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Defence Food Research in India

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Abstract. The Defence Food Research Laboratory, Mysore, is a major centre of research in India, particularly in Defence feeding. It is a multi-disciplinary laboratory, well equipped to do research work in food technology, food preservation, packaging, nutrition and biochemistry and food microbiology. Special emphasis is laid on development of light weight processed foods suiting Indian palate.

This paper gives a bird's eye view of the activities and achievements of the laboratory and indicates the scope of future work.

1. Introduction

About 25 years ago a number of laboratories were formed under the Defence Research and Development Organisation, solely to cater to the specialised needs of the Defence Forces. Prior to the formation of the Defence Food Research Laboratory (DFRL) at Mysore in 1961, there was little or no organised Defence food research in India except for a few quality control laboratories working under the Directorate of Supplies and Transport. The establishment of a separate laboratory has given a fillip to the R & D activities in this area.

From a very small beginning, this laboratory has grown into an important and well equipped research centre looking after the problems related to operational as well as peace time garrison rations. It would be difficult to give an exhaustive record of the effort made to solve the many problems related to food referred to this laboratory by the Services.

In the early sixties topics like the development of ten men compo pack, five men compo pack, light] weight five men compo pack or even one man compo pack and survival rations used to be very prominent areas of R & D work. But during the late sixties and seventies, the shift was towards convenience foods, lighter packaging materials, high altitude nutrition and low calorie diet. In the succeeding pages it is

intended to bring into focus some important developments in products, processes, use of flexible packaging materials, newer techniques of packaging, novel processing techniques, use of additives/chemicals for preservation and their safety of consumption, quality control measures, nutritional requirements under stress conditions and the new insights that have been gained during the last 2½ decades in the area of Defence Food Research in India.

2. Products/Process Development

Ever since it was established, DFRL has fully justified its existence by developing a number of new and novel processing methods and new products. In this task, it has had to go through the well established procedure of identifying or modifying the qualitative requirements to suit the users, develop new processing method wherever necessary, conduct storage studies to assess the useful life of the product, carry out field trials to test their acceptability and finally to locate trade sources of supply from whom the users could obtain their requirements.

From the Services point of view, the most essential requirement of a processed food, apart from its compactness and light weight, is that it should be in a ready-to-eat form or in a form requiring only simple reconstitution in water at ambient or higher temperature.

DFRL has to its credit the development of a number of products such as short term/long term preserved *chapaties*, compressed ready-to-eat bars, preserved bread, canned Indian dishes, quick cooking convenience foods, survival ration and freeze-dried products. Side by side with the development of products the laboratory has modified existing test methods and developed new analytical techniques to monitor the quality of food products.

2.1. *Preserved Chapaties and Parotas*

Chapati is a common Indian food and staple ration item of the Armed Forces of India. *Chapaties* preserved in ready-to-eat form are therefore an operational requirement particularly in areas where facilities for cooking are limited or non-existent. Studies indicated that *chapaties* could be preserved on a short term basis for a period of 10-14 days by incorporating sorbic acid and then packaging in polythene pouches. Heating the *chapaties* by dipping the polythene pouch in hot water improved the acceptability of the chapaties. The method is simple and can be easily adapted in any army kitchen without any additional facilities. The *chapaties* packaged in paper foil/laminate pouches could be preserved for 6 months. Incorporation of fat, milk powder and oleoresins of cumin seeds and cardamom improved the texture and flavour and acceptability of preserved *chapaties*.

2.2. *Compressed Meat and Vegetable Bars*

Several compressed ready-to-eat formulations based on processed cereals, pulses, vegetables or mutton mince were developed. These products are compact and withstand transportation better when packed in flexible pouches. The bars have a shelf life of more than one year at ambient temperature and under diverse field conditions. Depending on calorific requirements, bars can be issued at the rate of 4 or 5 per man per day. They are useful as an individual ration for subsistence during emergency or as part of pack rations.

2.3. *Long Keeping Bread*

A fungistatic wrapper was developed for keeping bread for a period of 7-10 days. Oven fresh bread when wrapped in a fungistatic paper with an overwrap of paper polythene laminate remained in acceptable condition for a period of 7-10 days. Long keeping bread has been found very useful in submarines and on board IN ships. DFRL regularly supplies the fungistatic paper to Navy who get their requirements of preserved bread directly from bakeries.

2.4. *Canned Products*

In India, canned products constitute the largest volume of processed foods, most of them catering to the requirements of the Defence Forces. However, only a few canned products cater to the Indian palate. Hence, processing conditions were standardised for canning a number of items of the traditional Indian dietary.

Canned pulav (vegetarian and non-vegetarian), *kofta* curries, peas *paneer*, potato peas curries, mutton *keema*, luncheon meat from mutton, *puries*, *parotas* and puddings like *kheer*, *suji halwa* and pumpkin *halwa* and *upma* have been developed. Another product which has found very good acceptance is canned avial mix.

2.5. *Quick Cooking Foods*

The traditional Indian diet comprises three important components viz., rice, pulses and vegetables and to a lesser extent, meat. As they require long cooking time particularly at high altitudes, these foods as such cannot find a place in the ration packs. The shelf life is also limited in the case of vegetables and meat. Therefore, precooked dehydrated products having short reconstitution time and longer storage life have been developed. These products are used either as such after rehydration or for the development of convenience foods like *pulav* (vegetarian and non-vegetarian), *khichidi*, omelette mix, avial mix, curry mixes, *sambar* mixes, cutlet mixes (vegetarian and non-vegetarian), soup mixes, hamburger mixes, stew mixes and various types of sauces.

Novel techniques like use of enzymes, high temperature short time pneumatic drying, spray drying or foam-mat drying were used for developing these products

which reconsitute either instantly or within a short time. Conventional hot air dehydration at 60-70°C, requires considerable time to bring the moisture level of the product to 5-6%. This adversely affects the texture, flavour and reconstitution of the product. The drying time can be considerably reduced by adopting the HTST method. With this technique the products were superior in texture and flavour and had low reconstitution time and very high acceptability.

2.6. *Freeze-dried Products*

In spite of the advantages of conventionally dehydrated foods, acceptability of several items has suffered because of a few disadvantages like poorer texture, rather prolonged reconstitution time and difficulty in preparing products having particulate pieces. Freeze drying technique which had been earlier confined to expensive pharmaceutical products has been successfully utilised in freeze drying a number of products like mutton chunks, curried mutton, vegetables, fruits, *kheer*, mushroom and *pulav*. Freeze dried juice powders, particularly pineapple and mango juice powders, have a very high rate of acceptability and convenience in use.

2.7. *Intermediate Moisture Foods*

This technique aims at stabilising dried foods at intermediate moisture (IM) level (25-50%) and to keep water activity at safe levels to prevent microbial spoilage. IM foods have the advantage of having sufficient moisture to be eaten without further preparation and will also keep long without refrigeration or thermal processing. The products developed include carrot, apple, pineapple, guava and banana.

2.8. *Survival Ration*

One of the major problems for which a satisfactory solution is yet to be found is the provisioning of survival foods which would allow a person to survive for a period of 5-7 days with minimal water requirement and minimal losses of physical and mental faculty and which are suitable for use by soldiers, sailors and airmen isolated during action. A soft candy bar (fudge type) with cocoa flavour was developed taking into consideration the physiological requirements and other limiting factors under survival conditions. The soft candy bar packed in flexi pack has a satisfactory storage life under all conditions of Service use.

3. Development of Packaging Systems

The functional requirements of packaging materials used for Defence packaging applications are more stringent and demanding than those for civil market as the packages have to withstand extreme climatic conditions, hazardous storage, transportation and handling. In keeping with the general trends in advanced countries

and in view of the logistic requirements of the Armed Forces it was considered necessary to switch over to the flexible packaging system from the current practice of using rigid and costlier materials like metal cans and glass bottles. However, the flexible packagings available indigenousiy were very much limited and even those which were available were not made to any standards, suitable for food application.

Three distinct approaches were made in the field of food packaging viz., (1) evolving standards in respect of indigenously available packaging materials, (2) utilising the available packaging materials for Service rations and (3) developing new types of flexible packaging materials in collaboration with industry.

3.1 *Flexible Packaging Systems for Service Food Items*

The existing IS specifications are not comprehensive and do not cover all packaging materials. Hence the available materials were surveyed for possible use with processed foods. It has been possible to identify laminates for use with (1) pickles and other oil containing foods, (2) dehydrated foods which are highly sensitive to oxygen and moisture like freeze dried meat, (3) dehydrated items like peas, preserved *chapaties*, etc. and (4) in pack processed ready-to-eat foods. Light weight packaging systems using flexible materials and cartons have been developed for composite pack rations. By this the weight of the packaging could be reduced to 75 per cent and the cost be brought down considerably as compared to the previous systems of packaging in tin containers. A simple technique was developed to enhance the shelf life of perishables like fruits and vegetables. The method can be conveniently utilised for transporting fresh fruits and vegetables in forward areas and also on board IN ships.

Conventional jute bags used for wheat based milled products like *atta*, *maida* and *suji* do not provide adequate protection against moisture and insect ingress especially under humid tropical field conditions. A single packaging system, viz., bags made of HDPE woven fabric coated with LDPE followed by 'A' or 'B' twill jute bag was found suitable for adoption for types of rations.

Retort processing of various foodstuffs of Indian dietary was undertaken as soon as polypropylene film and its laminates were indigenously available. Because of the thermal changes occuring during processing, an overall packaging system and a modified processing technique was developed to suit this material. Items developed by this method include mutton and vegetable *biriyani*, mutton *kofta*, curry *suji halwa*, *kheer*, and baked beans in tomato sauce.

4. Storage Studies and Preservation of Foodstuffs

The food stocks for Armed Forces are stored under varied climatic conditions ranging from hod dry desert to hot humid tropical and cold high altitude and are therefore

subject to microbial and chemical deterioration resulting in lowering of quality. The factors which influence the flavour and texture of Indian foods are not available in literature. Flavour of processed foods often deteriorates long before their nutritive and other functional properties are lost and thus is one of the limiting factors in the shelf life of the processed foods. New approaches in this field include use of flavour precursors, flavour enzymes and flavour potentiators for enhancing the shelf life.

4.1. *Prevention of De-emulsification of Butter Under Service Conditions*

De-emulsification of butter is a serious problem during summer months. Laboratory and field storage studies have established that butter with 10 per cent milk solids incorporated in it, remained in good and acceptable conditions under all types of climatic conditions prevailing in India. The process can be easily adopted by any commercial manufacturer of butter. The treatment on a commercial scale had no adverse effect on the microbiological and organoleptic acceptability.

4.2. *Refined Groundnut Oil Fortified with Vitamin 'A' as a Substitute*

Hydrogenated vegetable oil has been the only source of dietary fat authorised for Service personnel but it does not meet the dietary needs of polyunsaturated fatty acids (PUFA). The feasibility of replacing oil hydro with an oil having a higher PUFA content in the diet of Service personnel was explored. Refined groundnut oil containing about 25 per cent PUFA seems to satisfy all the criteria like bland taste, odourlessness, availability in the country and popularity with a large segment of Indian population. The oil remained in good and acceptable condition for a period well over one year under different climatic conditions prevailing in India. It was found that replacement of oil hydro to the extent of 60 per cent would provide about 12-13 per cent PUFA on total fat basis in the Army diet.

4.3. *Flavour Improvement in Dehydrated Vegetables*

Flavour degradation and discolouration are the two major causes of spoilage in dehydrated fruits and vegetables. In dehydrated carrots the factor determining the shelf life of the product has been found to be the degradation of carotenoid which results in hay and violet type of odours during storage. The various volatile and non-volatile products of stored carrots have been identified and the role of lipids, antioxidants, salt and water activity on the rate of carotenoid degradation has been established. Pretreatments for carrot have been standardised to improve carotenoid retention and texture. In the case of onions, the major cause of lower acceptability is the low level of pungency in dehydrated products. Effect of temperature, varieties and additives on the allinase activity which determines the pungency have been investigated.

4.4. *Chemical and Nutritive Changes in Dry Rations*

Walnuts and almonds obtained from various trade sources and stored at different temperatures and relative humidities were analysed to find the extent of spoilage, by different physical and chemical methods. A good correlation between organoleptic quality and formation of malonaldehyde in stored dry fruits has been established. Chemical and nutritive changes occuring in other dry rations like pulses, rice and milled products have been examined.

5. Nutritional Studies

Modern military nutrition presents a number of problems. Development o special rations for situations like high altitude picquets, submarines, life rafts, patrol duty, survival during emergency conditions, etc. calls for computation of calories from protein, carbohydrate and fat and animal experimentation to assess their nutritional adequacy. Users seek the assistance of DFRL under such conditions. In addition, we had undertaken the assessment of the nutritional requirements of the Services under combat situations. Secondly, studies are under way to understand the type of dietary protein required to overcome or to acclimatize to several stress conditions like high altitude, injury, low calorie intake, etc., which are incidental to the duties performed by Defence Forces. Thirdly, the toxicological aspects of processed foods are being investigated, to assess the effect of consumption of food preservatives present in the processed foods and of the plastic packaging materials leaching into the foods packed.

5.1. *Protein Quality of Processed Foods*

Various ready-to-eat or instant foods developed for Service use are subjected to changes in protein quality either during processing or during storage. Items like precooked, dehydrated *dals*, compo pack rations, processed mutton mince, the long keeping bread, preserved and stored chapaties, etc., were fed to experimental animals to assess that no significant deterioration takes place in the nutritional quality, Partial substitution of oil hydro by refined groundnut oil to get a better supply of polyunsaturated fatty acids had been shown to be beneficial in reducing the cholesterol levels.

5.2. *Nutrition Under Stress*

Comparative evaluation of a balanced protein (egg) and not-so-well-balanced protein (*dal arhar*) in experimental albino rats exposed to simulated high altitude stress suggested that the latter proteins may be well suited for overcoming the initial stress. Similarly, during the stress of an inflicted injury in experimental rats, wound healing has been shown to be accelerated by administration of glutamic acid which is not normally considered to be an essential amino acid. Experiments are under way to

find out the ideal dietary composition of patrol ration to keep loss in body weight to the minimum and which will cause less biochemical changes in the body following such a restricted intake of food and subsequent rehabilitation on normal food.

6. Food Toxicological Studies

Though scrbic acid has been in vogue as a preservative all over the world, its use in the preservation of *chapaties* has been identified in our laboratory. The special conditions of baking a *chapati* necessitates the establishment of safety limits of consumption of the preservative, as per the directive of FAO/WHO. *Chapaties* preserved with sorbic acid and stored for 6 months were fed to rats and rabbits for a long term. Longevity, growth rate, food efficiency ratio, etc., were not altered as compared to the fresh *chaptati* diet fed control groups. Histiopathological examination also proved the safety of consumption of sorbic acid preserved *chapaties.*

Sterile potable water in flexible PVC bags forms a part of the survival pack of the Air Force. The subtle toxic effects of phthalate plasticizers, a major additive present in PVC compositions, are being investigated.

There is a requirement for a compact, light weight and flexible container to serve as man-pack for storage and transportation of potable water in field areas. Indigenously available natural rubber and Hypolan 45 (a synthetic elastomer based on chlorosulphonated polyethytene) are being explored to develop the stores as per users qualitative requirement. The toxicological aspects of some of the rubber chemicals would be investigated in conjunction with the level of migrants present in stored water.

7. Quality Control and Microbiological Standards

The preparation of safe foods of good keeping quality requires intimate knowledge of food poisoning and pathogenic organisms and their behaviour with respect to types of foods and methods of processing. Newer methods of processing techniques and the use of sophisticated packaging materials call for a detailed investigative approach to understand the behaviour of residual flora during storage for purpose of laying down standards.

Because of the poor hygienic practice prevailing in slaughter houses. animal meat gets contaminated during dressing, transportation and display. After detailed investigations, specifications and standards were worked out for ideal slaughter practice. Conditions of ageing of meat for optimum tenderisation and microbiological safety were standardised. Lack of hygiene on the part of the food handlers in food preparation was shown to be responsible for incidence of many spoilage oaganisms in general and salmonellae and coliforms in particular.

The residual flora in preserved *chapaties* and *parothas* were identified to be members of the genus *Bacillus*. All cultures were inhibited by sorbic acid at 0.15% level. The efficacy of the preservation process was related to the initial spore load.

Microbiological quality of compressed bars, canned curries, convenience mixes, stuffed parottas and omelette mix were assessed and standards laid down. Online studies were carried out in all cases to pinpoint the vulnerable stages of contamination where extra precaution has to be taken. In canned curries maintenance of uniform size of vegetable and meat pieces and the consistency were found to be critical factors.

Foodstuffs stored in ASC depots often harbour a large number of fungal spores and under certain conditions of storage some of them could grow and bring about spoilage. In addition, the mycotoxins produced by some of them are known to be potent carcinogens. Occurrence of mycotoxins as contaminants in food and their raw materials is widely known. The climate prevalent in the north-eastern region of India with an average temperature of 30°C and 83% RH is highly conducive to the growth of fungi. A study was conducted to enumerate the type of fungi present in the food commodity stored in the Service depots located in this region.

8. Training Facilities

As per the charter of duties, DFRL acts as a reference laboratory to which all problems pertaining to Defence food and nutrition are referred by the users. In this way the laboratory has been able to build up good rapport with the Services. It is the next logical step that the expertise available is shared with others in the larger interest.

With this in view DFRL has an ongoing programme of conducting refresher courses in Food Science and Technology for officers/staff of the Supplies and Transport Directorate. The trainees are exposed to the latest techniques and methodology in their respective fields which will be of use to them in their day to day work.

A separate 3 months' orientation course in the latest microbiological techniques has also been started for the staff of CFL's and other laboratories so. In addition, at the instance of the Ministry of Health a short term course for food inspectors was also held in which a large number of food inspectors from Central and State Govt. departments were exposed to the latest methods of handling food.

9. Food Study Group of the Commonwealth Defence Science Organisation

India is a member of the Food Study Group of the CDSO and participates in the triennial meeting of the Group which gives all the members an opportunity to exchange views and to keep abreast of developments in other countries in the field of Defence Food Science. India also contributes to the periodical newsletters brought out by the CDSO Secretariat.

10. Spill Over of Defence Food Research to Civilians

Although the Defence Food Research Laboratory mainly caters to the requirements of the Services, other institutions are able to draw upon the facilities and expertise available in the laboratory, The main categories of beneficiaries are members of mountaineering expeditions, rowing expeditions, motor rallies, Border Security Force and the Antarctic expeditions. Based on the qualitative and quantitative requirements, ration packs have been formulated, packing system developed and the rations prepared to suit each situation.

The laboratory also gives advice to other institutions and State and Central Govt. departments in respect of nutritional requirements, institutional catering and allied matters,

11. Interaction with Trade

The laboratory is primarily an R & D unit and as such has only limited production facilities, Hence the results of the research can be put to practical use only if there is an active cooperation between the laboratory and the trade.

In the past there had been sporadic collaboration with private trade for the production of some processed food items. With increasing tempo of work a stage has come where constant and active interaction with the trade is necessary. The knowhow for a few selected processed food items has been passed on to private entrepreneurs for exploitation in the civil market. In addition, a leading industrialist is associated as a member of the Food Research and Development Panel of the R & D Organisation.

12. Special Facilities Available at DFRL

As a premier food research establishment, DFRL has built up the latest facilities for processing of foods as well as for analysis. Some of the mention-worthy facilities are :

Amino acid analyser
HPLC and GLC
UV Spectrophotometer
IR Spectrophotometer
Freeze dryers
Lyophilisers
Ultra centrifuges
Refrigerated centrifuges
Luminometer
Spectro densitometer
Urschel Cutting machine
Coating machine
Inta Rota laminating machine
F_0 value recorder
Texturometers
Microwave oven
Oxygen analyser
Fluidised bed dryer
Liquid Scientillation Counter

13. Future Areas of Work

Development of various items of food products, evaluation of their protein quality, development of suitable packaging systems and laying down of standards have by no means reached a stage where they have met the requirements of the Services completely. Some of the problems related to the production of these special foods and the scope for their future improvement are reviewed here.

Dehydrated items developed so far do not have low reconstitution times as can be considered to be ideal for meeting the Service requirements. Most of the items developed are by traditional methods of dehydration like cross flow drying, through flow drying, spray drying, etc. Further work is necessary to standardise the methods itemwise to ensure products which retain colour and texture even after the drastic processing and which reconstitute instantly. Items requiring improvement are cereals, pulses and vegetables.

In the field of meat and meat products, there is considerable scope to improve the characteristic of the freeze dried meat. Also, there is a necessity to devise quicker methods to monitor the microbiological quality of fresh mutton.

Canning is a relatively well established process and a large number of canned foods are available commercially. However, in India, tin has to be imported which limits its free use in canning. R & D effort is underway to find a suitable substitute for tin plate such as aluminium, tinless steel plate or thermostabilised plastics for the fabrication of containers.

Thermostabilisation of foods like stuffed *parotas*, *suji halwa* (semoline pudding), *rajma* (beans) in sauce, mutton *biriyani*, mutton curry and pumpkin *halwa* in flexi packs has been achieved. This process can be extended to almost any item capable of being canned. The drawback at the moment. however, is that the packaging material for this purpose indigenously available is not the most suitable one. High priority is being accorded to utilise indigenously available materials. Development of suitable materials for shrink packaging of common items of Indian dietary and techniques for such packaging are also required to be developed.

The HTST method for food dehydration and aseptic packaging can be utilised to develop processed products of superior quality. The aseptic process offers the only method to produce large size packs suitable for institutional or group feeding, though in India the method has not yet been exploited.

Problems in the field of food engineering relate mainly to the development of processing equipment for items developed on laboratory scale. By and large this involves adaptation of unit operations already available. Most of the food processing equipment are already available indigenously or are within the capacity of indigenous engineering industry. However, efforts are necessary to develop indigenous equipment for spray drying, drum drying, vacuum drying and if possible accelerated

freeze drying. Equipment is also required for continuous frying, vacuum frying, explosive puffing and compressed foods.

The special foods required by the Armed Forces of India, the present status of development of the various items and problems yet to be solved in this field have been briefly reviewed. Obviously some of these problems are beyond the capacity of one single establishment and call for collaborative endeavours with other research institutions. The R & D endeavours made in the development of foods for the Services will be fruitful only if the item developed is capable of indigenous manufacture. It is therefore necessary that industry is invited to associate itself with the R & D work at an appropriate stage so that successful production of the items developed can be achieved easily.

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"The quest for food has probably been the most potent of all forces in making people work and in encouraging inventions. Next, agriculture, which is the main method of obtaining food, has been of paramount importance in the early development and growth of the civilized mode of life. Diet, through its effect on health and vigor is one of the main factors in determining human efficiency and thus has a great effect upon a national character and national progress. This proposition finds general acceptance but the part played by diet in determining national character is not sufficiently emphasized".

Huntington