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Organizing Intermediate Moisture Food (IMF) Technology in the tropics

Z.A. Obanu

ABSTRACT

The paper discusses the history, principles and techniques of food preservation at intermediate moisture activities and moisture contents. The characteristics, merits and roles of the resulting intermediate moisture foods are also discussed. The suitability of IMF technology to the Tropics as a simple, cheap and efficient method of increasing the non-refrigerated shelf-life of cheaply packaged perishable foods is implied.

The term 'intermediate moisture food (IMF)' has entered food processing vocabulary during the past decade to identify a heterogenous group of foods which resemble dry foods in their resistance to microbial deterioration but which contain too much moisture to be considered as dry (Brockmann, 1970; Obanu et al., 1975). An intermediate moisture food has been defined as one that can be eaten directly, without rehydration, and yet is shelf-stable without refrigeration or thermal processing (Kaplow, 1970). This stability of relatively moist foods is the result of depressing the water activity below the growth requirements of most spoilage and pathogenic microorganisms (Anon., 1972; Brockmann, 1973). Generally speaking, any food can be classified as intermediate moisture food if it has a water activity greater than that of common low-moisture (conventionally dried foods) but less than that of most fresh food (Heidelbaugh & Karel, 1975). In a strict sense, however, intermediate moisture foods are specifically those semimoist shelf-stable foods that owe their stability to the infusion of humectant which, besides being antimicrobial, depresses water activity below limits to below the growth requirements of most bacteria.

BASIS AND HISTORY OF INTERMEDIATE MOISTURE FOOD (IMF) TECHNOLOGY

If full dependence were placed on the role of salt for suppressing microbial growth, the aw of intermediate moisture foods would be confined to the range safe for storage of cereal grains, i.e. 0.65 - 0.75 (Snow et al., 1944; Stille, 1948; Von Schelhorn, 1933a) and higher water activities are required. Accordingly, the lower aw limits have been arbitrarily fixed at 0.7 for processed IMF foods (Brockmann, 1971a). The upper aw limit of shelf-stable IMF foods depends on the nature of the food, its treatment, the tightness of its container, its storage and other considerations. The inability of Clostridium botulinum spores to germinate in canned bread (Desrosier, 1970) at an aw of 0.85 (Denny et al., 1969) sets a theoretical upper limit for the aw of IMF foods. In practice most of the IMF foods have aw in the range of 0.7 to 0.85, the majority being within aw = 0.70 to 0.85 (Obanu et al., 1975). In these IMF ranges, many yeasts and moulds can grow (Scott, 1975) but intermediate moisture foods thus inevitably contain excreta antimycotics, such as potassium sorbate which is effective in controlling the growth of yeasts and moulds (Brockmann, 1973c; Desrosier, 1970; Obanu et al., 1975).

Preparation of traditional IMF foods requires the addition of salt (or sugar) and/or removal of a portion of the water initially present (by drying). Except for certain products high in soluble carbohydrates, fats, proteins and prunes, removal of amounts of water results in an unacceptable degree of hardness and toughness. Confectionery items, which contain at least a fair amount of sugar, have been well suited to IMF (Brockmann, 1975b). Sugar preserves, such as jams and jellies, of aw in the range 0.65 - 0.75, have been common items of Control of aw in sweet foods, however, disqualifies the traditional IMF meat products, such as dry sausages, biltong, charqui and jerky, has been found to depend on the use of sugar rather than salt (see Helmer & Tuomy, 1969). Salting (curing) has had a time-honoured practice in meat and fish preservation. However, the amount of salt required to go down to the shelf-stable products has a marked effect on taste, rendering the products unsuitable for direct consumption. The desire for palatable products with less salt has resulted in the reduced efficacy of salt as a preservative. This is illustrated by the evolution of bacon and ham from a salty, unpalatable, shelf-stable product to a palatable, shelf-stable product with a lower salt content (see Ingram, 1970). The use of dry sausage in IMF products or advancing the solute-infusion technology of existing IMF products (Brockmann, 1980) due to lack of information on the technolo...
The typical examples of intermediate moisture foods often quoted in the literature can be classified as in Table below into the following groups:- (1) Products which have been dried with no addition of solutes; (2) Products to which sugar has been added; (3) Products which have been dried with added salt; (4) Products which have been dried, salted and sugar added; and (5) Bakery products.

### CLASSES OF TRADITIONAL INTERMEDIATE MOISTURE FOODS

<table>
<thead>
<tr>
<th>Dried without added solutes</th>
<th>Dried with added solutes</th>
<th>Dried with added salt &amp; sugar</th>
<th>Bakeries</th>
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<tbody>
<tr>
<td>Prunes</td>
<td>Candied fruits</td>
<td>Sausages</td>
<td>American Country ham</td>
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<td>Soft candles</td>
<td>ham</td>
<td>American pemmican</td>
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<td>dates</td>
<td>Marshmallows</td>
<td>bacon</td>
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<td></td>
<td>honey</td>
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<td>Fruit cakes</td>
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*Adapted from Heidelbaugh & Karel, 1975.

### MODERN EVOLUTION OF INTERMEDIATE MOISTURE FOOD (IMF) TECHNOLOGY

The recent surge of interest in commercial IMF food processing has been due mainly to the remarkable success and excellent record of stability of manufactured semi-moist pet foods (Burgess & Mellentin, 1965, 1969; Rank, 1967; Bone, 1968; Coleman, 1969).

The stability and palatability of accepted IMF foods have aroused great interest in IMF technology especially during wars, when their logistic merits (US Army Natick Lab; 1969) have made them of prime importance in military feeding (Brockmann, 1969, 1970; Anon. 1969). Most of the IMF foods for humans have been developed in the United States to meet the demand of the army for less bulky, shelf-stable, easy-to-prepare nutritious foods which are stable under tropical climates (Hollis et al, 1969; Pavey, 1972). The benefits of IMF foods for military use have also attracted the National Aeronautics and Space Administration (NASA, USA) who are developing suitable foods for astronauts in the various space flights (Klicka, 1969; Lachance & Klicka, 1969; Labuza, 1973). In this regard it is noteworthy that the first solid food eaten by man in the moon was an intermediate moisture food (Smith & Berry, 1969). The desirability of IMF foods for space flight use has been reviewed by Smith and Ashby (1969). Besides these logistic uses, some commercial firms have formulated IMF human foods which are now being test-marketed.

Others are investigating IMF foods for use in special diets such as those required in chronic renal failure. Several mixed and single intermediate moisture foods have been prepared at laboratory and pilot-plant levels, but the full potential of IMF technology still remains unexploited.

### TECHNOLOGY OF PRODUCING INTERMEDIATE MOISTURE FOOD

Since intermediate moisture foods have moisture and water activity levels intermediate between fully dried foods and normal moisture perishable foods, IMF levels can be attained either by raising the activity and water content of fully dried foods or by reducing the water activity and content of normal moisture foods. (Hollis et al 1968). The former involves soaking pre-dried foods in water containing desirable concentrations of solutes (and antimycotics) to give the required water activity; while with the latter procedure the full-moisture food is soaked in a hypertonic solution calculated to give the desired IMF water activity at the attainment of equilibrium. The procedure which uses pre-dried starting material is called "Adsorption" or "Dry infusion" processing (Labuza, 1973; Heidelbaugh & Karel, 1975) and involves the food absorbing water and solutes from the infusing solution to reach the higher water activity and content of the intermediate state, i.e. going up the moisture sorption isotherm. Conversely, the procedure whereby a normal moisture food exchanges part of its water for solutes in the infusing solution to reach the higher water activity and content of the intermediate state, i.e. going up the moisture sorption isotherm. Conversely, the procedure whereby a normal moisture food exchanges part of its water for solutes in the infusing solution is called "Desorption" or "Moist infusing" processing (Labuza, 1973; Heidelbaugh & Karel, 1975) and involves the food going down the moisture sorption isotherm to acquire a lower water activity and content. These two processes occur simultaneously when dry and wet foods (and water-soluble compounds) are blended and heated together as in the manufacture of IMF pet foods (Burgess & Mellentin, 1965, 1969; Rank, 1967; Bone 1968).

In this case water-soluble compounds dissolve and diffuse into the water of the wet food components which, therefore, lose more of their water to attain osmotic balance with their environment. For the
same reason, the water-insoluble dry components of the mix absorb the exuded water together with its dissolved solutes. Thus, with time both dry and wet components of the mix attain an equilibrium state with the infusion solution i.e., sometimes called the "external solution." This, after equilibration in a hypertonic solution, is referred to as the "internal solution" within the foodstuff (Pavey & Shafik, 1969).

Therefore the dry process procedure used to produce such materials is of critical importance. A cheap and simple drying method is not produced a perishable food material (Van Wychen & Copley, 1963, 1964). Most workers were free to vary the production of the dry starting material which was a brittle, hygroscopic product (Pavey & Shafik, 1969). For adsorption processing, it is required that the dried material be uniform and stable (Hollis et al., 1966). Consequently, the drying process, rather than adsorption process, is the critical one in the development of semi-moist foods that are as close as possible to their natural counterparts.

In all three techniques of IM food processing, various steps are quality controlled to optimize efficiency of the process and quality of the product. These steps are identified by variations in procedures used (Dunlop & Karel, 1975). These steps include (1) heating or other means to accelerate equilibration and (2) adjusting nutritional and enzymic deterioration. Also colouring agents may be added to improve or remove undesirable qualities in the products. In addition, steps are variations in the adsorption steps, there are variations in the sequence and method of addition of ingredients.

**WATER CONTENT, CHARACTERISTICS AND MERITS OF INTERMEDIATE MOISTURE (IM) FOODS**

The water content of IM foods has been variously defined, e.g. as shown in the range of 10 - 40% (Labuza, 1975), 15 - 30% (Brockmann, 1973) 16 - 40% (Brockmann, 1972; 20 - 40% (van Wychen, 1976); 20 - 30% (Cook, 1975); 15 - 50% (Maule, 1971), Obanu, 1976, and 20 - 50% (Bone, 1968; Potter, 1970). These differences in definition derive from method of preparation and quantity of humectant added (Pitman et al, 1973). Usually an IM food prepared by desorption or removal of water from the natural moist material has a higher water content than one of the same kind and raw which is prepared by adsorption of infusing solution by a prehydrated material (Labuza, 1968). Also the amount of moisture will depend on the method and intensity of infusing following infusing (Pacev, 1972).

The merits of IM foods derive from their characteristics. They are semi-moist and similar in appearance to the natural product, still are shelf-stable. They are pleasurable, regarding on the extent of water removal (or drying) after the infusing process and subsequent storage, the texture may vary from brick hard to very soft and pliable (Labuza, 1975; Heidelbaugh & Karel, 1975). Being plastic they can be moulded into cohesive blocks of uniform shape to facilitate packaging, transport and storage. Since IM foods are cooked and moist they are suitable for direct consumption with no preparative effort apart from removing a protective wrapper (Brockmann, 1970). This makes them suitable for use as "convenience foods" and in strict situations in which diversification of time or access to the preparation of food is difficult. With certain processing techniques, such as the blending technique used for semi-moist pet-food production, the composition of IM products can be easily controlled. Such control allows incorporation or elimination of certain nutrients or food components to meet the requirements for "balanced diet" for specific purposes (W.H.O., 1974) and for "special diets" cases such as those of diabetes, chronic renal failure, and "inborn errors of metabolism".

**SIGNIFICANCE OF IM TECHNOLOGY IN THE TROPICS**

Intermediate Moisture Food technology has an obvious role in the developing countries as it is a simple, cheap and efficient method of increasing the storage life of perishable foods. Thus, simply immersing fresh food in a solution (e.g. of salt and/or glycerol or sugar in water) the useful life of the food can be extended by several weeks without need for refrigeration. The relatively simple equipment available in most homes is sufficient to produce such shelf-stable foods. For example, in its simplest form, a pot or plate can serve as the infusing tank while sun drying can be depended upon to remove excess free moisture from infuded foods. Such foods can be...
12. Collins, J.L. & Yu, A.K. (1975). Stability and germinated foods. They have for gen stored on counter-top without refrigerated foods, they have for gen packaged (simple water-proof plastic bags are adequate). Also, biltong in Africa, jerky and pemmican in North America, and various dried sweet meats like der in Asia. Since food habits are flexible (Committee on Food Habits, 1943, 1945), it is likely that IM foods would be preferred to fresh products of intermediate-technology (Harper, 1961, Obanu, 1973). As observed by Brockmann, (personal communication) under whose jurisdiction IM food processing for humans was initiated, "the involvement of water activity in the preservation of food is of such significance that one has difficulty in understanding why professional food scientists have focused so little attention on it. This is particularly true of developing unpasteurized products without requiring refrigeration."

REFERENCES


