2 Preservation of fish by curing (drying, salting and smoking)

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2.1 Introduction

Curing, as a means of preserving fish, has been practised perhaps longer than any other food preservation technique. Marine fish bones found in cave dwellings, inhabited 20 000 years ago and situated many days' walk from the coast of Spain, indicate some form of curing, probably by drying in the open air. Salting, smoking and drying have all continued as preservation techniques virtually unaltered from prehistory to the present day. Modern developments have centred around understanding and controlling the processes to achieve the standardised product demanded by today's market. A major exception has been exploitation of the sublimation of ice to dry food so that it resembled the starting material in volume and shape. This only became possible with the development of pumps which could create, and valve seals which could maintain, high vacuum.

None the less, for all the developments in cure-processing accommodating continuous production lines, the time required to achieve a long shelf-life product purely by water removal is much greater than for any other commonly used preservation method. This is because the process relies upon the diffusion rate of either water from the centre of the food to its surface, or the diffusion rate of salt (or other solute) in the opposite direction, or a combination of both.

2.2 Water content, water activity (a_w) and storage stability

Unlike canning, which engenders the destruction of micro-organisms and their spores, curing preserves by rendering the medium an unsuitable environment for microbial propagation. Increasing the concentration of soluble substances in the medium either by abstracting water or by causing soluble substances to diffuse in (salting, brining or sugar curing) are the principal means of accomplishing this. In addition to concentrating the soluble substances by brining and dehydration, smoking preserves by depositing bacteriostatic chemicals like formaldehyde and phenols in the system.

The addition of salt is more effective weight for weight than the addition of sugar because salt ionises to a sodium cation and a chloride anion each of

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which attracts a sheath of water molecules. These ionically associated water molecules are unavailable for use by micro-organisms and there is a tendency for the ionic forces to pull water molecules from the microbial cells dehydrating them to the point where they die or sporulate and lie dormant. Sucrose also withdraws water molecules from the system and holds them by hydrogen bonding. However, far fewer molecules become bound or unavailable in this way than is the case for an equal mass of sodium chloride.

This availability of water in the system for use by micro-organisms directly relates to the effectiveness of preservation and can be represented physically by the water activity (a_w).

2.2.1 *Basic definitions*

The water content of fresh white fish is about 80%. When this is reduced below approximately 25%, bacterial spoilage stops, and below approximately 15%, moulds cease to grow. These figures are calculated on a wet mass basis, where water content is defined as

$$M_w = \frac{\text{mass of water in the wet solid}}{\text{total mass of solid}} \times 100\%$$

Occasionally water content is quoted on a dry mass basis defined as

$$M_d = \frac{\text{mass of water in the wet solid}}{\text{total mass of dry solid}} \times 100\%$$

The relationship between the two modes of expression is

$$M_d = \frac{100\,M_w}{100 - M_w} \quad \text{and} \quad M_w = \frac{100\,M_d}{100 - M_d}$$

If 10 kg of such fish is to be dried to 25% water content, wet mass basis, the amount of water to be removed is calculated as follows:

At 80% water content the composition of the fish is

10 kg = 8 kg water + 2 kg dry solids

At 25% water content, the 2 kg dry solids represent 100 − 25 = 75%, of the mass. Therefore, the total mass of the fish at 25% water content is

$2 \times \frac{100}{75} = 2.67$ kg composed of 0.67 kg water + 2 kg dry solids

Thus the amount of water to be removed is

$8 - 0.67 = 7.33$ kg

Clearly, the removal of quite a large proportion of the water, say 7 out of the 8 kg of water contained in the fish, does not prevent bacterial growth. Hence water content is not the most useful indicator of the ability of the medium to