FREEZE DRYING OF PRECOOKED MUTTON

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(*Received* 14 *Dec.* 64; *revised* 18 *Feb.* 65)

This communication reports a comparative study of contact heating and radiation heating, the two processes of heat transfer normally applied in Freeze Drying of food stuffs.

Freeze drying has been known for a number of years for preservation of blood plasma, vaccines and biological materials. Roughly the technique consists of freezing the material and removing the water vapour by sublimation under vacuum. The process, however, was considered not applicable to food due to its low handling capacities and protracted drying cycles. Dehydration can be accelerated by holding the food in vacuum and supplying the latent heat of sublimation. The limiting factor, however, is the problem of conveying heat energy into a near insulator, the drying food[1]. In fact the rate of heat supply is the controlling variable[2].

Heat supply can be effected either by radiation heating or by contact heating or dielectric heating. Dielectric heating is reported to have been found unsuitable for food dehydration[2,3]. Keeping all other parameters constant, this communication reports a comparative study of contact heating (Double Insert Contact Plate Method—AFD) and radiation heating (from both sides) techniques *vis-a-vis* drying cycles and quality of the product.

MATERIALS AND METHODS

Preparation

Carcasses used during the experiments were from animals in the age group of 2—2½ years. The dressed meat obtained confirmed to A.S.C. Specifications. Since the removal of fat is necessray to facilitate dehydration, superficial fat of the body was trimmed off. After defatting, bonding of the meat was done. Table 1 reports the result of the above mentioned operation.

TABLE 1

DRESSED MEAT—PREPARATION DATA ON

Product	Per 100 parts	Actual weight (kg)
Dressed Meat	100·0	37·0
Superficial fat trimmings	13·5	5·0
Bone	35·6	13·2
Boned Meat	50·8	18·8

Cooking

The boned meat (18·8 kg.) was divided into two equal parts of almost uniform composition. The method employed for precooking in cylindrical autoclaves was open steam under pressure. Meat was steam cooked under 15 p.s.i. for 70 minutes.

Bacteriological tests have shown that heating for this much period and temperature is sufficient to destroy *staphlococci* and other food poisoning organisms, if present[4].

Cooking yield is given in Table 2.

TABLE 2

COOKING YIELDS

Material	I Batch	II Batch
Raw Meat	9·4 kg	9·4 kg
Cooked Meat	5·2 kg	5·2 kg
Moisture Content of Raw Meat	76·5 %	76·0 %
Moisture Content of Cooked Meat	63·0 %	63·0 %
Gravy*	4·0* kg	4·2* kg

*Gravy was not incorporated in the products to maintain uniform constitution of the product.

TABLE 3

COMPARATIVE RECONSTITUTION

Time (Mts.)	Per cent water absorbed		Per cent reconstitution	
	Contact dried mutton	Radiation dried mutton	Contact dried mutton	Radiation dried mutotn
5	54·5	56·1	86·6	89·0
10	56·1	57·6	89·0	91·4
15	56·8	58·3	90·1	92·5
30	56·8	59·0	90·1	93·6
60	58·3	59·7	92·5	94·7
120	59·0	59·7	93·6	94·7

Pre-freezing

In order to facilitate uniform slicing of meat, the material was prefrozen at 0—5°C. With the help of a mechanical slicer the frozen meat was sliced to the required thickness of ½".

Loading and deep freezing

(1) The trays (27" × 27") employed were made of Aluminium. The sliced material was evenly distributed on trays and the average wet weight loading density of each tray was 2 lb./sq. ft. It was essential for the material to be loaded in such a manner that variations in food surface were as small as possible and the largest surface area was available for vapour escape during dehydration. As far as possible sliced chunks were arranged with their capillaries at right angles to the surface of the trays[5].

(2) The tray to be imparted contact heating was loaded using expanded metal sheet on both sides of the material. This technique called "accelerated freeze drying" was developed by the British Ministry of Food and Agriculture. In order to overcome the difficulties of effective heat transfer and smooth vapour flow from the material under vacuum drying, wire netting is inserted between the tray and the drying material, thereby providing adequate pathways for the vapours to escape. It has been observed that vapour flow restriction adversely effects the dehydration process.

(3) The Second tray was subjected to radiant drying. Therefore use of expanded inserts was not required.

Thermocouples were inserted in the sliced pieces to record the deep temperatures. To avoid the recording of wrong temperature, thermocouples were frozen with the material[1]. In case of radiation heating, one end of the couple is tied with a wire to record the surface temperature. Both the loaded trays were frozen (—20°C) in a deep freezer.

Freeze drying

Both the trays were simultaneously loaded in the same dehydration chamber. Surface tempratures of food were maintained constant in both cases. Contact drying was conducted with a pressure on food of 2 lb/sq. ft. Temperature of food surface was maintained at 50°C and the chamber was maintained at a vacuum of 0·1 mm. (Hg).

In radiant heating the source of heat *i.e.*, heater platen was kept ¼″ apart at the bottom, while the upper heater platen was 1/8″ apart from the food surface.

Results

The period of a drying cycle was 7 hours in case of radiation drying and 9½ hours in contact dehydration (Fig. 1). The maximum plate temperature reached in contact heating was 118°C and in radiant heating was 138°C.

Rehydration

Rates of rehydration of the product dried by the two different methods are recorded in Table 3. The experiment was performed under similar condition using tap water (85°F).

TABLE 4

PERCENT CHEMICAL COMPOSITION

Constituents	Raw dressed mutton		Cooked mutton	Processed mutton (Freeze Dried Mutton)	
	Bone in %	Boned defatted trimmed %	%	Contact %	Radiation %
Moisture	68·6	76·5	63·2	1·6	1·8
Protein	14·4	21·0	32·1	85·5	85·3
Fat	15·8	1·5	31·1	8·4	8·4
Ash	1·2	1·2	1·6	4·5	4·5

25 gm of the sample was placed in a 250 ml beaker covered with 150 ml of cold water (85°F) and allowed to soak for a given period of time at room temperature. Then free liquor is carefully poured off. The meat is allowed to drain for one minute, during which any remaining free liquor ran off. Now the weight of drained meat is determined. Calculations were made on the basis of the formulae given below

(*a*) $\text{Percentage of water absorbed} = \dfrac{\text{Wt. of water soaked} \times 100}{\text{wt. of drained meat.}}$

(*b*) Per cent reconstitution $= 1{\cdot}587 \times$ Percentage of water absorbed.

(1·587 is a constant factor, obtained on the basis of moisture content present in cooked meat *i.e.* 63%).

Chemical determination

Moisture was determined by drying 5 gm. of the material at 100°±1°C for 15—18 hours in a hot air oven[6]. Protein was calculated from total nitrogen determined by Kjeldahl method[7] and fat (ether extracted) and ash were determined as suggested by Jacobs[8,9].

The results are recorded in Table 4.

DISCUSSION

Heat transfer in dehydration of meat generally takes place with the help of moisture present. As the moisture content reduces, the heat transfer becomes difficult. Due to the very low thermal conductivity of the dry shell, heat transfer is almost a limiting factor in the freeze drying of foodstuffs[1].

Heat supply can be effected by three methods as stated earlier *e.g.* dielectric heating, radiant heating or contact heating. Dielectric heating had been tried and found unsuitable[2]. In contact heating the drying trays are directly laid on heating shelves. Possibility of scorching the food and incipient melting, therefore, always exists. To avoid this great care has to be taken and low temperatures are required. This enhances the cost of refrigeration and also lengthens the drying cycle. Moreover vapour flow restriction due to the application of food pressure has also been experienced by the present authors. Use of "expanded metal inserts" has been suggested[2, 10—12] to overcome this difficulty but they are fragile and require careful handling and placing in between the food layer and the tray.

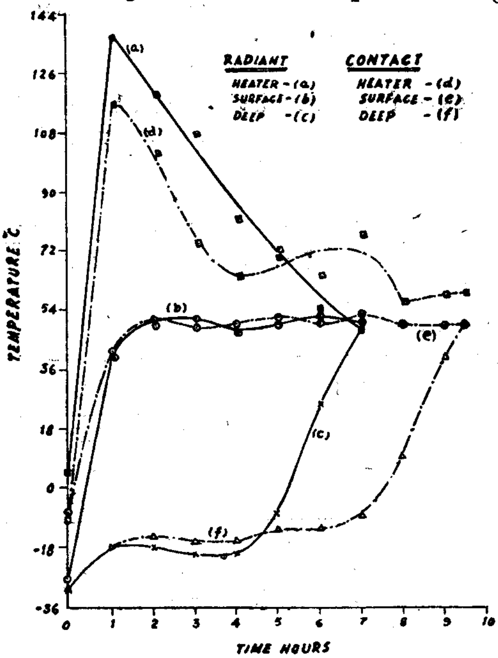

FIG. 1—Time—Temprature relationship for freezedrying of meat.

Radiant heating allows a very efficient and uniform heat transfer, easier control, short drying cycle (Fig. 1) and dispenses with use of "expanded metal insert". The maintenance of a hydraulic jack for subjecting the food to pressure is not necessary in case of radiation heating. This process is also best suited for vegetable dehydration where the application of food pressure may damage the size and shape of the material.

The authors have observed that time of dehydration cycle while freeze drying ½" thick meat chunks is about 2½ hours less than that required in contact heating (Fig. 1). The reconstitution characteristics of the products were same in both the cases (Table 3) *i.e.* within 15 minutes reconstitution is 90-92 per cent in both the samples.

REFERENCES

1. HANSON, S. W. F., *Food*, 28 (1959), 248.
2. WARD, K., *Food Manuf.*, 36(2) (1961), 60.
3. HARPER, J. C. & TAPPEL, A. L., *Adv. Food Res.*, 7 (1957), 171.
4. ROLFE, E. J., *Food*, 25 (1956), 199.
5. JACOBS, MORRIS B., "The Chemical Analysis of Food and Food Products" (Van Nostrand, Princeton) 3rd Edn. 1962, p. 21.
6. *ibid.*, (1964), p. 664.
7. *ibid.*, (1962), p. 659.
8. *ibid.*, (1962), p. 663.
9. DALGLEISH, J. MCN & THOMPSON, H. P., The Crown patent No. 27044/58 (1958).
10. DALGLEISH, J. MCN., *Food Manuf.*, 36(2) (1961), 56.
11. FORREST, J. C., *Bri. Chem. Engg.*, 4 (1959), 1.
12. SMITHIES, W. R., *Food Tech.*, 13 (1959), 610.