A LABORATORY SCALE LIQUID NITROGEN FREEZER

66

Abstract: A laboratory scale liquid nitrogen freezer for food and other biological samples is described. In the apparatus, liquid nitrogen is forced under pressure through a sprayhead fitted to a plastic pipe. The sample for freezing is inserted into the pipe under the liquid nitrogen sprays. Freezing times for strawberries, mushrooms and tomato slices were 6, 4 and 2 min respectively with this system.

Introduction

Cryogenic freezing of food in liquids such as liquid nitrogen (LN) generally results in a high quality product due to the rapid rate of freezing (1). In commercial LN freezers the food is conveyed through a tunnel and meets progressively colder nitrogen gas which causes crust freezing. It finally passes under LN sprays which completely freeze the food.

Many laboratories cannot afford the high capital cost of an LN freezer and test freezing must be done either by simply dipping the food directly in LN or by availing of a commercial LN freezer—if there is one in the locality. The practice of freezing by direct immersion in LN may be undesirable since it can cause the product to crack due to the cold shock. For these reasons it was decided to build a low-cost tunnel system fitted with spraying devices for applying the LN. It should be stressed that this system was not built to simulate a commercial LN freezer, but only as an improvement on the dipping technique. Use can also be made of the cold nitrogen gas (as a precool) with this system.

Apparatus

The system is shown in Fig. 1. The tunnel is a 3-m length of 'Wavin' plastic pipe (diam. 230 mm) fitted with 13 mm wide aluminium rails which run the entire length of the tunnel and protrude at each end. The rails are joined by cross ties and will only fit in the pipe when inserted diametrically, i.e., the rails are almost 230 mm apart.

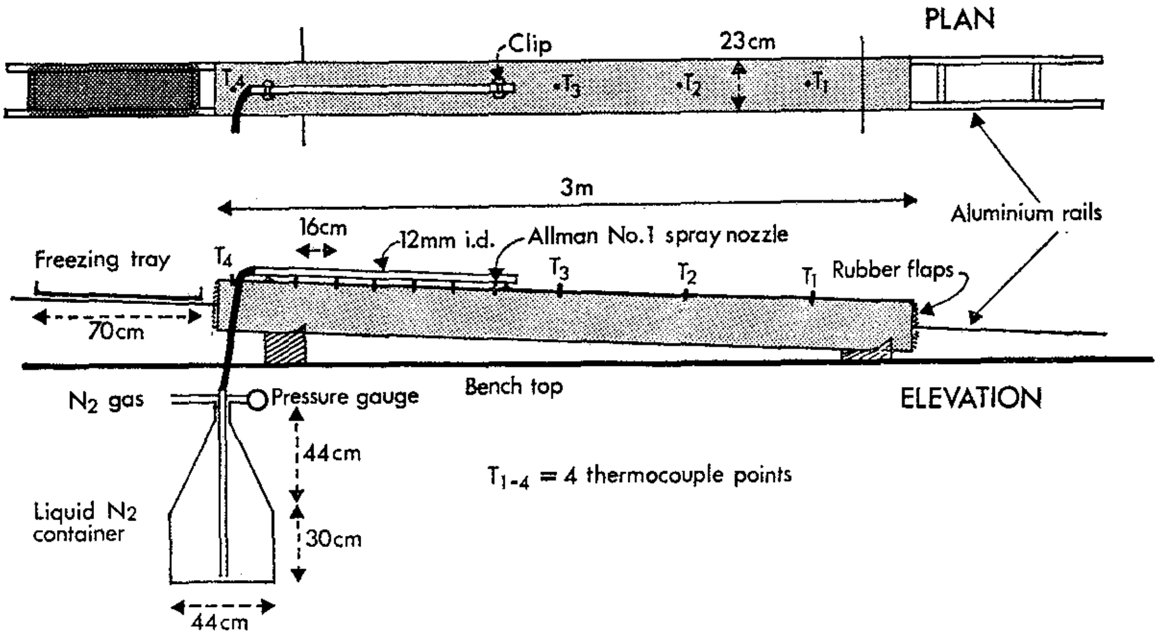

Fig.1 : Diagrammatic representation of the freezing apparatus

The tunnel is slightly inclined to cause the cold nitrogen gas to flow from left to right. The freezing tray framework, made with 13-mm wide aluminium and covered with stainless steel wire mesh, slides on the rails and is kept from falling off by the sides of the tunnel. Two semicircular rubber flaps were fitted at each end of the tunnel to restrict air movement, thereby minimising temperature fluctuations. Thermocouple attachment points were drilled at four places along the length of the tunnel (0.44, 1.00, 1.56 and 2.96 m from the right hand side) and are referred to as thermocouples 1, 2, 3 and 4 respectively. The copper-constantan wires were connected to a Honeywell multipoint recorder calibrated in the range plus 50° to minus 50°C.

The sprayhead consists of 5 × No. 1 brass Allman spray nozzles fitted to a 12-mm diameter copper tube. The tube is held in position by two clips attached to the tunnel and the five nozzles are accommodated through five holes drilled in the tunnel. Each nozzle gives a fan shaped spray of LN across the diameter of the tunnel. The sprayhead is attached by a flexible copper hose (20 mm external diameter) to a Cryovac LN container. There is a T junction at the mouth of the container consisting of a thread which fits into the neck of the LN container, a stainless steel pipe which takes LN from the bottom of the container, a pressure gauge, and an entry point for nitrogen gas. The rate of consumption of LN was followed by placing the LN tank on a Berkel scales during an actual run.

Operation and performance

It is important to prepare all the material for freezing before starting up the system in order to avoid wastage of LN. Operation is commenced by pressurising the LN in the tank (20,684 Nm^{-1})* with nitrogen gas from a cylinder. This forces the LN up the tube and out through the spray nozzles into the tunnel. This operating pressure is maintained throughout the run. The rate of temperature drop in the tunnel at the four thermocouple points is shown in Fig. 2. It was fastest in the vicinity of the spray nozzles (thermocouples 3 and 4). After 10 min the tunnel is sufficiently cold and food samples can be introduced. The freezing tray will accommodate 1 kg of produce as a single layer. The food tray plus food can be moved to and fro under LN sprays by means of a copper rod attached to the tray. Alternatively, the tray can be introduced to the tunnel at the right hand side (Fig. 1) and pulled against cold nitrogen gas and finally under the spray nozzles.

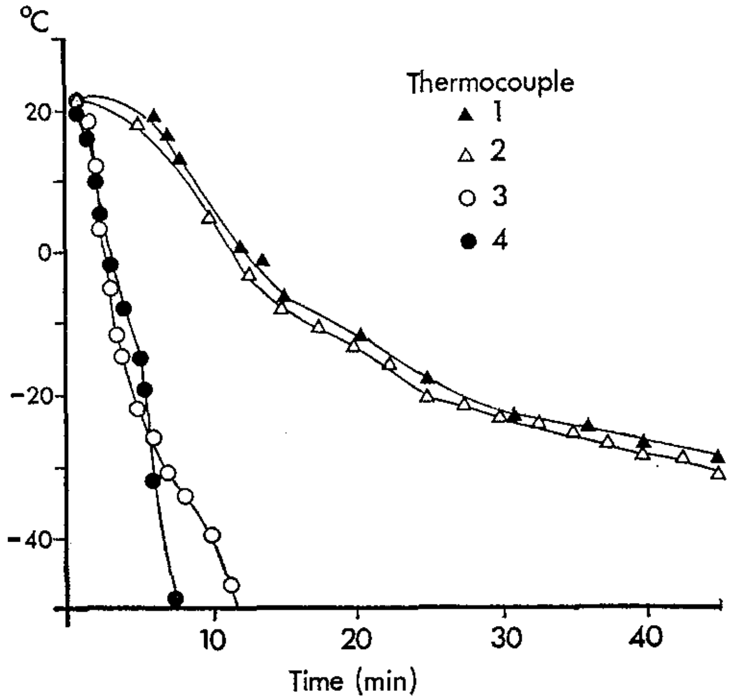

Fig. 2 : Rate of temperature drop at four points in the tunnel

3 psi

TABLE 1: Freezing time and drip loss for strawberries, mushrooms and tomato slices frozen in liquid nitrogen (LN)

Produce	Freezing time (min)[a], [b] LN	Drip loss (%) LN	Drip loss (%) Blast freezing
Strawberries (Cambridge Vigour)	6	29	41
Mushrooms	4	5	27
Tomato slices	2	22	—

[a] Temperature change +18° to −50°C
[b] Product moved to and fro under sprays

Table 1 shows the results for freezing time and drip loss for strawberries, mushrooms and tomato slices (1 kg samples) frozen in LN. Comparative values for blast freezing are also shown. As expected, drip loss was lower for the LN frozen samples and the appearance of the products after thawing was good; this applied especially to the tomato slices.

The rate of use of LN was constant throughout the freezing run at 0.45 kg/min. Since the LN tank contains 20 kg the freezing tunnel can be kept in operation for 45 min with one charge of LN. If account is taken of the 10 min cooling down time, this leaves 35 min of actual freezing time which represents about 6 kg of strawberries or 9 kg of mushrooms or 18 kg of tomatoes based on the data in Table 1. Two freezing trays are required for this throughput. When one is removed from the tunnel the other is already loaded with product and can be put in without delay.

Conclusion

The freezing tunnel proved satisfactory under the operating conditions tested and has applications for freezing test samples of food or other biological materials.

Acknowledgment

The author is grateful to Mr. Sean Egan for technical assistance.

T. R. Gormley

An Foras Talúntais, Kinsealy Research Centre, Malahide Road, Dublin 5

REFERENCE

1. Gormley, T. R., *Technology Ireland 3* (8): 13, 1971.

Received January 29, 1975