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THE ELCRACK-PROCESS AS A NEW POSSIBILITY OF MAKING PRODUCTS OF A HIGH NUTRITIVE VALUE FROM FISH, MEAT, AND FAT, AS WELL AS FROM THEIR PROCESSING WASTES

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GENERAL

Fish and meat rank today among the basic needs of human nutrition. A further increase in their consumption is expected to take place in nearly all countries. The protein requirement will continue to be covered mostly by meat and fish.

Not all animal components can be used for human nutrition. In most cases, taste preferences or, in other cases, hygienic reasons are decisive factors.

Meat and fish number among the easily perishable raw materials and can only be maintained suitable for consumption over a longer period when in a deep-frozen condition. From this we can see that waste will be inevitable. In order to be able to make quality products out of the offals, they have to be processed in the freshest possible state.

The industry for the production of slaughterhouse wastes and fish meal has become an important and growing branch which keeps on gaining importance.

It is the objective of a suitable process to produce high-class meat and fish products for human and animal nutrition, as well as raw material and semi-finished products for the industry. Hereby a high yield, low production costs and high operational safety of the plants should be given. Hygienic condistions are, of course, of prime importance in all these utilization processes. Special measures will have to be taken due to the composition of the material and the high water content.

Quite a number of processes are being applied today and the more or less meat these requirements.

THE ELCRACK-PROCESS

All processes which serve to produce the above-mentioned products are based on the nearly complete separation into the following 3 components: solids, fat and water.

A separation becomes possible by destoying the cell structure. In this connection, particularly, the cell membrane is important. The membrane has a soft and plastic structure. It contains only 8-15% of the dry cell substance, but 70-90% of the cell lipids, that is triglycerides and phospholipids.

The shape of cell membrane is such (Fig. 1) that there is an aqueous environment to the outside and lipids can be found inside the double layer. The membrane is stabilized by hydrophobic interactions between the fatty-acid residuals of the lipids and by an electrostatic interaction between their hydrophilic heads. This means that the structure is not static, but it resembles a dynamic mosaic into which protein molecules are also embedded.

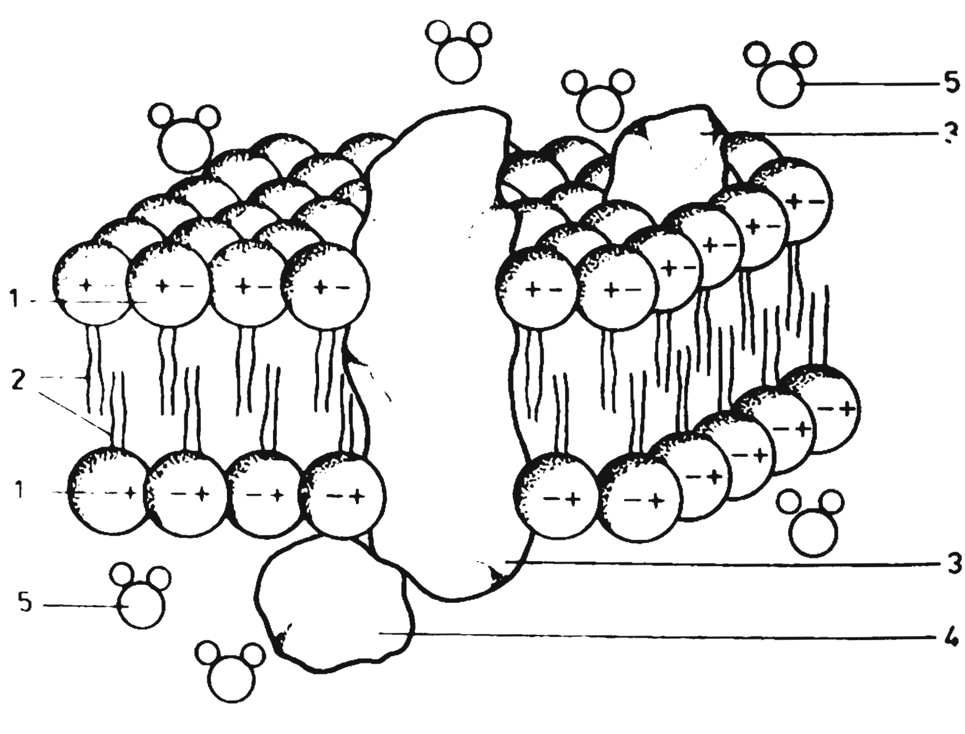

Fig. 1. Mode a cell membrane; 1 — hydrophilic part of a lipid (DIPOL), 2 — hydrophobic part of a lipid (residual fatty acid), 3 — integral protein, 4 — peripheral protein, 5 — water (H_2O)

In the ELCRACK-process use is made of this knowledge of the structure and the membranes are destroyed in the electric field (Fig. 2). High voltage can be used for this purpose which, with a certain frequency, changes the structure of the membrane. After the treatment the fat lies freely on the surface. The electrostatic forces are neutralized and the fat can be mechanically separated without any difficulties.

The dielectric breaking of the cell membrane is to be considered as consequence of a potential which was induced above the cell membrane. According to the potential theory, the cristal potential is a function of the cell size, that is decisive for the cell destruction are:

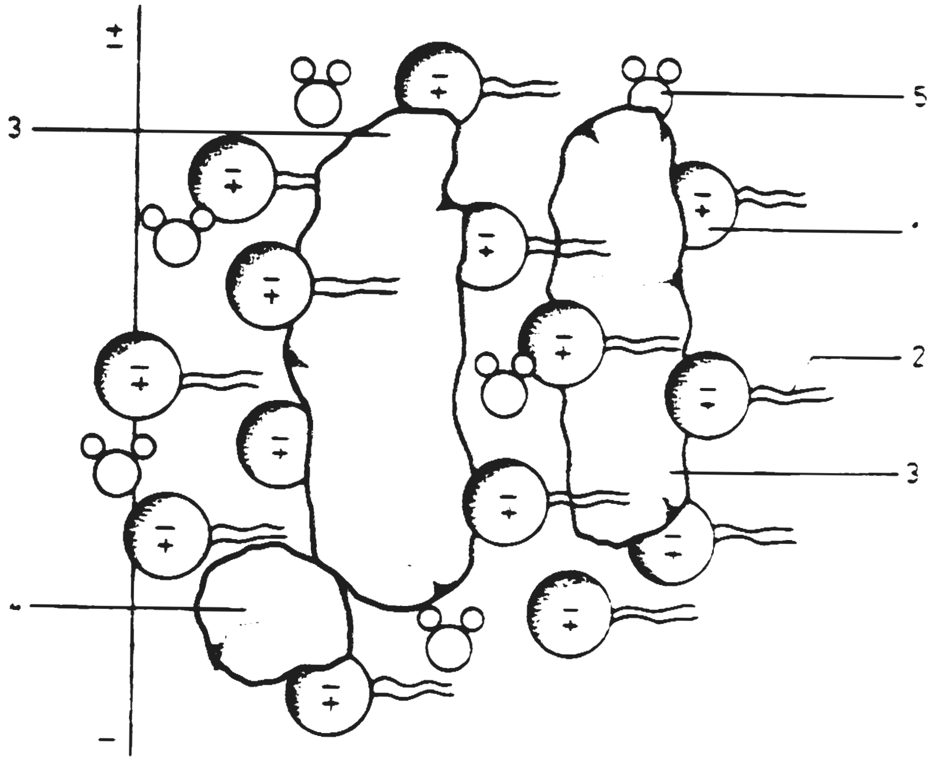

Fig. 2 Model of a cell membrane after polarization, denotations as in Fig. 1

the outer field strenght.
the cell radius.
maximum membrane potential at the cell poles.

The principal part of the process is the electric treatment unit. This consists, if we simplify it, of a piping part which is fitted in the inside, in the flow direction, with electrodes which are plane parallel. The material to be treated is pumped through this piping part (Fig. 3). By means of a given frequency, the capacitor is loaded by a high-voltage generator to a voltage of several thousand volts and discharged immediately afterwards onto the material flow (Fig. 4). The more conductive the material, the faster the voltage can be reduced. This shows also the limitation to be process. According to present experiences, it is only possible to treat material with sufficient conductivity.

Energy is transferred by the discharge current to the material to be treated. The thermal flow is not uniformly distributed in the material. Due to the different resistences of the substances, energy in passed on to the solids and the fat via water electrolyte. A heating up by approx. 10°C is to be expected during the treatment.

The followings separating process can be carried out at temperatures of between 30°C and 60°C depending on the melting point of the fat. Hereby 30°C should be reserved for the low-melting fats, e.g. fish oil.

The influences quantities of the working capacitor and the discharge zone depend on the plant, that is voltage, frequency, distance of electrodes, dwelling time, as well as the capacity of the capacitor. They influence the results in accordance with the material to be treated (Fig. 5, 6). Especially where field strenght E is concerned, corrections will have to be made as the shown examples are based on homogenous material.

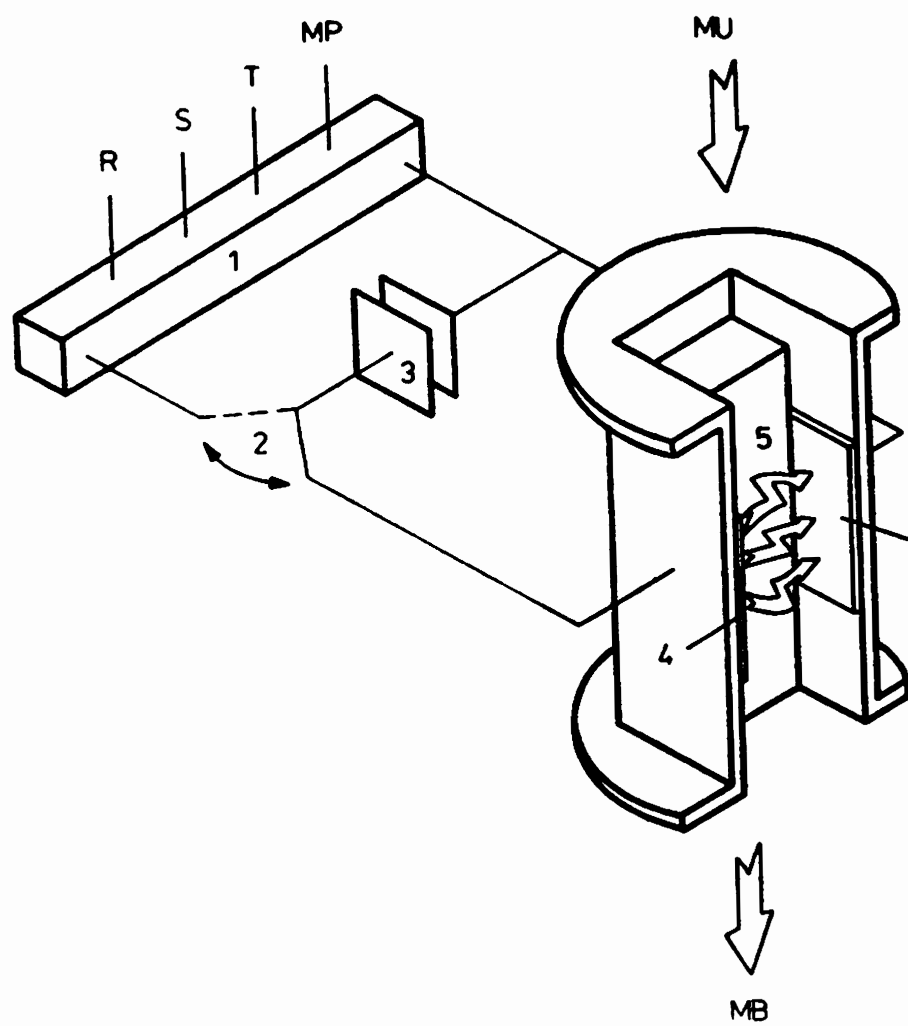

Fig. 3. Diagrammatic sketch of an electric pulse zone; R, S, T, MP — current connections; 1 — voltage converter control unit, 2 — switch, 3 — working capacitor, 4 — electrodes, 5 — discharge zone; MU — untreated material, MB — treated material

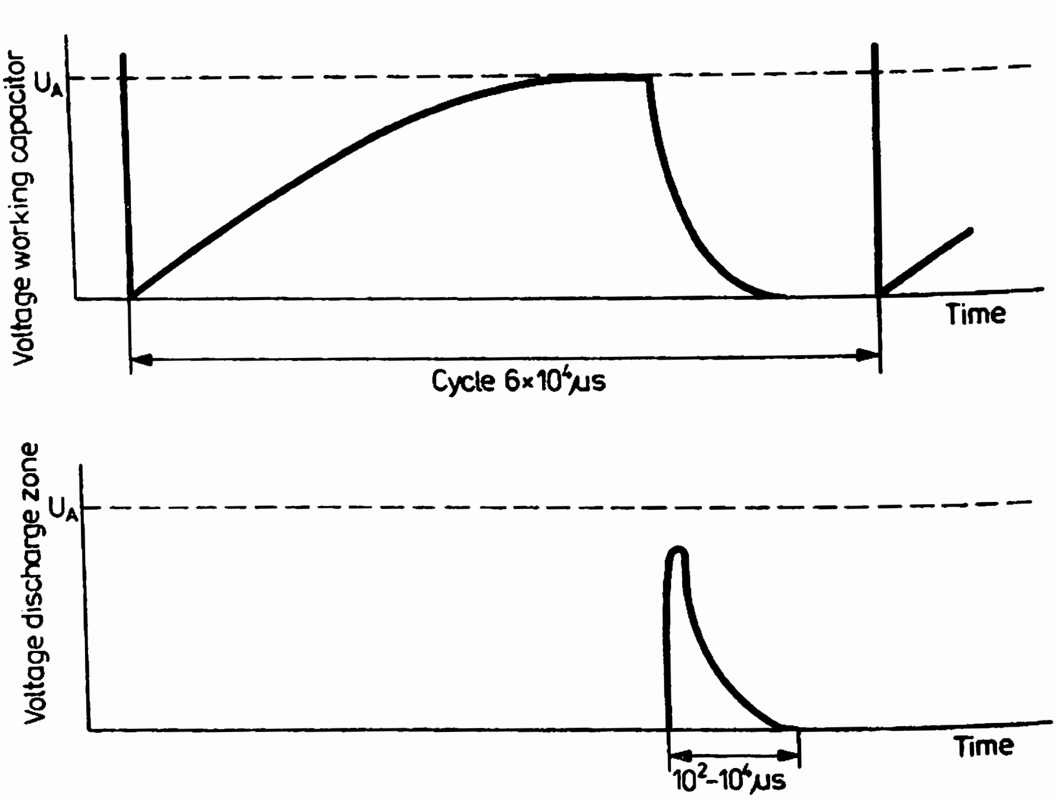

Fig. 4. Voltage gradient at the capacitor and the discharge zone

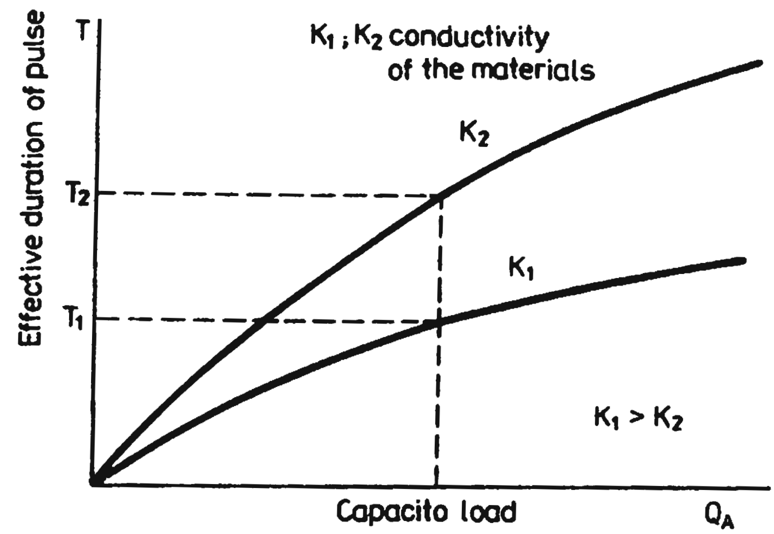

Fig. 5. Effective duration of pulse depending on the load of the working capacitor and electric conductivity

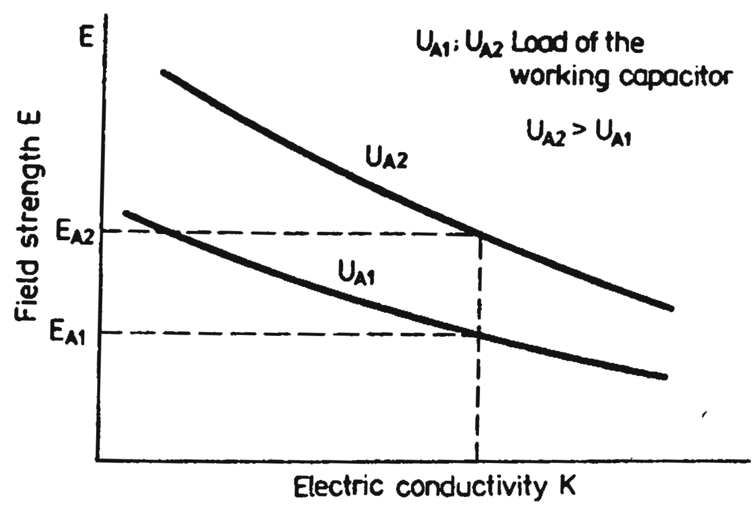

Fig. 6. Field strenght E depending on the electric conductivity and the voltage of the working capacitor

In the above-mentioned natural substances there is an inhomogeneity and consequently the effective field strenght can not be determined. Material of animal origin, however, has a sufficiently high conductivity so that this influence does not have any importance.

The complete process can be easily and understandably described (Fig. 7).

The raw material is conveyed from a trough to a breaker where it is crushed into parts which can be conveyed by a pump. The particle size should be around 20 mm so as to quarantee a safe operation. Parts which are too large cause difficulties in the coveying equipment, screw press and probably in the drier. Particles which are too fine cause a high solid share in the liquid phase.

A dosing device conveys the comminuted raw material through the reaction vessel, the ELCRACKER, and afterwards in a closed pipeline to the double-shaft screw press. The defatted solids are dried an, depending on their use, ground. The pressed-off liquid phase is separated by means of centrifuges. Decanters and separators or tricanters can be used here.

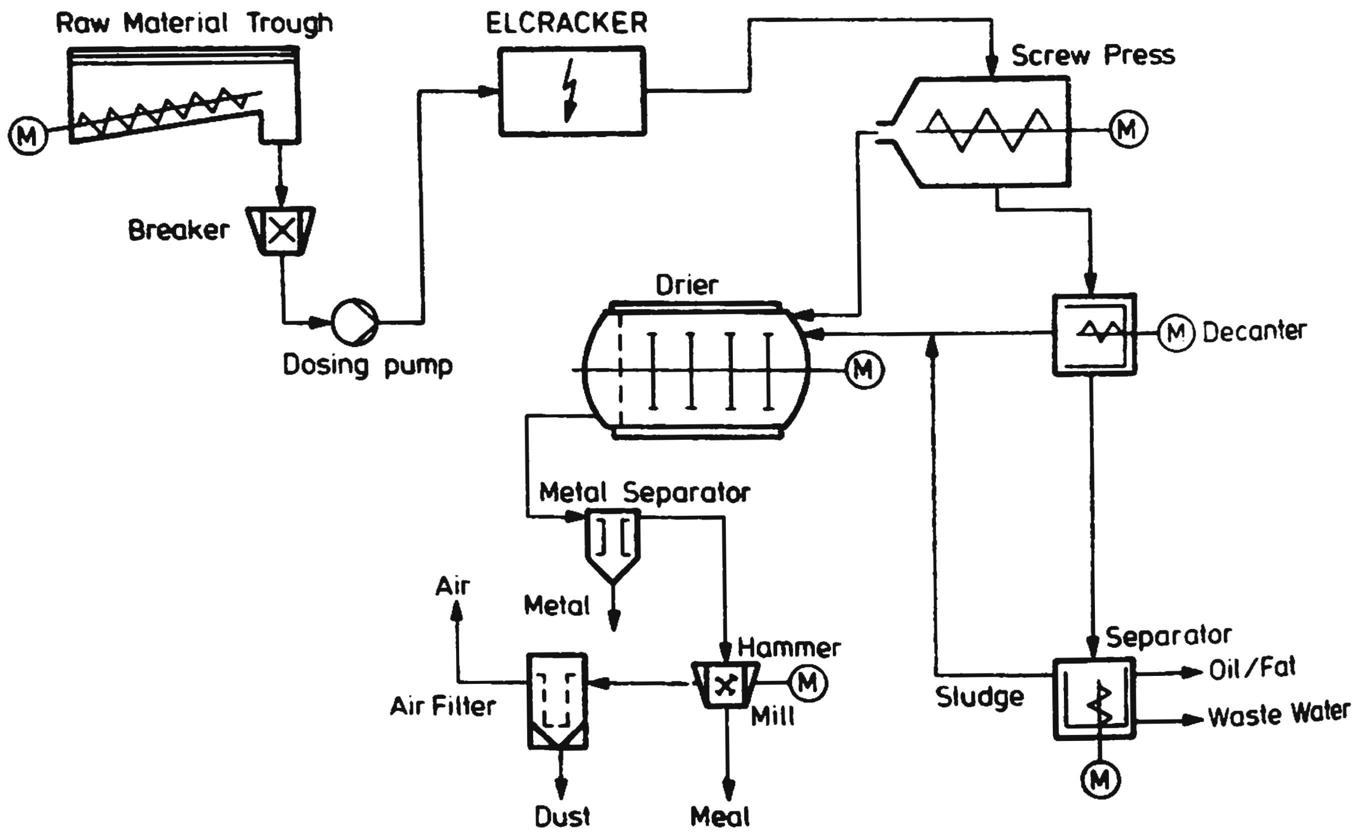

Fig. 7. Process flow diagram of the ELCRACK-process

The main part of the plant, the ELCRACKER, receives its energy impulses from the discharge of capacitors which are loaded by a high-voltage generator. The advantages of such a treatment are obvious. Due to the low temperature increase, no or hardly any denaturation of the protein takes place. A reduced solubility of the protein in the liquid phase is due to the low temperature and the short dwelling time.

This facilitates considerably the waste-water treatment. One of the prerequisits for best storability and for different application purposes is a good defatting of the products. Due to this it can be possible in a comparatively easy way to produce fish meal for human nutrition. The fat is also available in its natural form, i.e. the natural antioxidants can be preserved. In this connection, however an optimization of the temperatures for fat clearing has to be considered. According to present experience, there is no process known of in which the content in free fatty acids, the peroxide value, and the stability of the fat, depending in the raw material, are as favourable as they are in this process.

EXPERIENCES WITH A PILOT PLANT

We have tested a plant which has a troughput rate of approx. 200 kg/h different raw materials. The following raw materials were processed:

fish (herring),
fish waste,
poultry waste,
bones,

raw fat,
cracklings.

The plant comprises of a trough, a breaker, a pump, a treatment unit, a high-voltage generator, capacitors, a double-shaft screw press, a decanter, a separator and a drier.

As an example, we would like to present reults from fish and fish wastes processing and fat processing.

FISH PROCESSING

As already shown above, fish (herring) were treated, as well as fish wastes. The results are compiled in Table 1.

Table 1. Results of treatment herring and fish wastes

Processing of	Fish (herring)	Fish wastes
Fish meal		
protein content (%)	78.2	76.8
fat content (%)	5.4	2.2
digestible protein (%)	96.5	96.8
water content (%)	9.2	9.4
Fish oil		
ffa (%)	4.2	6.3
peroxide value (mÄquO_2/kg)	6.1	8.4
Waste water		
COD (mg/l)	1750	1900

These results show a significant difference in the residual fat content. This is due to the pilot screw press. It is fitted with 2 fields, i.e. very short. Since the waste showed a better pressure build-up in the screw press than the herring, it was not possible to obtain such a result as with the waste.

From the test results, a mass and energy balance according to Fig. 8 can be deduced.

This process is particularly economic due to the low energy consumption — the electric energy consumption corresponds approximately to the one of the conventional process — and the high yield with high quality. It is quaranteed that when the meal is dried in the fluid drier, its temperature during processing did not exceed 50°C. Due to its composition and stability it is then destined to find its place in human nutrition, too. The quality of the oil can not be compared with the quality of the oils which have been obtained up until now. Its range of application will exceed the present one.

RAW FAT PROCESSING

All over the world, the fats coming from the slaughtering process are separated by different processes into fat and cracklings. When high-quality fats

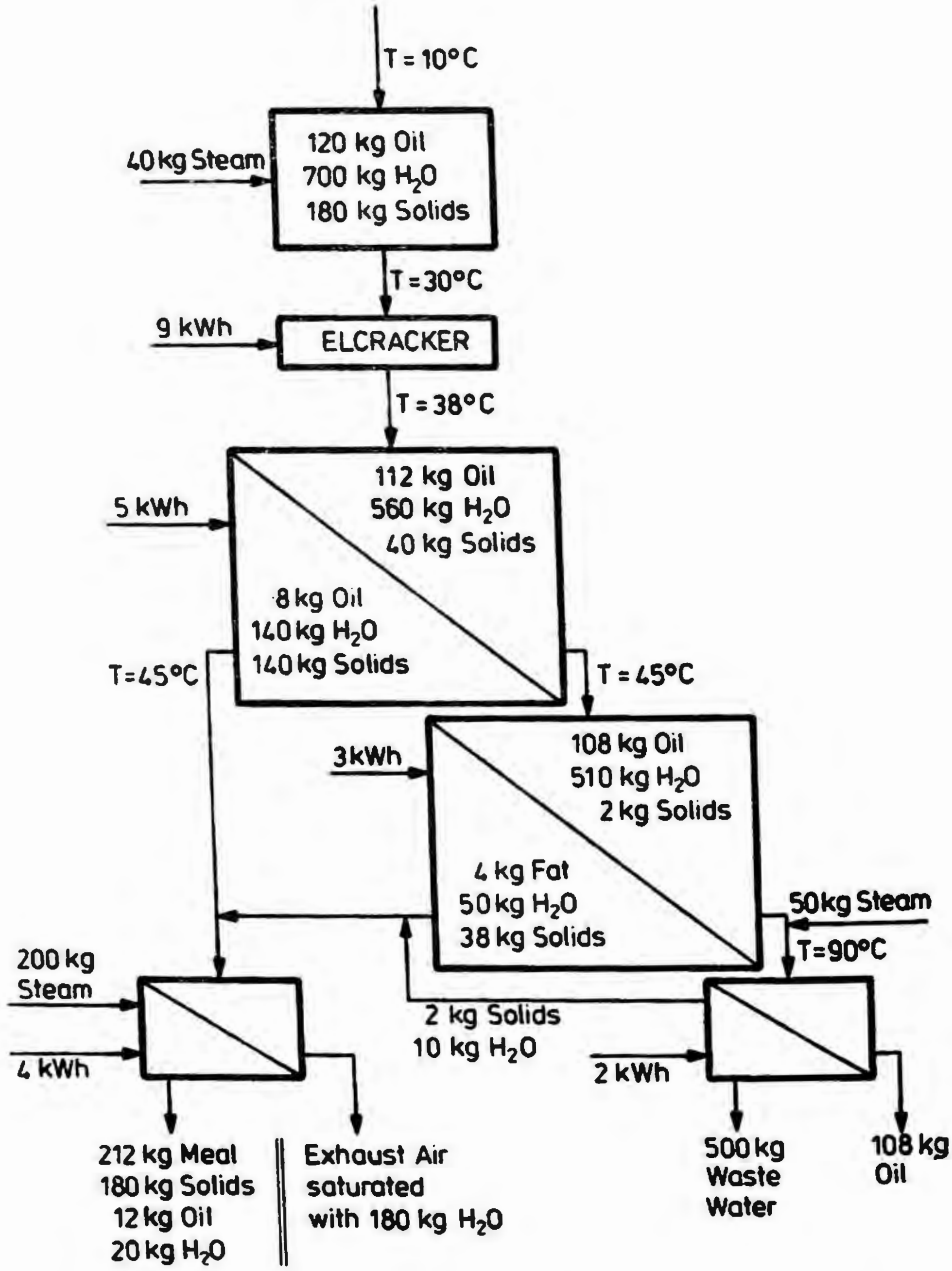

Fig. 8. Mass and energy balance when processing fish

Table 2. Results of treatment of fat

Grease	
ffa	0.5%
peroxide value	3 mÄquO_2/kg
unsaponifiables	0.5%
Tallow	
ffa	1.1%
peroxide value	2 mÄquO_2/kg
unsaponifiables	0.7%

are to be obtained then you must take into account that there will be problems with the waste water, which may cause a considerable increase in costs.

The described ELCRACK-process may also be used for the fat rendering process. With this process you can produce fats of best quality. Table 2 contains the results which were obtained by means of the pilot plant.

Cracklings are available with a fat content of less than 6%. They have a high protein content and can be easily dried. The economical efficiency of the process can be represented by the energy and mass balance (Fig. 9).

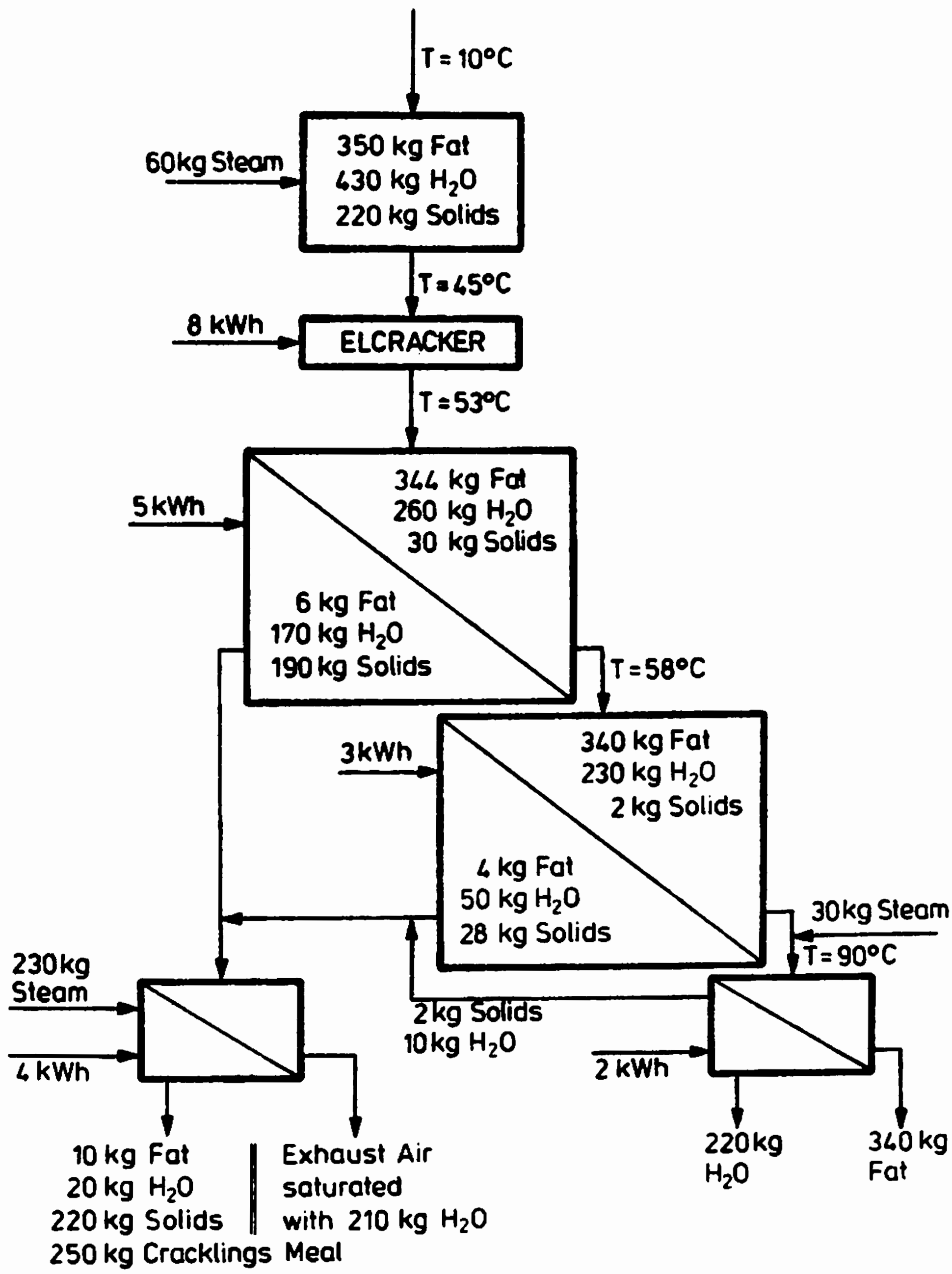

Fig. 9. Mass and energy balance of fat rendering process

The high product quality combined with the high yield, low energy requirement, and comparatively low waste water pollution make this process very interesting.

PROSPECTS

From the large scale of applications of this process, when separating animal raw material into fat and protein, product innovations may be expected due to the low thermal load. This is especially so since during the process the number of germs in considerably reduced, by more than 99% according to measurements taken. This means that the process for opening the cells is at the same time a sterilizing process.

E. W. Münch

PROCES ELCRACK JAKO NOWY PROCES OTRZYMYWANIA PRODUKTÓW (PASZOWYCH) Z RYB, MIĘSA, TŁUSZCZU I PRODUKTÓW ZWIERZĘCYCH UBOCZNYCH

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Streszczenie

Zasada procesu ELCRACK polega na naruszeniu struktury błon komórkowych materiału w polu wysokiego napięcia o określonej częstotliwości i następnie separacji materiału na części stałe beztłuszczowe, tłuszcz i fazę wodną. Naruszenie struktury błon komórkowych zachodzi pod wpływem indukowanego w nich potencjału, który osiągając wartość krytyczną prowadzi do ich zniszczenia.

Podstawowe urządzenie linii składa się z segmentu rurowego z umieszczonymi w nim równolegle elektrodami, przez który przepompowuje się przerabiany materiał. Elektrody zasilane są z generatora wysokiego napięcia prądem o napięciu kilku- kilkunastu tysięcy woltów. Napięcie, częstotliwość prądu, odległość pomiędzy okładkami elektrod, a także szybkość przepływu masy mogą być regulowane.

Proces jest prowadzony w łagodnych warunkach termicznych (30-60°C), podczas procesu temperatura wzrasta nie więcej niż o 10°C. Po przejściu przez segment wysokiego napięcia części stałe są oddzielane na prasie ślimakowej, część płynna separowana na wirówkach na tłuszcz i fazę wodną. Zilustrowano działanie procesu na przykładach przerobu surowca rybnego i tłuszczowego.