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POWER ECONOMIC PROBLEM IN FOOD PRODUCTION — TRENDS IN PRESERVATION OF FRUITS AND VEGETABLES IN THE G.D.R.

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Reasonsaare given for extensive food preservation on the basis of the international situation in food industry and the energetic efficiency of food processing in the G.D.R. The trends in refrigerating as well as in freezing and sterile preservation of fruits and vegetables are considered with respect to energetic and economical aspects.

EFFICIENCY OF FOOD PRODUCTION

To guarantee the nourishment of the world population a mean daily per capita energy amount of about 10 000 kJ is necessary. With a recent world population of 4.9 billion the daily total energy consumption is thus $4.9 \cdot 10^{13}$ kJ as food yield.

In 1982 the world food production was about 3900 Mt with a food energy content of $35 \cdot 10^{15}$ kJ [1]. This amount corresponds to a mean food supply of about 21 000 kJ per capita per day (referring to the world population of 4.5 billion in 1982) exceeding the requirement by 100 per cent.

Malnutrition and famine in many countries of the world are obviously the result of unequal distribution due to economic problems and not the result of insufficient supply [2]. The large growth rates in population of many of the developing countries is in contrast to the insufficient energy resources there. Food production depends strongly on the available energy supply. Additionally, the energy consumption for producing plant and animal raw material for food industry increases faster than the agricultural yield due to the rising consumption of fertilizers, plant-protecting agents, pesticides, concentrates, and medicaments. In the developed countries the energetic efficiency η_E, i.e. the ratio of the energy content of the raw material to the necessary production energy, ranges from 0.1 to 0.5 (fruits, vegetables, meat) and only exceptionally exceeds 2 (maize, rye, potatoes, oil plants). The energy consumption necessary for the production of eggs and milk is five times, for the production of chops ten times, and for the production of fish fillets twenty to fifty times that of the final energy content of the food. A total of 15 to 20 per cent of world energy consumption takes place in food production (production of raw materials, processing, storage, transport). The share of energy going to the particular processes varies in different countries and is determined by the stage of development of productive forces. Taking into account the energy for producing machines, plants, means of transport, and materials the energy consumption by agriculture in developed countries amounts to 25-40 per cent [3].

In the G.D.R. the energy used for food production (without the municipal sector, transport and households) amounts to about $293 \cdot 10^{15}$ J per year. The farm production of plants and animals including drying, pelletizing, and greenhouse production requires $130 \cdot 10^{15}$ J per year, or 44 per cent of the total energy in food production.

Statistically, every inhabitant takes up. 4.85 GJ of food energy anuualy (13 300 kJ per day), 63 per cent of which is provided by plant food. The total consumption of food energy amounts to about $81.2 \cdot 10^{15}$ J per year.

Assuming food production energy to the 24 per cent (corresponding to $293 \cdot 10^{15}$ J per year) of the total energy consumption, the mean energetic efficiency of food production is

$$\eta_P = \frac{81.2}{293} = 0.28$$

Taking into account the energy consumption of machines, fertilizers and estimated as

$$\eta_G = \frac{81.2}{476} = 0.17$$

This value is in agreement with data for developed capitalist countries, e.g. for Switzerland $\eta_G = 0.14$. The energy consumption of $476 \cdot 10^{15}$ J includes energetic investments of 25 per cent for plant production and of 75 per cent for animal production.

This energy balance shows that one joule of food energy requires four to six joules of power supply. The present losses in food production in industrial countries of 20 to 40 per cent, portly higher for fruits and vegetables, are coupled with considerable energy loss which increases within the production cycle. The general aim should thus be maximum preservation of the produced raw materials because the energy consumption in preservation is partly much lower than in food production. Thus, reducing losses by preservation means saving energy.

STATE AND TRENDS OF PRESERVATION OF FRUITS AND VEGETABLES IN THE G.D.R.

Energy-economic food production can be achieved by suitable preservation methods. The preservation method to be applied depends on the particular kind of raw material, on its utilization, on energy consumption, and on costs, but also on consumer customs and on the traditional structure of food plants.

Unlike some other foods fruits and vegetables can be preserved by different methods. In the last 20 years the refrigeration of fruits, in particular the CA-storage (Fig. 1), was vastly expanded in the G.D.R. CA-storage will be applied mostly to apples. The mean energy consumption amounts to 680 MJ per ton for 160 days of storage.

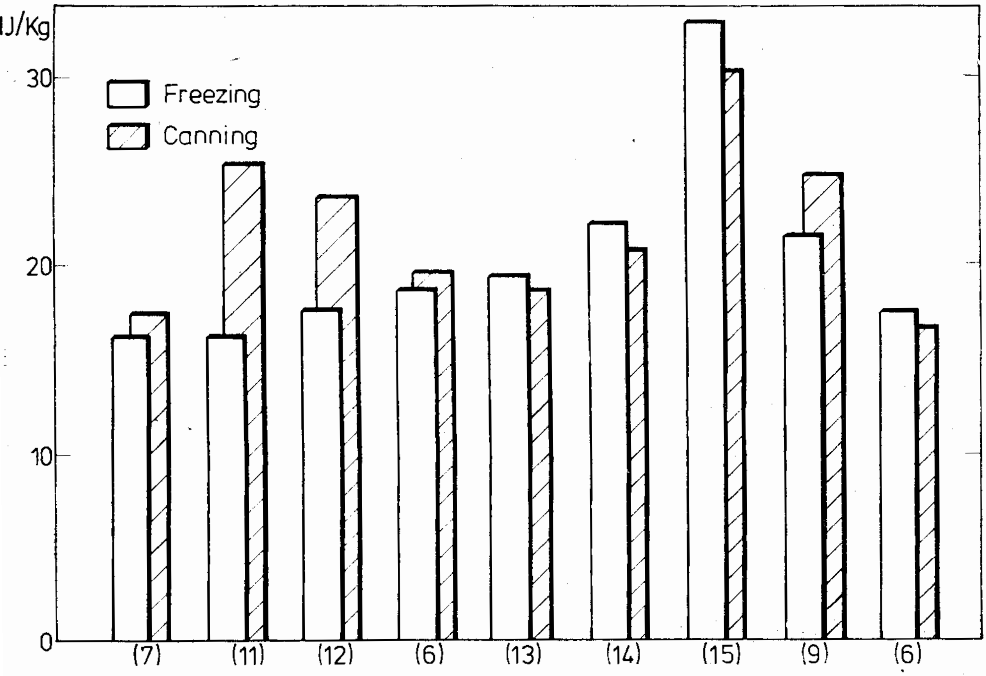

Fig. 1. Energy consumption in freezing and canning of vegetables according to the literature and to our studies

To increase the degree of utilization of fruit cold stores an extensive production of champignons will be launched there in the future. During summer 20 to 30 kt champignons can be grown per 1 kt fruits store capacity. This requires an additional investment of only 3500 Mark per ton of champignons [4]. Energy economy studies for green peas were performed at the Engineering College of Koethen in preparation for a development of freeze and sterile preservation of fruits and vegetables [5, 6]. Various stages of processing were compared, such as preparing, processing, packaging (including packing material), storing, and distributing. The results are presented in Table 1 and 2. Sterile preserves were packed in unified glass bottles volume 0.9 l sterilization was performed in a standing autoclave WAA 6.

Table 1. Energy consumption for sterile preservation of green peas (kJ kg^{-1})

Stage of handling	New glass use (%)			Reuter [7]	Khaladij-Nia [8]
	100	40	20		
Preparing	1 650	1 650	1 650	1 250	740
Processing	5 300	5 300	5 300	2 880	2 700
Packaging (including packing material)					
Storage	—	—	—	—	430
Distribution	966	966	966	1 160	2 050
Total	27 158	16 631	13 131	21 360	24 870

Table 2. Energy consumption for freeze-preservation of green peas kJ (kg^{-1})

Stage of handling		Reuter [7]	Khaladij [8]	Gorlee [9]
Preparing	1 650	1 980	2 970	681
Processing	1 554	1 670		970
Packaging (including packing material)	1 122	2 290	2 540	2 496
Cold storage	3 087	1 930	1 209	2 795
Trade storage	3 774	6 510	10 080	8 578
Domestic storage	6 201	3 600*	3 974	3 396
Cold transport	580	580	940	656
Total	17 968	18 560	21 713	19 572

*) Estimated

The frozen products were produced in a fluidized bed freezing unit FGF 80 of the factory "VEB Kuehlautomat Berlin" and then packed in polyethylene bags. For comparison we give the necessary energy values of fruits and vegetables according to Reuter [7], Khaladij-Nia [8] and Gorlee [9]. Fig. 2 shows the total energy consumption of sterile and freeze preservation of fruits and vegetables according to the literature and our own studies. Sterile preservation requires on the average 21.5 MJ kg^{-1}, and freezing preservation — 20.4 MJ kg^{-1}.

The variation in energy consumption in different countries is mainly caused by different structures of energy supply for the preservation process. Thus from Table 3 it can be seen that energy for the fruit and vegetable industry of the G.D.R. is supplied mostly by lignite whereas

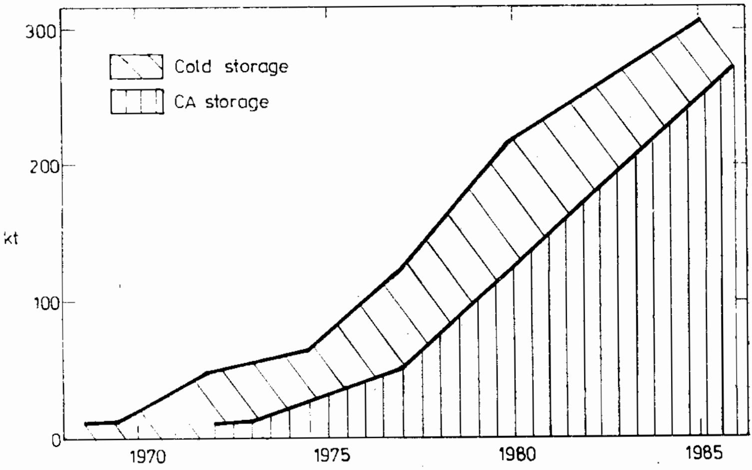

Fig. 2. Cold store capacity for core-fruits

Table 3. Share of energy sources in per cent for food processing industry fruits and vegetables in different countries [16-18]

Energy	G.D.R.	F.R.G.	U.S.A.
Coal	67.3	0.6	3.0
Electric energy	7.7	10.3	16.0
Fuel oil	0.7	83.1	15.0
Gas	3.8	6.0	66.0
Long-distance heat	17.5	—	—
Other energy supply	3.0	—	—
Total	100.0	100.0	100.0

Table 4. Energy equivalent of steam, electric energy and auxiliary agents according to Kindler and Nikles [19]

	MPa	
Steam	(0.4)	3122 MJ t^{-1}
Steam	(1.6)	3180 MJ t^{-1}
Electric energy		10.2 MJ kWh^{-1}
Cooling water	(0.2)	1.0 MJ m^{-3}
Nitrogen	(0.8)	0.9 MJ m^{-3}
Compressed air	(0.4)	0.6 MJ m^{-3}
Truck transport		1.0 MJ $t^{-1}km^{-1}$

fuel oil and fuel gas prevail in the F.R.G. and the U.S.A., respectively. The energy equivalents are given for estimation in Table 4. Steam is predominantly applied in sterile preservation and electric energy in freezing preservation. The real energy consumption of sterile preservation depends strongly on the efficiency of the boiler plant, ranging from 58 to 87 per cent [16, 20]. Furthermore the sterilizer that is used influence energy consumption (cf. Table 5).

Table 5. Energy consumption per kg of product (kJ kg^{-1}) of various sterilizers in dependence on the efficiency of the boiler plant

Sterilizer	Heating medium	Boiler efficiency (%)		
		87	80	58
Rotational autoclave	full water	1950	2102	2843
	steam/compr. air	1317	1416	1882
	half water	1538	1662	2246
Large-capacity autoclave	water	2216	2393	3229
	irrigation	1048	1136	1547
Tower sterilizer	water/steam	1070	1155	1553
Sterilematic	water/steam	889	979	1344
Standing autoclave WAA 6	water	3950	4240	5899
Hunister OHS-3	water/steam	636	683	916

Energy values for freeze preservation amount to 740 kJ kg^{-1} in the freezing tunnel on tray cars, to 529 kJ kg^{-1} in the fluidized bed freezing plant, and to 500 kJ^{-1} in the plate refrigerating plant [21, 22].

The costs are estimated according to the values given in Table 6.

Table 6. Specific costs of energy and processing materials

Steam	46.84 Mark t^{-1}
Water (municipal)	0.90 Mark m^{-3}
Waste water	0.60 Mark m^{-3}
Electric energy (industrial)	0.15 Mark kWh^{-1}
Electric energy (domestic)	0.08 Mark kWh^{-1}

Table 7 shows the costs of the particular processing stages in sterile and freeze preservation of green peas. The additional costs in sterile preservation are due to packing material about 450.00 Mark per ton and transport (about 100.00 Mark per ton). On the other hand, in the case of freeze-preserved products there are high costs of storage (about 300.00 Mark per ton).

In general one can state that freeze preservation and sterile preservation of fruits and vegetables are comparable as regards energy consumption. However, the current prices make freeze preservation more profitable. Increasing production of freeze preserves is also justified by their better nutritional and sensoric properties. This international trend is observed for perishable food (cf. Table 8) and in some cases,

Table 7. Specific costs of sterile and freeze preservation of green peas (in Mark per ton)

	Freeze preservation (polyethylene bag in cardboard box)	Sterile preservation (0.9 l unified glass bottle, %)		
		100	40	20
Preparing	31.—	31.—	31.—	31.—
Freezing and filling	62.—	—	—	—
Sterilizing and bottling	—	110.—	110.—	110.—
Packing material	392.—	772.—	885.—	919.—
Packaging	—	75.—	75.—	75.—
Transport	148.—	247.—	247.—	247.—
Cold storage (224 days)	211.—	—	—	—
Storage for sale (23 days)	53.—	—	—	—
Domestic storage (14 days)	46.—	—	—	—
Raw material	2235.—	2235.—	2235.—	2235.—
Mass loss	11.—	—	—	—
Total	3189.—	3470.—	3583.—	3617.—

e.g. in potato products, the rate of growth is above average, at 20-40 per cent.

Furthermore the outfit of households with freezing units increased enormously. From 1980 to 1985 the number of these units rose in the G.D.R. from 15 to 30 per cent in 6.5 million of households. The energy consumption of the households with freezing units and refrigerators increased from 2.3% to 2.4% of the total electrical energy production (e.g. 1984 — 110 093 GWh). The energy consumption of the industrial cooling and freezing food processes amounts to 0.5% only. Thus the total energy consumed for cooling and freezing food is 3200 GWh per

Table 8. Per capita annual consumption (kg/a) of frozen food (without poultry and ice cream) in different countries

Country	1969	1971	1974	1977	1980	1983	1985
USA	25.7	29.1	33.8	37.6	41.0	43.0	—
Sweden	11.6	12.7	14.8	18.8	20.1	20.2	21.2
UK	6.4	6.8	12.9	13.6	14.5	18.5	20.9
Denmark	5.4	8.0	11.1	13.3	14.7	17.0	20.6
F.R.G.	3.1	3.6	4.8	6.6	8.2	10.1	12.6
Finland	2.9	3.9	5.1	6.2	6.7	7.5	8.1
Switzerland	3.6	5.3	7.0	7.6	9.5	11.8	13.2
G.D.R.	2.3	3.0	3.8	3.8	4.0	4.0	4.2
France	1.3	2.2	3.3	4.3	7.5	11.2	14.6
Hungary	—	0.6	—	—	3.5	4.2	—
Italy	0.5	0.7	1.2	1.8	3.0	3.7	4.4

year, given a population of 16.7 million this corresponds to 1890 kJ per capita per day. Compared to the daily consumption of food energy of 13 300 kJ per capita, the energy used for cooling and freezing will be 14.2 per cent.

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PROBLEMY EKONOMICZNO-ENERGETYCZNE W PRODUKCJI ŻYWNOŚCI — TENDENCJE DOTYCZĄCE PRZETWÓRSTWA OWOCÓW I WARZYW W NRD

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Streszczenie

Efektywność energetyczna w przetwórstwie żywności w NRD jest dyskutowana na tle sytuacji światowej.

W NRD ogólne zużycie energii w przetwórstwie żywności na rok wynosi 81.2.10^{15} J, tj. 4.85.10^{6} J na głowę. Produkcja żywności bez handlu, transportu i gospodarstw domowych wymaga energii 293.10^{15} J na rok, tj. 24% ogólnego zużycia

energii w gospodarce. Biorąc pod uwagę dodatkową energię zużywaną do produkcji maszyn, nawozów itd., ogólne zużycie energii wyniesie 476.10^{15} J, co daje efektywność energetyczną rzędu 0,17. Na każdy joule energii w żywności potrzeba 5-6 J energii zewnętrznej. Dlatego też należy zapobiegać stratom żywności przez stosowanie optymalnych, z energetycznego punktu widzenia, technologii utrwalania.

Właściwą metodę utrwalania żywności możemy wybrać na podstawie analizy zapotrzebowania na energię. Utrwalenie żywności należy traktować jako część łańcucha otrzymywania żywności od produkcji surowego materiału do spożycia żywności.

Zgodnie z naszymi badaniami i wynikami publikowanymi w literaturze, średnie zużycie energii na utrwalenie metodą apertyzacji wynosi 21.5 MJ/kg, a przez mrożenie 20.4 MJ/kg. Niezależnie od prawie jednakowej ilości energii zużywanej w obu metodach produkcja żywności mrożonej będzie rosła ze względu na niższy koszt i lepszą jakość sensoryczną i odżywczą.