THE PROSPECTS OF FREEZE DRYING IN INDIA

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Freeze drying (FD) has become an accepted method of food preservation and is gaining more and more popularity because of the several advantages it offers to the housewife. Though the method has been known for over fifty years and was widely applied for preserving costly pharmaceutical items like blood plasma, vaccines etc., experiments on its application to foodstuffs were initiated only about twenty-five years back and its commercial exploitation commenced in the middle 1950's.

Drying as a method of food preservation depends for its effectiveness on the removal of water from the food to such an extent that there is insufficient water remaining to meet the needs of spoilage microorganisms, which are thus prevented from developing. On the other hand, freezing of foods preserves them by lowering the temperature to such an extent that the rate of reproduction of the spoilage organisms is slowed to a minimum—even to zero.

FD, in spite of its name, depends on water removal rather than on low temperature for its preservative effect and the food is in fact stored at ambient temperature, though preferably in a cool place. The process consists in first preparing the food (by removing waste, cutting into conveniently sized pieces and giving heat and other treatments to improve quality retention in storage); the prepared food is then frozen and placed in the drying chamber in the frozen state. The water is removed by direct sublimation of ice without allowing the food to thaw, the temperature remaining low until drying is almost complete. The dry products are lightweight porous solids, retaining the original form of the pieces of food almost completely; when placed in water they absorb it very rapidly and are then ready for the table or for further preparation as may be appropriate.

According to Kermit Bird of the U.S. Department of Interior, Marketing Economics Division, there were twenty-one FD plants in the United States and Canada together in January 1965 with a total shelf area of 5361 sq. meters and a maximum production of 1,38,172 kg of prepared material processed per day. Working 200 days in the year, the throughput during 1965 was 27.7 million kg of prepared material. Kermit Bird goes on to predict a throughput of 144 million kg of prepared material per day by 1970. There is every reason to believe that this prediction will come through taking into consideration the growing popularity of such products. The main FD products on the U.S. markets in 1965 were shrimp, crab, meat, beef, chicken, ham, mushrooms, strawberries, peaches, blueberries and coffee. Rapid expansion of the method to other food materials like potato, cheese, ice-cream, mutton, ready-to-eat foods like salads and soups has taken place since then and many of these products are on the U.S. markets today.

FD has assumed commercial application in many of the European countries also, notably The Netherlands and Ireland; but

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it is still in the experimental stages in several of the developed and developing countries including ours. In India especially, FD holds out a promising method of food preservation in so far as frozen foodstuffs require maintenance of chain of cold storages and refrigerated transport at—18 to—23°C which is costly and hence adds to price of the food material. Compared to the frozen material, FD product is very light, for example, 5 kg of a food material when frozen weighs 7 to 8 kg with the weight of the glaze which is absolutely essential to prevent dehydration during frozen storage, while the same 5 kg of the material gets reduced to 1 kg or less on freeze drying. This considerably reduces the handling and transportation charges of the FD products. Another advantage of this new process is that when once the product is packed properly (air-tight inert gas packing is generally employed for FD products) it no longer requires any refrigeration and thus saves a lot in this way compared to frozen products. In contrast to products dehydrated by employing other methods, FD products reconstitute almost instantaneously and can be prepared for the table much more easily, while the former requires elaborate soaking (2 to 3 hrs) and preparation. There is almost 100 per cent retention of nutrients and flavouring compounds in the new method, while considerable amounts of them are lost or destroyed in the conventional methods of dehydration. Regarding shelf-life also, FD products are much superior (life counted in years) to other dehydrated products (life counted in months). The most important advantage of the new process is that high calorie ready-to-eat foods like soups and salads can be preserved by this method which can be either boiled up with water (soups) or sprinkled with water (salads) and consumed. This is especially important for defence forces stationed in difficult terrain and those in action who cannot afford to cook their foods. Space travellers also make wide use of FD foods which are perhaps the most suitable for their purpose, being light to carry and easily reconstitutable. Of course there is no saving of weight in this case since the water for reconstitution also must be carried.

One serious defect of FD foods at present is that the capital and processing costs are considerably high in this method which is reflected in the cost of the finished product. Hence, with a view to finding out how far these factors of capital and operating costs of FD process influence the cost of the finished products under Indian conditions, we have made a tentative cost calculation based on Kermit Bird's work (Freeze drying of foods: Cost projections, U.S. Department of Agriculture, Marketing Research Report No. 639). Calculations have been made for a plant which can dry five tons of frozen products in three shifts per day. This size of the plant is considered to be the minimum that can work profitably on a commercial scale, because in smaller plants, the capital and operating costs do not decrease proportionately with the size of the plant and hence, the smaller the size of the plant the higher the cost of the finished product*.

For the purpose of calculation, it is assumed that (1) the raw material is fish with a moisture content of 80 per cent which is reduced to 2 per cent by freeze drying, (2) drying time is 8 to 10 hrs per batch with a tray loading of 12.2 kg/m^2 and the plant operates 24 hrs a day for 250 days in the year, (3) the plant is composed of four drying chambers loaded at quarter cycle intervals day and night and the evacuation system is a combination of steam jet ejectors and

* These calculations were utilised by one of us (C.G.T.) in 'Report to the Government of India on Freeze Drying of Tropical Fishery Products, FAO Fish. UNDP (TA) Rep. TA 2308, in Appendix V' in which they appear in a slightly fuller form.

mechanical pumps with refrigerated condensers, (4) refrigeration required for freezing the input material is four tons per 100 kg per hour and that for sublimation 22 tons per 100 kg water per hour and (5) two-thirds of the total water sublimated are held by refrigerated condenser and the remainder removed by steam jet ejectors.

Prepared fish charged per day = 5000 kg

Dried product per day $= 5000 \times \frac{20}{100} \times \frac{100}{98} = 1020$ kg

Water removed per day = 3980 kg

Minimum total shelf area required $= \frac{5000}{12.2 \times 2.4} = 171$ m²

Recommended area = 186 m²

Refrigeration required for freezing $= \frac{5000 \times 4}{100 \times 24} = 8.3$ tons

Refrigeration required for sublimation $= \frac{3980 \times 2 \times 22}{24 \times 3 \times 100} = 24.3$ tons

Refrigeration required for storage before drying = 20 tons, say

Hence total refrigeration required = 52.6 tons

Recommended installation = 60 tons

I. Fixed costs

Freeze dryer (including refrigeration) @ $ 1615/m² shelf area = Rs 22,50,000

Adding 100 per cent to cover import duties, freight, insurance, erection etc., total investment = Rs 45,00,000

Annual fixed costs on this amount = 23½% (depreciation: 12½%, interest: 6%, insurance and taxes: 3% and maintenance: 2%)
= Rs 10,57,500..... A

Ancillary equipments

Forks, trucks, pallets, conveyors, work tables and scales = Rs 37,500

Boiler, working pressure 10 kg per cm² and evaporating capacity of 1800 kg per hour = Rs 1,00,000

Hence total ancillary equipment cost = Rs 1,37,500

Annual fixed cost on this account—23½ per cent = Rs 32,325..... B

Building: Factory, office, storage etc.

Total floor space required for factory, office, laboratory and storage = (280+70+280)=630 m²

Cost of building @ Rs 323 per m² = Rs 2,02,500

Annual fixed cost on building = 17% (depreciation: 5%, insurance and taxes: 4%, interest: 6% and maintenance: 2%)
= Rs 34,425 C

Hence total fixed cost per annum = A + B + C = Rs 11,24,250

Fixed cost/kg of freeze dried product $= \frac{11,24,250}{1020 \times 250}$ Rs $= 4.41$... I

II. Utility costs

(*a*) *Steam*

Steam required per day for sublimation @ 2.5 kg/kg of water = 2.5 × 3980 = 9,950 kg

Steam required per day by steam jet ejectors @ 15 kg/kg water $= \frac{3980}{3} \times 15 = 19,900$ kg

Total steam requirement/day = 29,850 kg

Boiler capacity = 18,000 × 24 = 43,200 kg/day

(The excess capacity of the boiler can be used for other purposes when required)

Furnace oil consumption/day @ 150 kg/hr = 150 × 24 = 3600 kg

Cost of furnace oil @ Rs 150/ton = Rs 540.....(*a*)

(*b*) *Electricity*

Electricity used/day @ 0.968KWH/kg of water removed = 0.968 × 3980 = 3,860 KWH

Cost of electricity/day @ Re 0.03/KWH = 0.03 × 3860 = Rs 116.....(*b*)

(*c*) *Nitrogen*

Nitrogen required per day = 250 m³

Its cost @ Rs 135/100 m³ = Rs 338.....(*c*)

(*d*) *Water*

Water consumed/day @ 50 kg/kg of water removed = 50×3980=1,99,000 kg i.e. 2,00,000 kg, say

Its cost @ Rs 1.50/1000 kg = Rs 300.....(*d*)

Total utility costs per day = *a*+*b*+*c*+*d*=Rs 1,294

Utility cost/kg of freeze dried product $= \frac{1294}{1020} = \text{Rs } 1.27$... II

III. Raw material cost

Raw fish required for 5000 kg prepared material for drying	= 10,000 kg
Its cost @ Rs 2 per kg	= Rs 20,000
Hence raw material cost per kg of freeze dried product	= $\frac{20,000}{1020}$ = Rs 19.61 III

IV. Labour cost

Total annual salary for 27 salaried staff required @ Rs 9,400/month	= 9400 × 12 = Rs1,12,800
Fringe benefits @ 15%	= Rs 16,920
Annual expenditure on daily paid staff (16 males @ Rs 4/day and 80 females @ Rs 3/day)	= 304 × 250 = Rs 76,000
Fringe benefits @ 5%	= Rs 3,800
Medical services etc.	= Rs 6,000
Total labour cost	= Rs 2,15,520
Hence labour cost/kg of freeze dried product	= $\frac{2,15,520}{1020 \times 250}$ = Rs 0.85 IV
Packing, distribution and marketing charges	= Rs 11/kg V
Hence cost/kg of FD product	= I+II+III+IV+V= **Rs 37.14**

This cannot be said to be very high, because 1 kg of FD fish is equivalent to 5 kg of frozen fish which in turn is equivalent 10 kg of fish as landed. Hence the actual cost comes to only Rs 3.71/kg. of fresh fish when it reaches the consumer in the interior markets in the FD form.

In quality FD foods are only slightly inferior to good frozen products. This is naturally to be expected since the frozen product undergoes a drying cycle of 8 to 10 hrs after which it cannot be better than or even equal to the starting material itself. However, such foods are far superior to those preserved by conventional methods of dehydration in organoleptic and nutritional qualities.

The comparatively higher cost of production of FD foods will be more than compensated by the lower handling, transportation and distribution charges compared with those of frozen foods which require costly refrigerated transportation and distribution chain. This in a tropical country like ours presents immense problems of proper maintenance and manipulation. Hence even though at first FD products might seem to be most suitable for purchasers of luxury and 'high convenience' foods, they are sure to be well accepted in our interior markets. Mountaineers and picnicers will find FD foods the most suitable. Again, in the matter of proper feeding of our defence forces where financial considerations can be given only secondary importance, FD method is the solution. It is gratifying to note that our Defence Authorities are already seized of the necessity and importance of FD foods and have commissioned a FD plant with a throughput capacity of 5 tons per day. Hence on the whole, we may conclude that FD foods will have a very bright future in our country not only as regards defence efforts but also from the point of view of proper conservation and distribution of our limited food resources which are of absolute importance in a country like ours whose population is increasing at a very rapid pace and is under constant threat of shortage of food materials.