj" catch is processed

by means of the atmospheric freeze-drying. The output of dry fish is equal up to $20 \cdot 10^6$ kg. Moreover, the people used as food other dry products, for example, pepper, onions, mashrooms, garlic.

The atmospheric drying depends upon weather and upon its change. Therefore the drying process is a lasting one, but the product quality is not always high.

The present dryed fish output capacity is considerably lower then the people's demand for it both in the DPRK and abroad.

Setting up the PMPP laboratory with the testing and demonstration freeze-drying equipment

The UNIDO expert together with the senior counterpart specialists prepared "List of the testing and demonstration freeze-drying equipment for D.P.R. of Korea" (Annex 4). The numbers of the items are in a descending order of the priority.

The list includes the expendable and non-expendable equipment, which is necessary both for research works, and for the training of specialists of freeze-drying technology. Estimated grand cost was $14,814 without the delivery cost.

UNIDO input in accordance with points 41.00 and 42.00 of the project are equal to $15,000. Therefore it was decided to recommend for the headquarters purchase order a minimum of equipment which else allows to put in operation a vacuum freeze-drying unit.

Such equipment is (Annex 4, p.1): 1) laboratory freeze-dryer 8, 2) vac-stop tray dryer, 3) vacuum pump for freeze-dryer 8. An estimated cost of this equipment is equal to $13,063 excluding the delivery cost.

The recommendations for the purchase order, approved by the senior counterpart staff, were cabled to UNIDO, Vienna (misc 955, Annex 5).

The delivery of the experimental vacuum freeze-drying installation is expected in October 1987.

Food processing and quality control

There is a laboratory at the PMPP which analyses the raw materials and foodstuffs with respect to their quality properties, such as: mass fraction of protein, of fat, of water in the products and the bacteria content [Bact. coli, Bact(Proteus) vulgare] in them.

There are the out of date measurement devices at the PMPP laboratory. Measurements of the quality properties take too much time. Therefore they do not provide a proper statistical control of output production quality.

Assessment of the complete organization and management system, qualification of staff, their functions and responsibility

The CLIC of the DPRK is a counterpart committee. The PFIA is a specialized agency of the CLIC. PMPP is an industrial enterprise of the PFIA and the main duty station of the UNIDO expert.

Chief technologist of the PMPP Mr.Li Sa Ho is a senior counterpart officer of the PMPP. He is also an interpreter from Russian into Korean language. List of the senior counterpart officers is in Annex 1.

The PMPP receives the agricultural production and the frozen fish, stores it in a cooled or frozen state in the refrigerating chambers, processes the raw materials for ready or semiready for eat foods. Only a part of the raw materials should be stored a lasting period.

The PMPP is headed by the general director. There are the posts of chief engineer, chief technologist, chief of the new machinery, head of a shop, foreman, engineer, technoligist, team leader, technician. They guide the workers of different specialities.

The duties and responsibility of each staff member is defined with the title instruction. All recommendations of the title instruction are punctually fulfilled.

As a result of conversations with the engineers and technicians concerned the machinery and technology of refrigeration and refrigerating storage, it is established that they are specialists of a high qualification and as a rule with large experience of practical work.

Installed equipment is supported in a working state.

Training programme and its attainment

The training programme is based on the assessment of the background and experience of the PMPP staff. It includes three interdependent parts: the refrigerating engineering technology, the freeze-drying machinery and technology (Annex 6).

Attention is paid to physics of processes, problems of energy saving, problems of mass losses of products, problems of quality of product preservation.

The main objective of the training programme is to rise the qualification of specialists in order to accelerate the modernization of national food storage through freeze-drying technology.

The lectures were begun in the People's Culture House and were finished in the Grand People's Study House. The classrooms were well-equipped. Illustration (tables, formulars, charts, schemes) were prepared by the expert beforehand. The consultations took place both after lectures and individually. Answers to the questions were given after each lecture, and even during the lecture. 45 listeners from 17 organizations attended the lectures (Annex7).

The training programme is also suitable for 4 specialists to be trained in the operation of the freeze-drying equipment and in the processing methods in Denmark for approximately one month (Annex 8).

An additional training course was attained for 4 participants of study tour. This course concerns the particular questions of work of the industrial freeze-drying installations. The methods of calculation of the water fraction after sublimation and after the whole cycle of drying were discussed in detail. The recommendations for utilization of thermophysical property data in the table and chart forms were given to listeners.

The methodical materials, instructions, recommendations, transactions concerned the training programme were handed to the counterpart officer from the PMPP [1 + 6] (Annex 3). The listeners were informed about the other published materials, used in lectures [7 + 11] (Annex 3). The training programme was successfully completed.

As for the study tour abroad it is expected that the participants will travel sometime in October 1987.

Account of activities

Studies and analyses of the food processing capacities at the PMPP show, that the main refrigerating equipment is a long used one and does not prove the proper food quality preservation. The refrigerating equipment of the PMPP should be modernized. The utilization of the process cooling should be enlarged during the treatment of milk, chickens and fish. The freeze-drying

technology and machinery give a possibility to rise the product quality and increase the equipment capacity in the shortest period of time with the comparatevely low expense.

An experimental vacuum laboratory freeze-drying installation was selected for the PMPP. Its technical data and estimated cost were cabled to UNIDO for the purchase order. The training programme was worked out in accordance with the work plan. It was approved by the counterpart committee. 45 Korean engineers rose their qualification. 4 Korean specialists to be trained in Denmark or FRG were drilled additionally.

The draft final report with the recommendations for the DPRK Government and with findings was prepared in scheduled time and was discussed in detail with the senior counterpart officers and with UNIDO substantive officer.

D. Findings

1. Government of the DPRK is interested in the lowering of the food mass losses during treatment and storage of food and in the enlarging of the production of high quality food.

It is planned for the PMPP to increase the production output in 1990 in comparison with 1986:

milk	- 33%
beef and pork	- 50%
poultry	- 150%
fish	- 200%
fruit	- 67%
vegetables	- 100%

Investigation of the food processing capacities and the applied technology of the food storage and the refrigerating treatment at PMPP shows, that the refrigerating installations, air coolers, equipment of the milk processing shop, of the poultry processing shop, of the fish processing shop should be modernized.

Consumer should be supplied with the high quality foodstaffs. It demands a modernization the whole refrigerating chain including the agriculture, the food processing plants, the refrigerating transport, the trade refrigerating storage and the consumer refrigerator. This well-known method of solving the nutrition problems takes much time and expenses.

The solving of the discussed problem may be accelerated through the utilization of the industrial freeze-drying technology

and equipment. The freeze-dryed products can be stored for a long period of time at positive temperatures without the deterioration. The above mentioned eliminates the expenses for the refrigerating storage, the refrigerating transport, the home refrigerator.

Freeze-drying technology decreases the mass losses of foodstuffs, provides the high quality of the food after prolonged storage period.

The freeze-drying technology provides the other following product advantages and market benefits through:

- retaining the original form, flavour, shape, colour and structure;
- retaining the proteins and vitamins;
- quick and complete reconstruction.

Therefore, the solution of the problem, defined by the Government of the DPRK is preferable through the utilization of the industrial freeze-drying technology and equipment.

2. A winter fish drying is used in a large scale in the DPRK. This drying is not enough intensive variant of the atmospheric freeze-drying. The drying process is very lasting. It is influenced by the temperature and relative humidity oscillations. Thus, the quality of fish after the freeze-drying is not always good.

The traditional winter freeze-drying may be intensifyed by the atmospheric freeze-drying installations. The latter are less expensive in comparison with the vacuum freeze-drying installations. The atmospheric freeze-drying installations can be made in the DPRK with the national means.

The average air temperature and average relative humidity of air for Pyongyang are shown in the table.

Table 1

Month	1	2	3	4	5	6	7	8	9	10	11	12
Temperature, °C	-7,8	-4,3	1,9	9,8	16	20,7	24,2	24,3	18,8	11,8	3,7	-4,4
Relative humidity, %	72	70	66	63	65	71	79	81	76	73	73	73

A mass fraction of water in a liquid phase is shown in Table 2 in dependence from the temperature of product (beef, $\xi w = 0,741$, $\xi f = 0,038$) [4] (Annex 3).

Table 2

Temperature, °C	-1	-2	-3	-4	-5	-10	-20	-30	-40
Mass fraction of water in a liquid phase, $(1-\omega)$, %	87	43	31	25	22	14	8	6	5

Table 2 confirms, that the mass fraction of frozen out water is equal to 69%. The water in solid phase can be sublimed at -3°C.

In accordance with Table 1, air temperatures at level -3°C may be in Pyongyang from December to February. The atmospheric freeze-drying is possible in this period of year.

The water fraction in beef will be after freeze-drying at -3°C.

$$\xi_{w1} = \frac{\xi_w \cdot 0,31}{\xi_w \cdot 0,31 + (1-\xi_w)} = 0,47$$

If the water fraction in beef after freeze-drying is equal to 0,15, then mass fraction of water in a liquid phase will be:

$$(1-\omega) = \frac{\xi_{w1}(1-\xi_w)}{\xi_w(1-\xi_{w1})} = \frac{0,15\ \ (1-0,741)}{0,741\ (1-0,15)} = 0,06$$

By means of table 2 we find, that the freeze-drying temperature is equal to -30°C.

From these examples we can draw a conclusion, that up to 80% of ice can be sublimed at temperature of surrounding air in winter. The rest of water in the solid phase may be sublimed with a low temperature air, cooled with a refrigerator.

Thus the two variants of atmospheric freeze-drying installations should be utilized in the DPRK:

- with an open circulation system of surrounding air;
- with a close air circulation system and with an artificial refrigeration of air.

The description of the atmospheric freeze-drying installations is in Annex 9.

3. Atmospheric freezing of product up to temperature -3°C allows to freeze out 69% of product water (see Table 2). Thus, it saves the energy needs for complete freezing and increases the capacity of the low temperature air blast tunnels, operated as the second step freezers. A description of contact freezer for the preliminary freezing is in Annex 10.

4. The Pyongyang meat processing plant refrigerating systems should be modernized both for the lowering of cooling and freezing temperatures and for the enlargement of the utilization of cold for freezing before freeze-drying, for the technological processes of treatment of milk, fish, poultry and for the shop technological air conditioning in summer.

E. Output of the activities

The experimental laboratory vacuum freeze-drying was offered for the UNIDO purchase order. After the delivery the vacuum freeze-dryer will be put into operation at the PMPP.

After the nomination the four Korean specialists in the food technology and the food machinery were trained in the field of the freeze-drying technology and machinery before their study tour to Denmark.

A training programme for Korean engineers of the CLIC in the field of the refrigerating engineering, the refrigerating food storage technology, the freeze-drying technology and machinery was worked out and realized. The lectures took place in the People's Culture House and in the Grand People's Study House of Pyongyang. The recommendations for the national modernization of the food storage technology through the freeze-drying technology and the food processing quality control were proposed to the Government of the DPRK.

II. UTILIZATION OF THE OUTPUT OF THE ACTIVITIES

The knowledge acquired at the training course is used by the engineers of the DPRK for the modernization of the refrigerating systems and the refrigerating technology of the treatment and the storage of foods, for the enlargement of the utilization of cold in the food branch of the light industry of the DPRK.

The knoweledge acquired by the specialists of the DPRK, awarded the study tour to Denmark, will help them to master the industrial vacuum freeze-drying technology and the equipment.

The utilization of the laboratory vacuum freeze-drying installation will be useful for the preparation of the freeze-dryed national product assortment, for the development of the industrial freeze-drying technology of the national products, for the training of the engineers and technicians staff.

The management of the PMPP plans the manufacture of experimental atmospheric freeze-drying installations with the open and close air circulation systems for the intensification of the national freeze-drying of fish and for the rise of quality of the dryed fish.

To improve the usage of the activities results it is desirable, that the organization of the industrial freeze-drying technology and machinery should be included in the plans of the food branches of the light industry of the DPRK in 1988. For the research investigation the base from the experimental equipment and the trained engineers staff has already been found.

CONCLUSIONS

The third seven-year plan of the development of the national economy of the DPRK in the period from 1987 to 1993 shedules the growth of the output of industrial production in 1,9 times, and agricultural production in 1,4 times.

However, the acting equipment of the PMPP is the long used one. It does not provide the temperature regimes for long term storage of meat, fish, poultry, vegetables and fruit with their minimal deterioration and for their refrigerating treatment (cooling, freezing) under the growth of the agricultural production.

The installed refrigerating equipment should be modernized in order to increase the total compressor capacity, lower the temperature level of produced cold, to automate the refrigerating installations and to get better of the energy efficiency of the latter.

The used technology of the storage and food production can be improved through the enlargement of the utilization of the quick cooling of food after the heat treatment. First of all it concerns the production technology of dairy products, fish and poultry products.

The technology of freeze-drying is the most preferable means of improvement of the storage and treatment of food.

Experimental laboratory vacuum freeze-drying installation and national staff, trained both in the DPRK and in Denmark, are the base of DPRK for the development of the national freeze-drying industry.

The commercial technology of vacuum freeze-drying of the national raw materials can be developed and approbate on this base.

It is desirable in the future to mount the industrial vacuum freeze-drying installations at the PMPP.

There is a staff of attendants of high qualification. The national technology of winter freeze-drying of fish can be improved and the quality of dryed fish can be increased through the utilization of the installations and the technology of the atmospheric freeze-drying.

It is desirable to make the experimental atmospheric freeze-drying installations with the means of the PMPP for the acceleration of the mastering of the atmospheric freeze-drying technology. The PMPP has all technical means for this.

Success of the improvement of the food storage through the refrigerating technology and the freeze-drying technology can be attained only after the inclusion of the above mentioned works in the national development plans, beginning with 1988.

By means of the UNIDO the CLIC is expected to improve the quality of dairy products through purchasing the modern instruments for processing quality control.

ANNEX 1

LIST OF THE SENIOR COUNTERPART STAFF
PROJECT SI/DRK/86/881

1. Zu Jong Ryol - chief of the section of the technical Department of the Chemical-Light Industry Committee of D.P.R. of Korea

2. Kim Du Nam - instructor of the technical Department of the Chemical-Light Industry Committee of D.P.R. of Korea

3. Li Sa Ho - chief technologist of the Pyongyang Meat Processing Plant

ANNEX 2

Approved by:Zu Jeng Ryel

WORK PLAN OF UNIDO EXPERT, PROJECT SI/DRK/86/881, MODERNIZATION OF FOOD STORAGE THROUGH FREEZE-DRYING TECHNOLOGY

N°	Activities	Sheduled completion	Counterpart persons
1	2	3	4
1.	Arrive in Pyongyang, solve the organization questions	(6-8)7.87	Kim Du Nam Li Sa Ho
2.	Work out list of laboratory equipment of freeze-drying technology suitable for the D.P.R.of Korea	(9-10)7.87	Li Sa Ho
3.	Approve the list of laboratory equipment and cable to UNIDO, of 10/T/AGRO	(11-14)7.87	Kim Du Nam
4.	Develop the project of work plan of UNIDO expert	(15-19)7.87	Li Sa Ho
5.	Approve the work plan of UNIDO expert	(20-22)7.87	Kim Du Nam
6.	Study the food processing capacities and the applied technology of food storage and refrigerating treatment(cooling and freezing)	(23-31)7.87	Li Sa Ho

1	2	3	4
7.	Analyze the results of investigation and introduce freeze-drying processing of meat, fish and other foodstuffs		
8.	Assess the complete organization and management system, qualification of staff, their functions and responsibility	(10-12)8.87	Kim Du Nam
9.	Determine training requirements and prepare a training programme, assist in training places and conduct on-the-spot training	(13-17)8.87	Kim Du Nam
10.	Assist in training of 4 Korean engineers for the study tour	(18-20)8.87	Li Sa Ho
11.	Assist in setting up the plant laboratory with the experimental freeze-drying installation and put it into operation(if it is procured by August 1987)	(21-30)8.87	Li Sa Ho
12.	Prepare the draft final report	(31.8-6.9)87	Kim Du Nam Li Sa Ho
13.	Approve the draft final report	7.9.87	Kim Du Nam Li Sa Ho
14.	Finish the formality, departure to Vienna via Moscow	8.9.87	Kim Du Nam

UNIDO expert V.P.Latishev

Counterpart specialists
Kim Du Nam
Li Sa Ho

ANNEX 3

LIST OF REFERENCES

1. Meroprijatija po snijeniju raskhoda elektroenergii na virabotku kholoda pri ekspluatazii ammiachnikh kholodilnikh ustanovok. Moskva, VNIKTIkholodprom,1982, 22p. (Russian).
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10. Ts.Tsvetkov. Vacuumni sublimazionni installazii. Tekhnika. Sofia, Dordzavno Izdatelstvo "Tekhnika", 1977, 213p. (Bulgarian).
11. Pravila ustroistva i bezopasnoi ekspluatazii ammiachnikh kholodilnikh ustanovok. Moskva, VNIKTIkholodprom,1981, 160p. (Russian).

ANNEX 4

Approved by:Zu Jang Ryel

LIST OF THE TESTING AND DEMOSTRATION FREEZE-DRYING EQUIPMENT FOR D.P.R. OF KOREA PROJECT SI/DRK/86/881

N°	Goods	Quantity	Unit	Unit price	Amount
1.	Laboratory freeze-Dryer,8,220V,50HZ, spec.23(same as Fisher10-269-9a)	1	ea	US-$	4,753
	Vac-stop Tray Dryer, 220V,50HZ,Spec23 (same as Fisher 10-269-7)	1	ea		6,665
	Vacuum Pump,220V, 50HZ,Spec.23(same as Fisher 1-130)	1	ea		1,645
2.	Crimper,Fisher 10-319-490	1	ea		115.45
3.	Freeze-Drying Flask Volume 40 ml,Fisher 1-0269-50	16	ea	45.80	732.80
	80 ml 10-269-51	1	ea		47.05
	600 ml 10-269-54	1	ea		75.25
4.	Dew Point Meter,Spec. 23(same as Fisher 11-662-50)	1	ea		768.75
	Lithium chloride solution 120 ml				11.57
	Grand total				14,813.87

Item Number is in descending order of priority.

UNIDO expert: V.Latishev Counterpart specialist: Li Sa Ho

ANNEX 5

UNIDO

UNIDO VIENNA

10 July 1987
DRK/86/881

ZCZC POYO45
DD VIP
PYONGYANG (UNDP/UNIDO) 10/7 1135
MISC995 VASSILIEV FOR GALAT RE SI/DRK/86/881 FOOD STORAGE FROM LATISHEV. AS AGREED IN MOSCOW CONFIRM INCLUSION FOLLOWING EQUIPMENT IN PO (1) LABORATORY FREEZE DRYER 8 (2) VAS-STOP TRAY DRYER (3) VACUUM PUMP. FREEZE DRYING LAB INSTALLATION CANNOT BE PUT INTO ACTION WITHOUT VACUUM PUMP.
(WIBERG)
COL 955 86/881 (1) 8 (2) (3)
NNNN

Carl-Erik-Wiberg
Res.Rep.

Mr.Latishev

Latishev/EVW/lms

ANNEX 6

Approved by: Zu Jang Ryel

TRAINING PROGRAMME FOR SPECIALISTS OF DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA IN THE FIELD OF FREEZE-DRYING ENGINEERING AND STORAGE OF FOOD (MEAT AND FISH) PROJECT SI/DRK/86/881

1. Introduction.
2. Ammonia refrigerating equipment and systems.
2.1. Up-to- date/status and development.
2.2. Energy efficiency, utilization of heat, worked out with refrigerating machines.
2.3. Utilization of surrounding cold for cooling, freezing, storage and drying of food.
2.4. Utilization of solar energy for production of cold.
2.5. Screw compressors.
2.6. Separation of oil and air from refrigerating system.
3. Cooling, freezing and storage of food.
3.1. Up-to-date state and development. Normalization of cold consumption and of mass losses, contact apparatus for cooling and freezing, electric stimulation (tenderization) of meat before freezing.
3.2. Fundamentals of heat and mass transfer during cooling and freezing of food, influential factors of mass losses, mathematical mass losses model.
3.2.1. Lowering of heat flow into storage chambers.
3.2.2. Lowering of storage temperatures (air temperature inside of storage chambers).
3.2.3. Utilization of (vacuum) packing.
3.2.4. Utilization of ice shields (covers) for food in storage chambers.
3.2.5. Velocity of air movement and area of heat transfer surface of air coolers. Its influence on mass losses.
3.2.6. Air and moisture exchange with surroundings. Its influence on mass losses.

3.3. Parameters to be maintained during food storage.
3.3.1. Temperature. Proper arrangement of food inside the storage chambers.
3.3.2. Relative air humidity inside a storage chamber.
4. Vacuum freeze-drying of food.
4.1. Up-to-date state and development.
4.2. Physical bases of freeze-drying. Moving force of drying. Food protection during freeze-drying.
4.3. Vacuum freeze-drying.
4.3.1. Scheme of periodical operation of vacuum freeze-drying installation.
4.3.2. Sublimator and its action.
4.3.3. Desublimator and its action.
4.3.4. Mechanical vacuum pump and its action.
4.3.5. Cold supply system and its action.
4.3.6. Heat supply systems and their action.
4.3.7. Control devices, measurement instruments.
4.3.8. Typical vacuum freeze-drying technology of food.
4.3.9. Packing and storage of freeze-dryed food, definition of sorption and desorption.
4.4. Atmospheric freeze-drying.
4.4.1. Scheme of atmospheric freeze-drying installation for (action) operation during cold season.
4.4.2. Sublimator and its action.
4.4.3. Air filter, ultraviolet lamp and their action.
4.4.4. Heat supply system.
4.4.5. Air circulation system and its action.
4.4.6. Possible atmospheric freeze-drying technology of food.
4.4.7. Packing and storage of atmospheric freeze-dryed food.
4.4.8. Scheme of atmospheric freeze-drying installation for operation in summer.
4.4.8.1. Additional equipment for operation in summer (air cooler, closed air circulation system, defrosting system).
4.4.8.2. Utilization of the installation both for freeze-drying and for freezing.
5. Consultations.
6. Conclusion.

UNIDO expert: V.P.Latishev

Counterpart specialists:
Kim Du Jam Li Sa Ho

ANNEX 7

Approved by: Zu Jeng Ryel

LIST

OF THE LISTENERS OF THE TRAINING PROGRAMME IN THE FIELD OF FREEZE-DRYING ENGINEERING AND STORAGE OF FOOD PROJECT SI/DRK/86/881

* Pyongyang food association

So Hen Chel - deputy chief engineer

* Pyongyang meat processing plant

1. Pak Son In - chief of a new machinery
2. Rjun Gun Won - team leader of refrigerating shop N°1
3. Kim Don Chel - chief of a designer section
4. Li Seng Ho - engineer-technologist
5. Go Ok Sun - engineer-technologist
6. Kim Goan Men - chief of vegetables and fruit processing shop
7. Ri Bong Su - team leader of refrigerating shop N°3
8. Zan Tae Sun - chief of fish processing shop
9. Rim Yong Suk - head of meat processing technology
10. Kim Mung Whoa - head of milk processing technology
11. Zen Myng Ung - chief engineer
12. Li Sa Ho - chief of technologist
13. So Chun Ryen - chief of bone processing shop

* Children's nutrition research institute

1. Mun Zen In - research worker
2. Kim Sung Gon - designer
3. Tae Ron Koan - designer
4. Whan Un - candidate of technical sciences, chief of section

* Local management design bureau

1. Choi Ri Zu - manager
2. Zang Kong Won - designer
3. Kim Man Ho - designer

* Pyongyang flour processing plant

1. Kim Song Hi - chief of a new machinery

2. Zu Hong Ren - chief of a designer section
3. Kim Zen Wan - designer

* Pyongyang starch-corn sugar plant
1. Zeng Jun Won - research worker
2. Kim Mun Whan - deputy chief of a shop
3. Jun Zun Ho - chief of a shop

* Pyongyang plant of children's food
1. Kim Rye Chun - research worker
2. Pak Gi Won - designer

* Pyongyang glutamate plant
1. Kim Yeng Hi - research worker
2. Gon Bun Goang - research worker

* Taedonggang chemical and food plant
1. Pak Zeng Whoan- chemist-engineer
1. Kim Ryng Ryen - chemist-engineer

* Pyongyang bear plant
1. Kim Tae Un - research worker
2. Kim Sun Gon - chief of a new machinery

* Samsok processing plant
1. Kim Gen Nam - research worker
2. Ju Gun Ok - research worker

* Pyongyang research institute of children's nutrition
1. Kim Zeng Su - chief of a section

* Pyongyang vegetables processing plant
1. Go Zang Su - research worker

* Seng gyo food plant
1. Choi Sin Muk - chief of a new machinery

* Fermentation research institute
1. Kim Yeng Su - research worker

* Maize research institute
1. Kim Sang Zun - chief of a section

* Research institute of food industry
1. Li Zu En - candidate of technical sciences, research worker
2. O Goan Zeng - research worker
3. Hong Go Yeng - research worker

UNIDO expert
V.Latishev

Counterpart specialists
Kim Du Nam
Li Sa Ho

ANNEX 8

LIST OF THE PARTICIPANTS OF THE STUDY TOUR
PROJECT SI/DRK/86/881

Name	Title	Speciality
1. Zu Zong Ryel	Senior of the technical department of the Commission of the Chemical and Light Industry of the DPRK	Food engineering
2. Li Sa Ho	Head of the laboratory of the Pyongyang meat processing plant	Food engineering
3. Kim Yong Lo	Foreman of the Pyongyang meat processing plant	Engineering of food machine
4. Choi In Guen interpreter	Programme officer of the Pyongyang UNDP office	Chemical engineering

Duration of the study is equal to a month.
Denmark and FRG are the possible places of study.

UNIDO expert: Vladimir P.Latishev

ANNEX 9
DESCRIPTION OF THE ATMOSPHERIC FREEZE-DRYING INSTALLATIONS

Project SI/DRK/86/881

Installation with the open air circulation

The installation can work when the surrounding air temperature is lower than -3°C (the lower the temperature the better). It can work both as an air blast freezer and as atmospheric freeze-drying installation. A scheme of the installation is shown on Figure 1. It consists of an air filter 1, a fan 2, a filter-equalizer of air velocity 3, heating shelves 4, a body 5, raw material 6, a heat air exhaust 8, an instrument for the measurement T and a relative air humidity φ .

A body 5 should be covered with an outside heat insulation. A system 7 can work from a different sources of heat: heat of condensation of refrigerating installations, solar heat, electrical heat, any low potential heat.

Entrance of cold air should be located rather far from the exit of heat air in order to avoid theirs mixtion.

Method of operation

Raw material 6 is located on shelves 4. Then a fan 2 is switched on. A cooled air flow freezes the raw material up to a sheduled temperature. After this a heat supply system 7 begins to work so, that to support raw material temperature at the sheduled level. It is quite excluded the defrostation of the raw material.

A duration of the drying and the water fraction of dryed material are as a rule founded experimentally.

It needs a sanitary treatment of a body 5, an air filters 1, 3, the shelves 4 and a channel 8 after a definite period of work.

Installation with the close air circulation

The scheme of an installation is shown on Figure 2. An

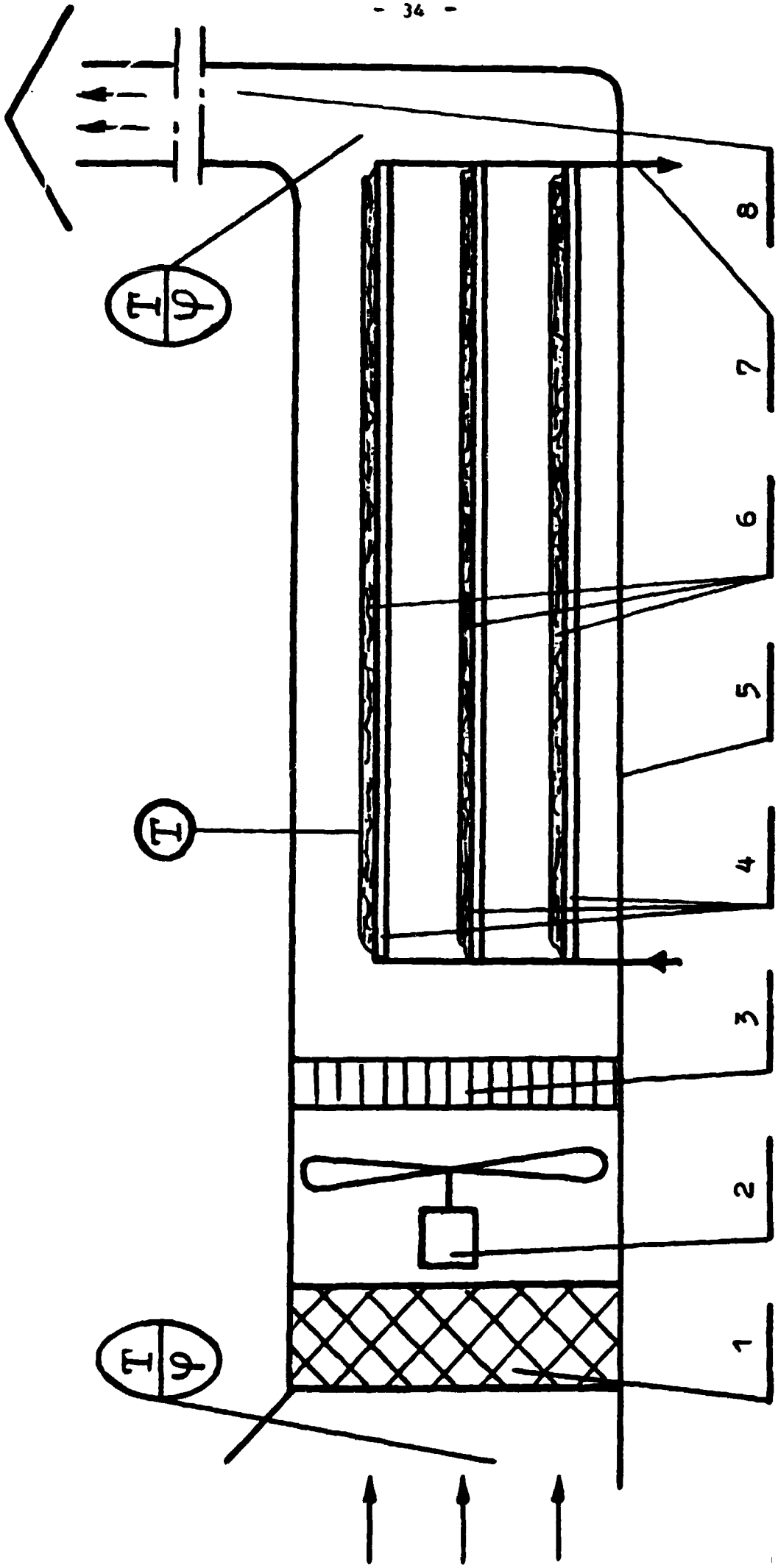

Fig. 1

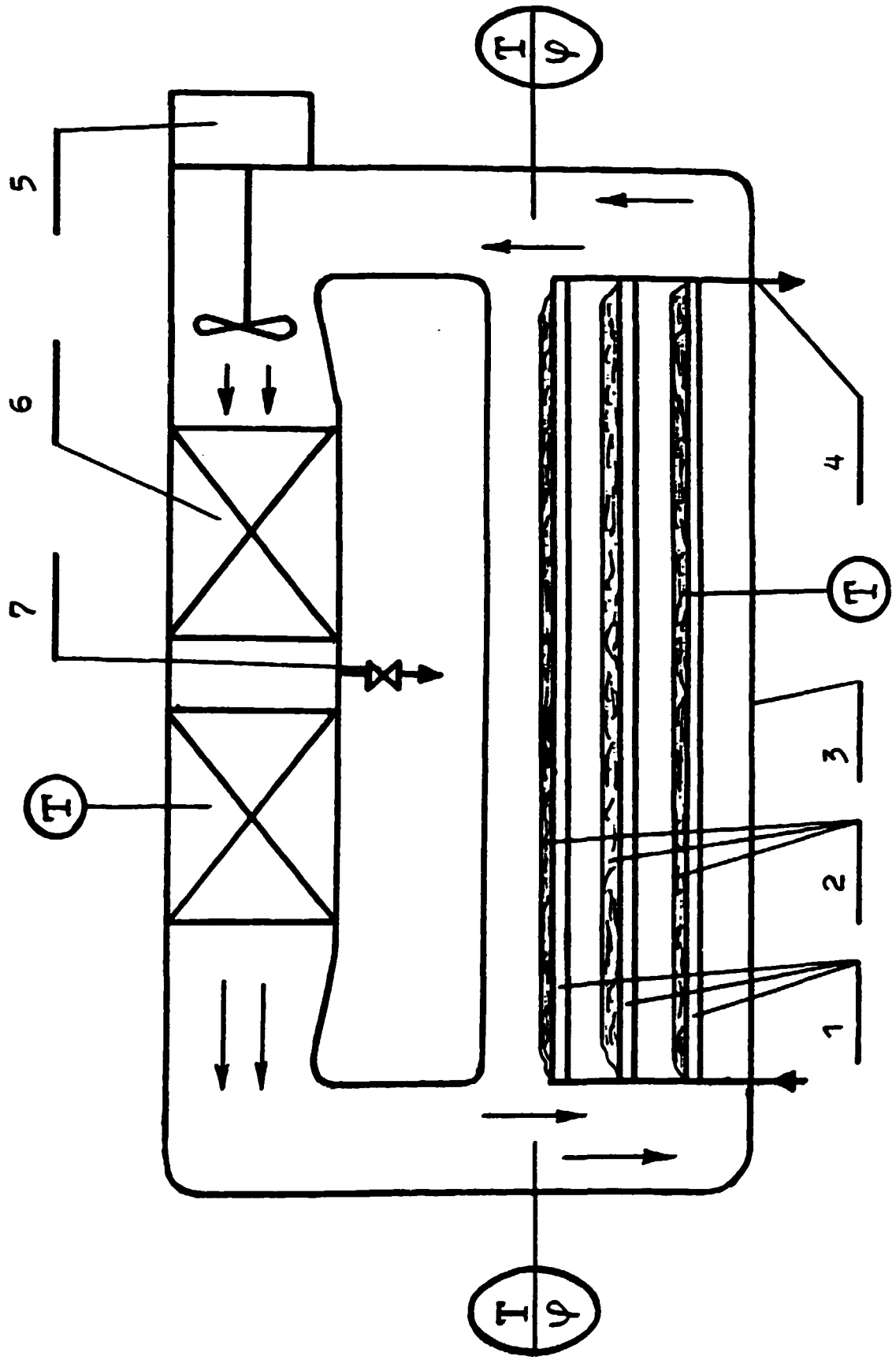

Fig. 2

ordinary air blast freezer is a base of an installation for the atmospheric freeze-drying.

Such constituents as raw material 2, a body 3 , a fan 5, an air cooler 6, a defrost drain 7 and devices for the measurement of temperature T and relative air humidity φ are the same both for a freezer and for freeze-drying installation of this kind.

The heating shelves 1 and a heat supply system 4 are the new additional elements of an atmospheric freeze-drying installation. The heating shelves 1 and the heat supply system 4 may be designed as a removed complex. Then the same installation can operate both as freezer and as freeze-dryer.

In this case the heat supply system 4 can use heat of condensation of refrigerating machine, which cools the air cooler 6.

The atmospheric freeze-drying installation can be in the exploitation the all year.

Method of operation

The raw material is arranged on the shelves 1. A body 3 is hermetized. The refrigerating system with an air cooler 6 and a fan 5 is switched on. The cool air freezes the raw material up to sheduled temperature. Then the heat supply system begins to operate. It compensates heat needed for the sublimation of ice in the material. The defrosting of the raw material is not desirable.

The duration of freeze-drying process, including the heat drying at the end of the process, and the water fraction in a dryed material, are as a rule defined experimentally.

After the drying process the air cooler 6 should be defrosted. The body 3, the shelves 1 must be sanitarilly treated.

The traditional freeze-drying of fish can be intensified by means of atmospheric freeze-drying installations.

In winter both kinds of installations are joint used. The installations with open air circulation operate on the first stage of the freeze-drying process with the utilization of a cold surrounding air. The process of freeze-drying is more intensive.

The installations with close air circulation operate on the final stage of the freeze-drying process if the temperature of cold surrounding air is not enough low.

The series utilization of the both installations allows to decrease the energy consumption, to increase quality of the dryed material and capacity of freeze-drying in comparison with the traditional national freeze-drying.

The atmospheric freeze-drying installation with close air circulation can also operate independently in summer.

ANNEX 10

DESCRIPTION OF THE CONTACT FREEZER FOR PRELIMINARY FREEZING

Project SI/DRK/86/881

A scheme of installation is shown on Figure 3. It consists of an air condenser 1, a fan 2, a tube for a liquid ammonia 3, a building 4, raw material 5, a contact freezer 6, a coil evaporator 7 in the body of the contact freezer 6, a valve 8 of the liquid ammonia of a thermal siphon, a valve 9 of a liquid ammonia of a refrigerating installation, a valve 10 of a vapour ammonia of a refrigerating installation, a valve 11 of vapour ammonia of a thermal siphon.

A thermal siphon consists of a condenser 1, a tube 3, a valve 8, a coil 7, a valve 11, a tube 12.

A refrigerating installation is not shown on Figure 3.

The upper level of liquid ammonia in a coil 7 should be low the valve 10, as it is in the usual regime of the evaporator operation.

The valve 9 and 10 are closed at the end of a low temperature freezing process. Then the valves 8 and 11 are opened. The proper level of a liquid ammonia inside a coil 7 is provided automatically.

The frozen material is removed from the freezer 6. The raw material is loaded inside the freezer 6. A fan is switched on. Surrounding air cools the heat exchange surface of the condenser 1. Vapour of ammonia condenses inside the tube. Liquid ammonia boiles inside the coil 7 from heat of raw material 5. Ammonia vapour moves into the condenser under the influence of the partial pressure difference inside coils 7 and 1.

Thus the circulating ammonia transfers heat from warm product to cool outside air.

Such a freezing system is suitable for the preliminary freezing up to product temperature below -2°C, at which more than 56% of the total quantity of the product water is frozen out.

Then the valves 8 and 11 are closed, but the valves 9 and 11 are open. In this case the contact freezer 6 is cooled with

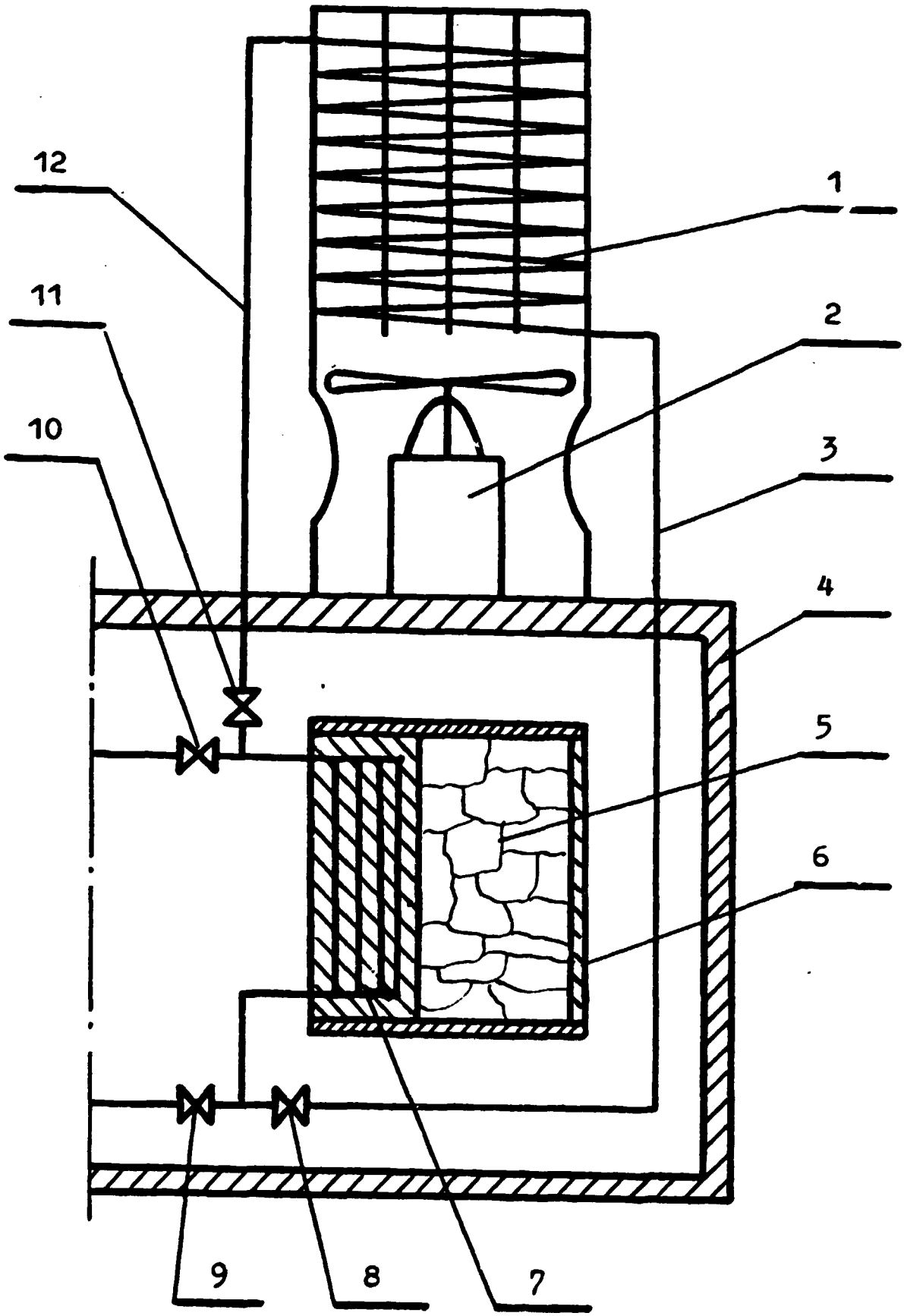

Fig. 3

the refrigerating installation. The product is frozen up to storage temperature. The consumption of energy during the second stage of freezing is less as much as twice or more.

The every refrigerating installation should be connected with the several independent contact freezers or with the several groups of the contact freezers in order to increase the freezing capacity.