Drying Fish and Beef Prior to Solvent Extraction

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The fat in fresh meat, such as beef or fish, containing a normal amount of moisture is extracted very slowly by solvents. Both fresh beef and fish were freeze dried and solvent extracted in glass, extraction-rate apparatus at four temperatures. Ethyl alcohol–dehydrated beef was similarly extracted. The meat dehydrated, by both freeze drying and ethyl alcohol, extracted much more readily than either fresh meat or meat dried in a conventional laboratory drying oven.

MOISTURE- AND FAT-FREE MEAT has, according to Furgal (*4*), possibilities as a very useful food for both military and emergency civilian rations. Fish—frequently available in considerable quantities not marketable in the usual channels—might, in the dry fat-free form, be used to supplement the food of peoples whose diets are now deficient in animal protein and who do not have adequate refrigeration facilities for fresh meat and fish. There are also large quantities of fish processing wastes (*11, 15*) and inedible fish (*10, 12*)—by-products of the fishing industry—which could be processed to form excellent high-protein animal feed. While some fish products are being solvent extracted, most of the fish oil and meal are being produced by either wet reduction or dry rendering (*11*). These processes consist essentially of cooking followed by pressing.

Extractors using azeotropic distillation with solvents such as heptane, trichloroethylene, and perchloroethylene (*3, 6, 8*) are in limited use on meat products.

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Fat in undried meat and fish does not extract readily (*11*). Previous work in this laboratory showed that inedible meat (*1*) and fish scrap (*2*) could be solvent extracted satisfactorily at moistures of 7 and 20%, respectively—provided the scrap was not overheated in drying. Ordinary drying-oven temperature (230° F.) coagulated the protein of both fish and beef sufficiently to prevent satisfactory extraction.

Freeze Drying Fish and Beef

In freeze drying, the water is evaporated at low temperatures under reduced air pressure to avoid any bad effects of high-temperature drying. Usually during freezing, ice crystals form outside the cells, facilitating drying. The frozen tissue is usually porous (*5*), which should allow good solvent extraction of the fat. Preliminary observation showed that freeze-dried meat was light and fluffy and apparently porous.

The greatest objection to freeze drying is the cost. However, Furgal (*4*) estimates that the cost of freeze drying should be comparable with that of canning and should produce a flavor in the reconstituted product more nearly like fresh meat.

Experimental Work

Raw Materials. The fish—Iowa lake carp containing 75% moisture and 12 to 16% fat—was ground in a meat grinder, with attrition-type plates, into thin slices which were well adapted to extraction.

Ground beef—corresponding to commercial hamburger—containing 68.4% moisture and 22 to 28% fat was used. The solvent was a solvent grade of trichloroethylene. This had the advantage of greater safety for laboratory use than the flammable petroleum fractions commonly used commercially. The toxicity to cattle of certain batches of trichloroethylene-extracted soybean oil meal has raised the question of possible toxicity of other products extracted by trichloroethylene. Recent work by Rehfeld and coworkers (*9*) and by McKinney and associates (*7*) indicates that a product toxic to cattle may be produced by the trichloroethylene extraction of other protein materials, such as fish and meats. As the work presented herein was a study of the effect of drying methods on extraction only, the use of trichloroethyl-

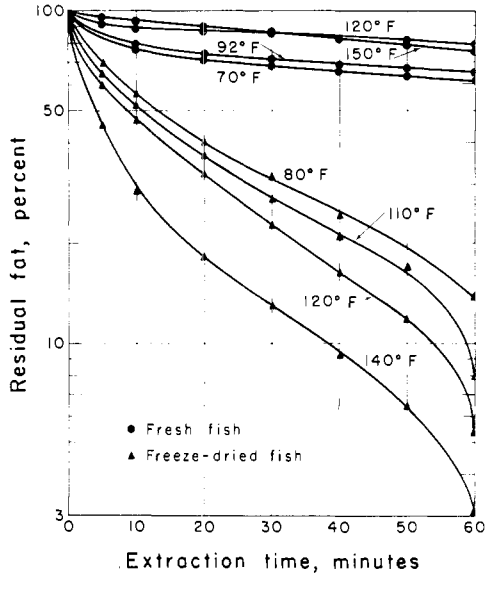

Figure 1. Extraction rate curves for fish

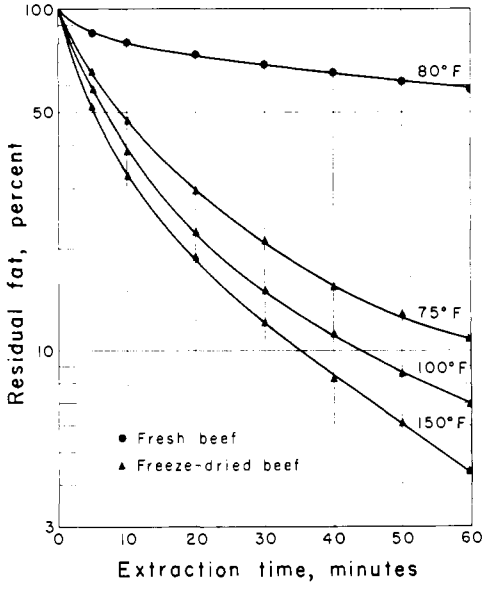

Figure 2. Extraction rate curves for beef

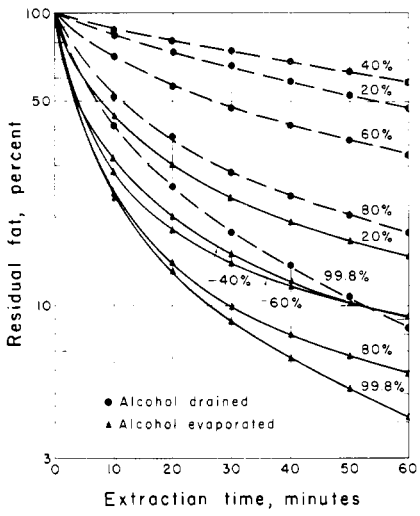

Figure 3. Extraction rate curves for ethyl alcohol dehydrated beef

Percentages are for ethyl alcohol by weight

ene as an experimental solvent should not be construed as a recommendation by the authors that the products resulting from this extraction are suitable for either human food or animal feed.

Experimental Procedure. Extraction rates were determined by passing the solvent upward through about 5 grams of ground fish or beef in a 1-inch jacketed glass tube at 10 ml. per minute. Water from a constant-temperature bath circulated through the tube jacket. The solvent was heated by water from the bath in a glass heat exchanger. The solvent-oil solution, or miscella, coming from the extraction tube in each 10-minute interval was evaporated separately, and the resulting oil was weighed to determine the amount extracted in that interval. Amount of oil in both the original and extracted product was determined by extraction in a Soxhlet apparatus after drying in an oven at 230° F. to determine the moisture content.

Freeze drying was done as follows: Fifty grams of ground fish or beef and 100 ml. of distilled water were frozen in a 2-liter round-bottomed flask by rotating the mixture in a bath containing dry ice and ethyl alcohol, to produce an even coating on the inside of the flask. The flask was connected through a water trap to a vacuum pump and maintained at a pressure of 0.2 mm. or less for 10 hours.

Results. Fresh, undried fish and freeze-dried fish containing 12.7% moisture were extracted (Figure 1). Results of similar extractions of beef are shown in Figure 2. Both the freeze-dried beef and fish extracted more rapidly than the undried material. The extraction of both dried materials increased with increase in temperature, but the undried fish extracted slightly better at 70° F. than at higher temperatures.

Table I. Dehydration Secured with Ground Beef by Different Concentrations of Ethyl Alcohol

Ethyl Alcohol Concn., %[b]	Moisture, %[a] Alcohol dehydrated	Air dried[c]
99.8	11.7	4.7
88.2	23.3	...
80.0	28.9	9.0
60.0	30.9	10.0
41.5	34.8	...
40.0	...	13.0
19.5	44.7	...

[a] Wet basis; initial moisture, 70.7%.
[b] By weight.
[c] Allowed to dry in open air, room temperature to remove alcohol.

Dehydration of Beef with Ethyl Alcohol

The dehydrating effect of anhydrous ethyl alcohol can be secured at room temperatures or lower and offers a possible means of drying animal tissue prior to extraction. Ethyl alcohol has some coagulating effect on protein, which apparently leaves the tissues porous as opposed to the hard nonporous product secured by drying at ordinary drying temperatures. As the effect on the suitability of the meat for extraction and the economics of the process may vary with the concentration of the alcohol, data were secured with several concentrations.

Experimental Work

Raw Materials. Beef and solvent were the same as used for the freeze-drying experiments. Anhydrous alcohol, 99.8% by weight, and various mixtures of it with water were used.

Experimental Procedure. To determine the amount of water removed by ethyl alcohol of different concentrations, 20 grams of ground beef were added to 50 ml. of alcohol and the mixture was stirred in a closed jar for 15 minutes. The alcohol solution was separated by filtration and an aliquot was removed for water determination. The remainder was evaporated to constant weight under vacuum to determine the extracted material, including fat. Water was determined by the Bryant and Smith method (*13*), using acetyl chloride and pyridine. As the amount of dissolved material was small, interference was considered negligible.

To dehydrate the beef prior to use of the extraction tube, 100 grams of beef were stirred with 300 ml. of alcohol for 15 minutes. After separating the liquid by filtration, the wet solids were divided into two parts. One part was extracted without further treatment, and the other after evaporating the alcohol at room temperature.

Results

Dehydration. The amount of water removed from beef initially containing 70.7% water is shown by the data in Table I which gives the final moistures in the beef. When the beef was air dried to remove the alcohol, some additional moisture was removed as shown in Table I, column 3.

Extraction. The extraction results for both dehydrated beef, from which the alcohol was simply drained, and air-dried, dehydrated beef, using trichloroethylene as a solvent, are shown in Figure 3. All extractions were at 75° F. The better extraction secured from the air-dried beef probably results from the lower-moisture content as well as from the absence of any interfering alcohol.

The data indicate that properly dried fish can be extracted readily. Prior work (*1*, *2*) in this laboratory using both trichloroethylene and hexane as solvents for the extraction of meat and fish scrap indicate that the latter would probably extract the freeze-dried and alcohol-dried materials readily although perhaps less rapidly. Costs have not been established although that of freeze drying is probably comparable to that of canning (*4*). Further work is needed on low-temperature drying methods.

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