"DEHYDRATED MEAT"

by

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Before discussing the dehydration of meats as carried out in New Zealand, I should like to apologise for the unavoidable absence of Dr. Andrews, who is unfortunately engaged on other important duties, and also for any deficiencies there may be in this account. I offer the explanation that the paper has been compiled hurriedly, since Dr. Andrews found that he would not be able to attend this meeting. I feel that I cannot do the subject the justice Dr. Andrews could do it, nor can I discuss its commercial aspects as he could, but I can give a brief outline of its development and of the process as it is carried out at present.

The main problems involved in producing a satisfactory dehydrated product are:-

(a) How to preserve the essential qualities of the meat.

(b) How to retain the flavour in an appetising and characteristic form, e.g. dried mutton should taste like mutton when prepared for consumption.

(c) How to obviate a gritty effect on the palate when the dried meat is used.

These difficulties are by no means insuperable, and the present product is very satisfactory and can be used for sausages, rissoles, meat pies, curries, etc.

Stated briefly, the problem of dehydration is that of removing a large proportion of the water present in meat without removing at the same time any of its nutritive elements. This is by no means an easy task on account of the presence of a large percentage of fat, and also because of the presence of water-soluble substances. In the dehydration of meat there are several factors which, in the ideal case, would be retained completely:-

1. Protein.
2. Fat.
3. Ash.
4. Vitamins.
5. Physical properties, such as softness, etc.

These factors will be gone into more fully later, when the dehydration process has been explained; and it will be sufficient to note here that all these factors are influenced to a greater or less degree by processing, with the possible exception of the physical properties. The retention of these properties, or rather the preserving of these properties in the dehydrated form so that they are similar in the reconstituted product to what they are in the raw meat, contributes a great deal to the success or failure of the whole of the dehydration project. In other words, unless the reconstituted meat is as soft and as easily cooked as raw meat, much of its commercial value immediately disappears.

The incentive for preparing meat in a dehydrated form is threefold, especially during wartime when the question of supply is uppermost.

First, meat represents nearly 60% by weight of the present imports of refrigerated cargo, into the United Kingdom. Dehydrated meats do not require refrigeration space in storage, transport, or in distribution; if packed properly dehydrated meats should keep for at least two years. It

is known that they are just as good after a storage period of over a year, and there is no reason to doubt that they would be inedible after being stored 2 years. There is insufficient water left to support putrifactive and other bacteria and molds, and dehydrated meat is not hygroscopic enough to build up a satisfactory water content from the air for their support; engyme action has been almost completely inhibited, and oxidative changes are at a minimum. So that, instead of needing refrigeration to preserve the meat, the problem is the much simpler and less expensive one of keeping the meat dry. In the laboratory, samples of dehydrated mutton which have been kept in open dishes for five months still appear as satisfactory as when they came from the dehydrator, which is a very good criterion considering that frequently and for long periods at a time the humidity was extremely high.

Secondly, the saving in shipping space is considerable, as will be realised when it is stated thatm with expert stowing, beef shipped in quarters stows at 90-95 cubic feet per ton, corresponding to approximately 115 cubic feet per ton of edible meat. Shipping boned beef saves approximately 20% in weight and 30% in space, while in the dried form there would be a further very considerable saving in weight and space. In the case of mutton, 17 tons of carcase mutton become 12 tons of boneless meat, which in turn become 3 tons of dehydrated meat, i.e., from carcase to dehydrated meat there is a saving of over 82% in weight and a still greater saving in space. This space-saving item constitutes an advantage over canned meats which, although they carry in ordinary now-refrigerated space, do not decrease the volume of the meat. A further advantage over canned meats is that it is not necessary to pack dehydrated meats in tins, and there is consequently a saving of tin-plate, which is especially advantageous at the present time.

And, thirdly, there is the convenience of supply under present existing conditions. The dehydrated meats can be taken anywhere, by any means of transport. In addition reconstitution is easy and rapid.

Up to the present, a small pilot plant in Auckland has prepared about 18 tons of dehydrated mutton, two tons of dehydrated pork, and ½ ton each of dehydrated beef and dehydrated bobby calf. The method outlined below has been used in each case and seems eminently satisfactory,but since the main problem at the moment is the dehydration of mutton, these other products are merely incidental. This plant is capable of producing 1½ tons dehydrated ewe mutton weekly.

The process of dehydrating meat as used at the pilot plant is as follows:-

Boned and trimmed ewe mutton is minced through a ½" plate and transferred to large, steam-heated pre-cooking pans with a capacity of 250-300 lbs. each. About 4 gallons of water or liquor from a previous batch are added and the meat cooked with constant stirring until the albumin begins to coagulate and the meat becomes a mass of separate particles. Up to this time a small amount of fat is rendered out, but with the contraction brought about by the coagulation of the protein a large amount of fat is extruded from the tissues. Pre-cooking is discontinued when this begins, as longer cooking results in the squeezing out of too much fat, and the final dehydrated product consequently has too low a fat content. During this pre-cooking also a large proportion of the moisture is removed, together with a small amount of water-soluble matter such as minerals.

From the pre-cooking pans, the meat is transferred to large perforated cylinders and allowed to drain. To hasten this, for reasons that will become obvious later, a slight pressure is applied. Upon this pressing depends to a con-

siderable extent the final fat content of the dehydrated meat. It is obvious that the pressure must be slight, as the temperature of the mass is still very considerably above that at which mutton fat solidifies, and too great a pressure will squeeze an appreciable amount of fat from the pre-cooked meat. In two batches weights were taken, and it was found that during pre-cooking and pressing there was a 50% loss in the original weight of the raw meat. Thus, in one batch, it was found that, of the 1660 lbs. of raw meat handled, the weight which actually entered the dehydrator was only 830 lbs. In another batch, where 2500 lbs. of boned untrimmed ewe mutton were handled, 800 lbs. of fat were extruded during pre-cooking and pressing, and only 1200 lbs. of meat entered the dehydrator, showing that almost 700 lbs. of water were removed before the dehydrator was brought into action. Incidentally, this particular batch had a very satisfactory final fat content.

While it is still hot, the pressed meat is spread on wire-gauze trays which are loaded into the dehydrator. This machine is of the circulating air type. A fan drives the air along a tunnel underneath the tray space, over electric heaters at one end, over the trays, and then through condensers and back into the tunnel again. The velocity of the air-stream is about 7 ft. per second, although a slightly higher velocity is advised. The average load is 1000-1200 lbs. of pre-cooked and pressed meat, and under a given set of dehydrator conditions the drying time is dependent upon the fat content.

The manipulation of the dehydrator temperatures and the rate of condensation are important. Originally, acting on advice received from the Low Temperature Research Station at Cambridge, the initial air temperature was 140°F. and this was gradually decreased to 120°F. as drying proceeded. It was found, however, to be more convenient and quite as satisfactory to raise the initial air temperature to about 200°F. and complete drying at about 160°F. The reason for dropping the temperature as the meat dries, is to prevent case-hardening; that is, if the temperatures are not carefully controlled, the outside of the meat particles will dry quickly and seal the capilliaries leading to the inside of the particles, resulting in a final product which is dry on the outside but still wet inside - in short, a product which offers excellent facilities for the growth of anaerobic bacteria. This case-hardening is prevented by decreasing the temperature as the humidity in the dehydrator decreases. The technique employed is to have the dehydrator heating while the trays are being loaded. When the dehydrator is fully loaded, it is sealed and the air temperature is allowed to rise to 195-200° F. at the condenser end of the machine. The air inside becomes saturated and the meat is kept uniformly soft all through. When the temperature is 195-200°F. the condensers are turned on just ebough to give a slow steady stream of condensed liquid flowing from the dehydrator. The temperature drops slowly when this is done, and is further hand-manipulated until about 6 hours later it is 160°F. This temperature is maintained for the remainder of the drying time. By this means, the temperature of the meat is prevented from rising too high. Initially most of the heat goes to vaporising the water, and when less heat is required for vaporising water and consequently more would go to heating the meat itself the temperature is decreased, so that using this technique the maximum temperature the meat itself reaches if 160° F. and this only towards the end of the process.

In the dehydrator there is again about a 50% loss in weight, and if 1000 lbs. of pre-cooked and pressed meat are loaded into the dehyrator the weight of final product is only about 500 lbs. Thus, in all, from raw material to dehydrated material the yield is about 23-25% for boneless raw ewe mutton.

Now let us return to the factors that may have been influenced during dehydration.

1. Moisture:

The final moisture content aimed at is 4-6%. Deviations from this introduce difficulties. If the meat is not dried sufficiently there is still scope for bacterial and mold growth, whereas if the final moisture content is too low, difficulties arise in the reconstitution of the meat. To attain this degree of dryness over 98% of the total moisture must be removed, and for 2000 lbs. of raw meat this amounts to about 1200 lbs. of water. As has been shown, much of this is removed during the pre-cooking process.

2. Protein:

There is a slight loss of nitrogen due to the breakdown of collagen to gelatin and also to the presence of small amounts of water-soluble bases such as creatinine, etc.

3. Fat:

During the process, 60-70% of the fat originally present is lost. In one batch of 1900 lbs. of raw meat containing 20.5% fat, the fat content of the dehydrated product was 30%, showing a loss of 250 lbs. or 66% of the original fat. The fat content aimed at is 35-40%. Fat contents below 30% result in the subsequent meat being rather dry to the palate, while in excess of about 40% the material is rather too greasy, as this fat is not all retained in the tissue but consists of rendered fat solidified on the surface of the meat. In many batches, the fat content was below 35%, and in an attempt to correct this, quantities of fatty tissue were minced in with the meat. This did not improve matters to any great extent, and it was found that high fat contents could be attained without the addition of extra fat by careful control of the pre-cooking and pressing processes. Australia, who is also interested in dehydrating meats, has a much less fatty material to work with, and it seems likely that New Zealand products will be more satisfactory from this point of view.

Careful packaging affords, among the other things, some protection against oxidation of the fat and the development of rancidity in the finished product. In practice, this is most readily achieved by the exclusion of the air and other factors, such as light, which contribute to fat oxidation.

The meat, when cool, is packed into tins which are then sealed and cased for shipment. To avoid the use of tin-plate a double carton has been developed, the inside of which is heavily waxed, and the product is pressed into a solid block in this carton, which is then sealed and cased for export.

The difference in the ratio of fat to protein in dehydrated meat from that in raw meat leads to a further problem which has just recently developed. From nutrition considerations an ideal dehydrated product should reconstitude to give the fat to protein ratio of good quality meat. Since very little protein is lost in the process this does not allow for the loss of any fat. One solution seems to be to dehydrate fatty tissue separately and add it to the product as prepared above. On account of the low melting point of fat, its ease of oxidation, and the presence of enzymes, this is a rather difficult problem and is as yet unsolved. Taking the average fat content of good quality as 43%, it is possible, from the knowledge that fat contains about 20% moisture and protein about 75% moisture, to calculate that, in this ideal case, the final fat content of the dehydrated product should be 70%.

4. Ash:

A certain amount of the ash of meat is water-soluble and is removed during pre-cooking. This brings about the question whether it is advisable to concentrate the juices from the pre-cooking pans and return them to the meat, or not. Actually it was found that the returning of the juices was very laborious and interrupted the drying process considerably, with no positive result. Since the juices have practically no nutritive value, and are found to exert no marked influence on the flavour or palatability of the final product, the practice of returning them was discontinued in the case of mutton.

5. Vitamins:

Meat is generally not given a prominent place as a source of vitamins. However, fatty meats contain Vitamin A, while lean meats contain small amounts of B. and E. Vitamin C, although probably present in fresh meat, is destroyed by cooking. The only vitamin estimation carried out on New Zealand dehydrated meat is the Vitamin B, or thiamine value of ewe mutton. From the values obtained it would appear that the dehydrated product still contains more than 50% of the thiamine present in raw meat.

6. Physical properties:

The retention of these is very necessary for reconstitution of the meat. If case-hardening has occurred, or if the meat has been dried too much, it does not reconstitute as easily as an evenly-dried product of 4-6% moisture. Reconstitution is brought about by soaking the meat for 6-8 hours in twice its weight of water, and then cooking for 1-2 hours. The product thus obtained is uniformly soft and shows no signs of grittiness, and above all, although not tasting quite as strongly as fresh mutton, it has a definite and characteristic flavour.

Dehydrated meat prepared by the process described above has an extremely low bacterial count. Precautions taken against possible contamination are:-

(a) All apparatus (press, tables, trays, dehydrator, etc.,) is steamed thoroughly immediately before use.

(b) The meat from the pre-cooking pans is practically sterile, and any contamination of the final product comes largely from contact with the atmosphere after pre-cooking. To minimise this, the meat is kept as hot as possible in the pressing and spreading processes, and is loaded into a heated dehydrator. Another obvious advantage of this procedure is that it helps to shorten the drying time.

(c) The dehydrator, as it is at present adapted, plays a large part in keeping down the bacterial load of the final product. It is a closed system in which moisture is eliminated by condensation and not by change of air. This reduces to a minimum the possibility of bacterial contamination from the air while the meat is in the dehydrator.

Since a palatable product is obtained from ewe mutton, it seems that the dehydration of meat may become a permanent adjunct to the meat industry. An order for 100 tons monthly has been accepted, and a commercial plant will soon be in operation. Australia has accepted a similar order.