Def Sci J, Vol 34, No 2, April 1984, pp 161-172

Development of Instant Foods and Emergency-Survival Rations for Service Use

K. S. JAYARAMAN
Defence Food Research Laboratory, Mysore-570011

Received 4 January 1984

Abstract. A variety of instant and ready-to-eat foods and emergency/survival rations were developed for use by the Services meeting logistic requirements. Items developed include quick-cooking dehydrated pulses and vegetables, curry mixes like the Avial mix and omelette mix, instant fruit flavoured milk and *lassi* beverage powders, soup cubes, fruit bars and intermediate moisture fruits and vegetables which could be used as such or as components of pack rations. Various types of compressed ready-to-eat bars were developed for use as combat rations by the Army and a soft, flavoured fudge bar as survival ration for the Navy. The various products remained acceptable for 6-12 months under ambient conditions when packed in flexible laminate pouches and were found acceptable in large scale user trials by the Services and several mountaineering and Antarctica expeditions.

1. Introduction

The Armed Forces in India have to fight under varied environmental conditions ranging from the hot-humid arid zones and hot-dry deserts to high altitudes and sub-zero temperatures and their successful functioning depends to a great extent on the food supplied to keep up the morale and operational efficiency of the troops. Diverse feeding situations, each with a specific operational requirement, are imposed by the modern land, sea and air operations demanding great logistic flexibility.

The food requirements of Defence services are therefore different from those of civil both as regards the types of foods supplied and their packaging. It must have reduced weight, be compact and convenient to carry on person without prejudice to other essential arms and ammunition, be ready-to-eat or require minimum of preparation under operational conditions and be nutritionally adequate to sustain the troops during heavy stresses of prolonged activity. Besides having variety, acceptability and familiarity, it should have stability to withstand varied climatic conditions and transportation hazards and have indigenous manufacturing feasibility. To meet these requirements, a number of instant and ready-to-eat foods and emergency/survival rations were developed at the Defence Food Research Laboratory (DFRL), Mysore, some of which are highlighted in this paper.

2. Instant Dehydrated Foods

Due to the several logistic advantages associated with dehydrated foods, dehydration of foods for defence needs still continues to be of strategic importance over other methods of food preservation. However, removal of water to low levels (below 5% to ensure microbiological stability), especially from piece form foods by the simple and most economical hot air drying techniques brings about irreversible textural changes mainly due to shrinkage and diffusion of solutes accompanying the slow drying processes and thereby yields products which do not rehydrate quickly into structures resembling the freshly cooked materials but remain tough and hard. There has been, therefore, a constant and continuing search for simple, economical processes which will minimise texture damage to hot air dried foods and yield products which will reconstitute almost instantly in water.

Several special techniques have been tried earlier by other workers to produce various quick-cooking dehydrated foods. Thus in the case of pulses and beans subjecting the cooked grains to the action of proteolytic enzyme, papain, was used by Bhatia, et al[1] to produce quick cooking dehydrated products. As regards air dried piece form vegetables, attempts made earlier to minimise shrinkage and improve rehydration characteristics include pretreatments with additives like glycerol prior to drying[2] and flashing techniques such as explosive puffing[3], vacuum puffing[4] and centrifugal fluidized bed drying[5] the latter involving high capital investment.

The technique of high temperature short time (HTST) pneumatic drying was applied to a variety of pulses[6], beans[7] and vegetables[7,8] to bring about porosity in the products thereby reducing their drying and rehydration times considerably with significant improvements in their texture and rehydration characteristics. This was achieved by exposing the cooked pulses (whole grams and *dals*) and blanched vegetable pieces (dice or strips) initially to air at a high temperature (160-200°C) for a short period (4—8 min) in a HTST pneumatic drier followed by conventional method of drying at 60-70°C in a tray or fluidised bed drier.

Optimum temperature and time for HTST drying were worked out for various foods to achieve the desired porosity without causing any heat damage (Table 1). This preliminary HTST drying caused significant reduction in the initial moisture content thereby cutting down the constant rate drying period considerably. The sudden flashing of water vapour from the food pieces resulted in an expanded structure as evidenced by the significantly lower bulk density thus further reducing the time for finish drying. Considerable reduction in the total drying time was achieved and the products had superior rehydration characteristics as judged by rehydration time, ratio, coefficient and curve (Table 2). They reconstituted in boiling water in

Table 1. Moisture content at various stages of processing and optimum temperature-time for HTST drying of pulses and vegetables.

Material	Moisture content (%)					Optimum for HTST drying	
	Raw	Soaked	Cooked/ blanched	HTST dried	Final dried	Temp. (°C)	Time (min
Red gram *dal*	6.5	54.2	53.4	20.9	4.9	180	4
Black gram *dal*	7.0	54.5	56.0	16.9	4.5	170	6
Bengal gram *dal*	7.1	52.3	52.8	21.7	4.6	200	4
Cow pea	12.3	62.6	55.8	17.4	4.6	190	6
Dry peas	11.5	56.9	59.2	14.8	4.8	200	4
Kabuli gram	11.0	44.6	54.4	33.0	4.9	200	4
Potato	82.2	—	83.3	59.3	4.1	170	8
Green peas	71.1	—	72.5	38.3	3.4	160	8
Carrot	89.3	—	91.0	52.9	4.2	170	8
Yam	76.6	—	78.3	50.2	3.9	180	8
Sweet potato	73.6	—	78.6	53.8	5.2	170	8
Colocasia	80.2	—	83.3	54.2	4.9	170	8
Raw plantain	80.8	—	83.3	58.8	4.6	170	8

Table 2. Drying time, bulk density and rehydrations characteristics of HTST dried pulses and vegetables as compared to direct tray dried products.

Material	Total drying time (min)	Bulk density (g/cc)	Reconstitution time (min)	Rehydration ratio	Coefficient of rehydration
Red gram *dal*	90 (180)	0.67 (0.71)	5 (10)	2.9 (2.2)	0.99 (0.70)
Black gram *dal*	75 (210)	0.59 (0.81)	5 (10)	3.5 (2.9)	1.00 (0.74)
Bengal gram *dal*	135 (240)	0.69 (0.96)	7 (13)	2.5 (2.3)	1.07 (0.95)
Cow pea	90 (150)	0.52 (0.71)	8 (15)	2.7 (2.2)	1.00 (0.82)
Dry peas	120 (240)	0.57 (0.69)	10 (12)	2.7 (2.1)	1.00 (0.79)
Kabuli gram	270 (330)	0.59 (0.86)	30 (60)	2.7 (2.3)	1.02 (0.86)
Potato	210 (330)	0.25 (0.62)	5 (12)	5.0 (2.7)	0.94 (0.51)
Green peas	150 (300)	0.38 (0.51)	5 (12)	3.5 (2.8)	1.06 (0.85)
Carrot	195 (300)	0.24 (0.44)	5 (12)	4.4 (3.8)	0.50 (0.43)
Yam	180 (360)	0.29 (0.50)	6 (12)	4.1 (2.4)	1.01 (0.59)
Sweet potato	180 (300)	0.45 (0.69)	2 (6)	3.8 (2.1)	1.06 (0.58)
Colocasia	180 (300)	0.26 (0.55)	2 (10)	4.7 (2.3)	0.98 (0.48)
Raw plantain	180 (300)	0.33 (0.50)	4 (12)	4.8 (3.5)	0.97 (0.71)

Figures in parenthesis represent those for the corresponding controls (direct tray dried without HTST treatment).

almost half the time as required for the controls. The HTST treatment did not adversely affect the shelf stability of the products which remained acceptable for more than one year under ambient conditions when packed in paper-aluminium foil-polythene laminate pouches.

The technique involves simple equipment and less capital investment as compared to other methods of drying such as explosive puffing achieving the same objective. It is amenable to continuous processing as the time of high temperature drying is short. In the case of vegetables, a starchy cell structure was essential for satisfactory expansion by the technique. Used as a pre-drying treatment, it also enables use of solar drying for finish drying to reduce drying costs yielding products with quality attributes comparable to artificially dried products[9].

In the case of vegetables like cauliflower and cabbage which were not amenable to the HTST drying technique, significant improvement in the colour, texture and other rehydration characteristics as well as shelf stability could be achieved by incorporation of salt and sugar at low levels by soak—infusion prior to conventional hot air drying which markedly reduced shrinkage during drying[10,11].

Dehydrated vegetables processed by the above instantising techniques were used along with other ingredients namely, curd powder, coconut powder and spices in the formulation of quick cooking convenient curry mixes like the Avial mix[12,13] (Table 3). An instant omelette mix was also developed using spray dried egg powder, dehydrated onions and green chillies and spices[14]. These products were found to remain acceptable upto 12 months under ambient conditions, when packed in paper-aluminium foil-polythene laminate pouches. They were found acceptable in user trials and introduced as part of submarine rations, besides having scope for the civil market. They have been used in the three Indian Antarctica Expeditions and also by several mountaineering expeditions. The process for manufacture of these mixes has been released to private entrepreneurs with a view to popularise them in the civil market and at the same time ensure their availability to the Services as and when needed.

Instant fruit flavoured milk and *lassi* beverage powders[15] and soup cubes[16] with a shelf life of more than six months have also been developed using the spray drying technique for use in operational rations (Table 3). Juices obtained from banana, mango and guava pulps after clarification using pectic enzyme and those from pineapple and orange were spray dried in admixture with preconcentrated milk or *lassi* prepared therefrom and formulated into instant beverage mixes which reconstitute instantly in cold water[15]. Similarly chicken and tomato pulp in admixture with skim milk were spray dried and used to formulate instant tomato and chicken soup cubes which reconstitute instantly in hot water for use in emergency rations[16]. Methods were also standardised for the preparation of fruit slabs from various fruits for use in combat rations in place of tinned fruits[17].

Table 3. Proximate composition (g/100g) of some ready-to-eat and instant dehydrated foods developed for Service use

Product	Moisture	Protein	Fat	Carbo-hydrate	Crude fibre	Ash	Calories per 100g
Avial mix	4.0	11.9	24.0	47.3	3.2	9.6	452
Omelette mix	1.9	36.0	38.7	13.7	1.5	8.2	547
Fruited-milk beverage mix							
Mango	3.3	11.3	9.2	74.0	—	2.2	424
Banana	2.1	10.5	8.9	75.3	—	3.2	423
Guava	2.0	10.2	9.1	75.6	—	3.1	425
Orange	1.8	9.2	10.7	74.4	—	3.9	431
Fruited-*lassi* beverage mix							
Mango	1.5	15.2	13.4	67.5	—	2.4	451
Banana	2.9	14.2	13.8	66.0	—	3.1	445
Guava	2.3	16.2	15.2	63.5	—	2.8	456
Orange	2.3	13.1	14.5	67.4	—	2.7	452
Pineapple	2.0	9.4	10.0	76.7	—	1.9	434
Instant soup cube							
Chicken	3.0	64.0	16.8	4.0	Nil	12.2	423
Tomato	3.9	18.5	10.0	54.3	1.6	11.7	381
Fruit bar							
Mango	13.4	2.7	0.1	80.4	1.7	1.7	333
Banana	9.3	3.4	0.1	81.6	2.4	3.2	341
Jamun	13.1	2.1	0.9	80.7	1.7	1.5	339
Compressed cereal bar							
Savoury veg.	4.1	5.9	24.4	61.1	1.9	2.6	488
Non-veg.	4.7	12.9	23.2	54.7	1.7	2.8	479
Sweet (cardamom)	3.3	4.8	25.3	64.7	1.0	0.9	506
Banana-rice	2.1	9.3	14.5	71.5	0.8	1.8	453
Curd-rice	2.5	9.9	25.0	59.0	0.9	2.7	500
Survival ration							
Soft bar	5.0	1.0	1.1	91.2	0.4	1.3	379

3. Intermediate Moisture Foods

In contrast to low moisture dehydrated foods requiring rehydration, a new class of foods called intermediate moisture foods (IMF) have emerged in recent times which need no preparation prior to consumption. They are characterized by a water activity low enough to prevent the growth of bacteria and by conditions minimising the potential for growth of other organisms. They have received new attention since the development of products based on the technological principles, namely, lowering of water activity by addition of an osmotically active solute such as glycerol, sucrose, glucose or salt and prevention of microbial growth by addition of antimicrobial, primarily antimycotic, agents such as propylene glycol and/or sorbic acid. The principal method used so far has been to combine glycerol with other food constituents to give products with 10 to 50% glycerol content. Such products were made unacceptable by the bitter sweet taste of glycerol objectionable in products like meat and vegetables. Alternate approaches to IMF production are therefore necessary.

In an effort to apply this technology to develop instant products for our service use, a variety of IM fruits namely, guava[18], pineapple[19], mango[20], banana[21] and apple[22] were prepared by the soak-infusion technique using solutions containing glycerol and sugar or sugar alone with potassium sorbate as preservative (Table 4). These products had excellent texture approaching fresh and could be eaten directly as compared to low moisture dehydrated fruits which needed prolonged rehydration and were poor in texture. When packed in flexible laminate pouches they are much lighter than fruits canned in syrup. Replacement of glycerol totally with the much cheaper sucrose has been found feasible to yield IM products. The process, in contrast to the well known osmotic dehydration using sugar syrup, eliminates the

Table 4. Composition and other characteristics of some intermediate moisture fruit and vegetable slices

Parameter	Guava	Pineapple	Mango	Banana	Apple	Carrot
Moisture (%)	36.0	34.8	34.8	30.2	33.6	49.0
Ether extractives (%)	0.1	0.3	0.7	0.8	0.1	0.6
Protein (N×6.25) (%)	0.3	0.7	0.8	1.3	0.3	1.4
Crude fibre (%)	8.5	1.2	1.8	0.1	0.8	2.6
Ash (%)	0.6	0.8	0.4	0.5	0.8	10.6
Carbohydrates (%)						
Reducing sugars (as dextrose)	—	1.9	2.4	4.8	3.8	3.3
Total sugars (as dextrose)	16.9	25.3	29.6	29.2	29.3	18.4
Glycerol	37.2	36.2	31.5	37.5	35.9	7.1
Others (by diff.)	—	—	—	—	—	10.3
Sodium chloride	—	—	—	—	—	8.8
pH	4.4	4.2	4.5	4.9	5.0	6.2
Acidity (as anhyd. citric acid, %)	0.18	0.45	0.23	0.18	0.1	—
SO_2 (ppm)	224	260	246	301	215	906
Pot. sorbate (%)	0.2	0.2	0.2	0.19	0.21	0.15
B-carotene (mg/100g)	—	—	8.5	—	—	23.0
Ascorbic acid (mg/100g)	106.2	6.2	16.6	5.2	—	—
ERH (%)	75.0	79.0	78.0	80.0	79.5	84.5
Yield (%)						
Raw wt. basis	30.0	40.0	35.0	40.0	50.0	25.0
Prepd. wt. basis	50.0	80.0	60.0	70.0	60.0	30.0

prolonged hot air or vacuum dehydration step and results in ready-to-eat products with a texture and flavour approaching the fresh.

The original method involving soak-infusion using solutions containing glycerol and salt or sugar gave products in which palatability was adversely affected with respect to vegetables. An alternate method of retaining microbial stability with reduced levels of additives was achieved by using soak-infusion to infuse additives into the blanched vegetable slices followed by partial hot air dehydration to remove major portion of the moisture to yield an IM product. The levels of additives used were sufficient to stabilise the product at the IM level while at the same time reaching a tolerable level on reconstitution. Since vegetables are generally preferred after cooking in water, such rehydration for a short period poses no serious logistic disadvantage. There is further the economic and logistic advantage due to marked reduction in weight and volume obtained through partial drying. This methodology was successfully applied to certain vegetables like carrot[23,24] which suffer serious textural damage in conventional hot air dehydration to low moisture.

4. Emergency and Survival Rations

The subject of combat/survival rations for troops has received much attention in recent times as it has become necessary to know how to keep a man surviving with the minimum amount of food including water for maximum periods with minimum impairment of his physical and mental faculties. Survival situations involve certain indeterminate factors like terrain, environment, availability of water, etc.

4.1. *Emergency Ration for the Army*

During combat/emergency as in case of short and long range patrols, commando raids and operations behind enemy lines the need is for compact, light weight, ready-to-eat concentrated foods of high caloric content which can sustain the troops for short periods till resupply is established. There is no specific combat ration meeting the above requirements under use at present by our Army. The five men compo pack ration which has been under use for some time as patrol ration does not meet the logistic requirement due to its bulk, weight and need for reconstitution/preparation of many items prior to consumption.

For use as combat rations the most suitable type of foods are, therefore, the ready-to-eat dehydrated compressed food formulations which have certain inherent advantages. Compacting dehydrated foods gives extended shelf life as the amount of oxygen throughout the pack is considerably reduced. It also gives reduction in bulk and consequently economy in transportation, storage space and packaging material. Being dehydrated with a moisture content below 5%, they are also resistant to microbial attack.

Compressed food formulations developed in other countries consist of conventionally dried or freeze dried meat, vegetables and fruits. Such products suffer from the disadvantages of weak flavour, hard texture and poor binding quality and need rehydration for prolonged periods prior to consumption. These drawbacks were eliminated by using deep fat fried ingredients in the formulations. Compressed ready-to-eat bars developed include varieties such as the vegetarian and non-vegetarian savoury bars and cardamom flavoured sweet bars[25,26,27], porridge bar[27], fruited-cereal bars[27,28,29] and curd-rice bar[27,29,30]. Cereals, pulses, vegetables, fruits, skim milk, curd and meat processed and dehydrated by simple drying techniques such as hot air drying, deep fat frying, osmotic drying, foam-mat drying and spray drying were used in the development of these formulations. They were compressed into tablets of 100 g each and heat sealed first in an inner wrap of MST cellophane and then in an outer pouch of paper-aluminium foil-polythene laminate to prevent relaxation after compression. The bulk density could be increased from 0.24 to 1.1 g/cc for rice based and from 0.55 to 1.18 g/cc for wheat based bars. The various types of bars packed as above retained their acceptability for more than 12 months under ambient and field conditions and were nutritionally adequate yielding on an average 450 to 500 calories per 100 g. Large scale troop trials were conducted on a few selected types of the ready-to-eat bars in units located under varied climatic conditions and terrain in all the five commands of the Indian Army with a view to assess their acceptability and operational suitability as emergency/patrol rations[29,31] The bars were evaluated both alone and in combination with tinned *parothas* and pickles on 15-20 men for 10 days while performing their normal routine daily exercises and patrol duties vis-a-vis normal lungar ration. The trials revealed that cardamom flavoured sweet bars were liked best followed by vegetarian savoury and banana rice. While a ration comprising solely of bars was suitable for a period of 3-4 days, bars in combination with tinned *parothas* were found suitable for 7-10 days and were more popular with the troops. They were found light in weight and easy to carry as compared to existing patrol rations (5 men compo pack) and were therefore preferred over the latter. No abnormal increase in water consumption nor any adverse effect on health was noticed as a result of consuming the bars. The marching capability and general performance of the troops remained unaffected as also their overall alertness and morale.

Extensive trials carried out with the savoury and sweet bars with many Mountaineering Expeditions and with the porridge bar as part of rations for submarine crew[32,33] have also confirmed their acceptability and logistic advantage.

4.2. *Survival Ration for the Navy*

Any survival/emergency ration meant for use by castaways at sea should be such as to spare body water to the maximum as the principal requirement under such situations is for water which has to be supplied along with the ration and cannot be supplemented by sea water[34]. Castaways are usually rescued within 14 days and no healthy man will die of starvation within this short period, nor will he suffer any permanent adverse effect but he can readily die of lack of water or from exposure.

Food is only to prevent the physical deterioration consequent upon total fasting and to sustain the morale of the survivor.

Survival performances have been shown to be better on a low-fat and low-protein ration[35]. Deprivation of protein during the short period will cause no harm nor will a similar temporary restriction of the intake of minerals and vitamins. Increased protein intake increases demand for water owing to the need for excretion of nitrogenous end products (urea) through urine. Similarly increased fat intake leads to ketosis and considerable loss of body water. Although some workers have advocated inclusion of some fat upto a maximum of 21% in survival rations to increase its caloric density, it is not considered desirable based on the data available so far. Although fat has the advantage over carbohydrate that it provides over twice the amount of energy (calories) per unit weight thereby reducing bulk, dietary carbohydrate is more effective than fat in sparing endogenous nitrogen metabolism and so will reduce the loss of body protein and also the urine volume. Carbohydrate also prevents ketosis that arises when excess of fat is metabolised. Inclusion of carbohydrate even at the expense of a corresponding reduction in the weight of water ration has therefore been advocated.

Experimental studies have shown that any ration supplying more than 5% protein and 5% fat upsets water economy[36]. Most countries therefore favour an all-carbohydrate survival ration as only such a ration is very near the ideal. Thus the British Admiralty have accepted boiled sweets and water as their survival rations. While the Indian Army has no specific survival ration, the emergency/survial ration presently used by the Navy consists of 3 oz boiled sweets and 2 oz milk toffees providing about 550-600 calories/man/day. The Air Force survival ration comprises of two tins each of 5 oz milk toffees providing a total of 1350 calories facilitating survival of an individual for 48 hrs. Both boiled sweets and milk toffees have, however, been reported unsuitable as survival ration because the former causes severe mouth sores, swelling and ulceration after continued consumption especially under restricted water supply while the latter has poor shelf life necessitating frequent turn over besides being physiologically unsuitable due to its higher protein and fat content increasing demand for water.

A trial was carried out by the Defence Science Organisation in collaboration with the Indian Navy during 1959 to assess the operational suitability of different types of rations for survivors at sea for 5 days[36]. Rations supplying 500 ml water and 700 calories of food containing not more than 5% each of protein and fat per man per day were found quite adequate for survival at sea in the tropics.

Keeping in view the above nutritional and physiological considerations and the fact that the present survival ration used by the Navy comprising boiled sweets was not entirely suitable, a survival ration was developed in the form of a soft fudge type cocoa flavoured confection containing less than 1% each of protein and fat and comprising mainly of carbohydrate with a caloric density of about 4 calories/g and shelf life of more than 3 years when packed in paper-foil-polythene pouches[25,37,38].

In collaboration with the Indian Navy two trials were conducted during 1977[39] and 1981[40] on the comparative suitability of soft bar and boiled sweets and milk toffees as survival ration under near survival conditions using Naval personnel as subjects. The trials proved the soft bar to be superior in both organoleptic acceptability and physiological performance to boiled sweets and milk toffees.

5. Future Developments

Major changes in the type and quality of instant convenience foods meeting Defence requirements are likely to be brought about as a consequence of newer developments in food processing techniques in the coming decade. Some important areas which are likely to show their impact are : (i) membrane concentration processes like reverse osmosis—a low-energy, no-waste process useful for concentration of heat sensitive liquid foods at ambient temperatures; (ii) immobilized enzyme technology—development of efficient techniques for immobilization of several enzymes has minimised the economic problem of recovery and reuse of enzymes and provided a method for stabilising them thus paving the way for finding new enzymes suitable for several food processing applications; (iii) extrusion cooking process which is rapidly evolving into a versatile, compact, highly space and energy efficient technique capable of producing an unlimited range of products and as such offers vast scope for making several convenience foods, especially fabricated foods, for service use; (iv) aseptic processing and retort pouch—recent efforts focussed on aseptic processing and filling techniques and on composite cardboard and plastic aseptic containers, besides developments in retort pouch foods, will make it feasible to supply a wider range of conventional foods with major savings in energy, packaging and transportation costs and (v) microwave processing—although savings in energy and reduction in processing time have led to the use of microwave heating in several food processing operations, its industrial applications are presently hampered by problems encountered in development of continuous processing units and high cost of equipment.

6. Summary

The food requirements of Defence Services are different from those of civil both as regards the type of foods supplied and their packaging. Diverse feeding situations each with a specific operational requirement are imposed by the modern land, sea and air operations demanding great logistic flexibility in the rations supplied. A variety of instant and ready-to-eat foods and emergency/survival rations were developed to meet these requirements. These include quick-cooking dehydrated pulses and vegetables treated by the high temperature short time pneumatic drying technique and those dried by the conventional drying technique after pretreatment with salt and sugar, convenience mixes like the Avial mix and omelette mix, instant fruit flavoured milk and *lassi* beverage powders, soup cubes, fruit bars and intermediate moisture fruits and vegetables which could be used as such or as components of pack rations. A variety of compressed ready-to-eat food formulations were developed for use as combat ration by the Army and a soft fudge type cocoa flavoured bar as survival ration for the Navy which have been found acceptable in large scale user trials. The various products were found to retain their acceptability for 6-12 months in flexible laminate pouches under ambient conditions.

References

1. Bhatia, B. S., Ramanathan, L. A., Prasad, M. S. & Vijayaraghavan, P. K., *Fd. Technol., Champaigne*, **21** (1967), 105.
2. Neumann, H. J., *J. Fd. Sci.*, **37** (1972), 437.
3. Cording, J. Jr., Eskew, R. K., Sullivan, J. F. & Eisenhardt, W. A., *Fd. Eng.*, **35** (1963), 52.
4. Eapen, K. E. & Ramanathan, P. K., *Fd. Technol.*, **20** (1960), 543.
5. Brown, G. E., Farkas, D. F. & De Marchena, E. S., *Fd. Technol.*, **26** (1972), 23.
6. Jayaraman, K. S., Gopinathan, V. K. & Ramanathan, L.A., *J. Fd. Technol.*, **15** (1980), 217.
7. Jayaraman, K. S., Gopinathan, V. K., Pitchamuthu, P. & Vijayaraghavan, P. K., 'Preparation of quick-cooking dehydrated vegetables and grams by high temperature short time drying', Paper presented at the Second Indian Convention of Food Scientists and Technologists (AFST, Mysore), Feb. 1981, Abstracts of papers, p. 69,
8. Jayaraman, K. S., Gopinathan, V. K., Pitchamuthu, P. & Vijayraghavan, P. K., *J. Fd. Technol.*, **17** (1982), 669.
9. Jayaraman, K. S., Gopinathan, V. K., Mohan Kumar, B. L. & Vijayaraghavan, P. K., 'Use of solar drying in the preparation of quick-cooking dehydrated pulses and vegetables', Paper presented at the First AFST (I) International Conference on Food Science and Technology, Ahara 82 (AFST, Bangalore), May 1982, Abstracts of technical papers, p. 6.5.
10. Das Gupta, D. K., Babu Rao, N., Jayaraman, K. S. & Vijayaraghavan, P. K., 'Studies on improvements in rehydration characteristics and storage stability of air dried cauliflower using additives', Paper presented at the First AFST (1) International Conference on Food Science and Technology, Ahara 82 (AFST, Bangalore), May 1982, Abstracts of technical papers, p. 3.5.
11. Das Gupta, D. K., Babu Rao, N. & Jayaraman, K. S., 'Improvements in rehydration characteristics and storage stability of sun dried and hot-air dried cabbage using additives', Paper presented at the Third Indian 'Convention of Food Scientists and Technologists (AFST, Mysore), June 1983, Abstracts of papers, p. 71.
12. Jayaraman, K. S., Gopinathan, V. K., Pitchamuthu, P. & Vijayaraghavan, P. K., 'Development of some quick-cooking and instant dehydrated convenience foods for the Defence Forces', Paper presented at the seminar on 'Convenience foods—opportunities and challenges' (AFST, Bombay) Dec. 1980, Abstracts of papers.
13. Jayaraman, K. S., Gopinathan, V. K., Babu Rao, N. & Das Gupta, D. K., 'Preparation and storage stability of a dehydrated vegetable curry mix (*Avial*) containing curd and coconut', Paper presented at the Third Indian Convention of Food Scientists and Technologists (AFST, Mysore), June 1983, Abstracts of papers, p. 73.
14. Jayaraman, K. S., Ramanathan, L.A., Pitchamuthu, P. & Bhatia, B.S., *J. Fd. Sci. Technol.*, **13** (1976), 325.
15. Jayaraman, K. S., Das Gupta, D. K., Goverdhanan, T & Vijayaraghavan, P. K., 'Preparation and storage stability of some fruit flavoured milk and *lassi* beverage powders', Paper presented at the Seminar on 'Convenience foods—opportunities and challenges' (AFST, Bombay), Dec. 1980, Abstracts of papers.
16. Jayaraman, K. S., Goverdhanan, T., Bhatia, B. S. & Nath, H., *J. Fd. Sci. Technol.*, **13** (1976), 29.

17. Mathur, V. K., Anthony Das, S., Jayaraman, K. S. & Bhatia, B. S., *Indian Fd. Packer*, **26** (1972), 33.
18. Jayaraman, K. S., Ramanuja, M. N., Bhatia, B. S. & Nath, H., *J. Fd. Sci. Technol.*, **11** (1974), 162.
19. Jayaraman, K. S., Ramanuja, M. N., Venugopal, M. K., Leela, R. K. & Bhatia, B. S., *J. Fd. Sci. Technol.*, **12** (1975), 309.
20. Jayaraman, K. S., Ramanuja, M. N., Goverdhanan, T., Bhatia, B. S. & Nath, H., *Indian Fd. Packer*, **30** (1976), 76.
21. Ramanuja, M. N. & Jayaraman, K. S., *J. Fd. Sci. Technol.*, **17** (1980), 183.
22. Ramanuja, M. N., Jayaraman, K. S. & Vijayaraghavan, P. K., 'Preparation and storage stability of intermediate moisture apple slices', Paper presented at the First AFST (I) International Conference on Food Science and Technology, Ahara, 82 (AFST, Bangalore), May 1982, Abstracts of technical papers, p. 7.11.
23. Jayaraman, K. S., Das Gupta, D. K., Ramanuja, M. N., Sharma, T. R. & Vijayaraghavan, P. K., 'Studies on the development of some intermediate moisture fruits and vegetables', Proceedings of papers presented at the Commonwealth Defence Science Organisation, Food Study Group Meeting, Canada, June 1978.
24. Jayaraman, K. S. & Das Gupta, D. K., *J. Fd. Sci.*, **43** (1978), 1880.
25. Bhatia, B. S., Jayaraman, K. S. & Vijayaraghavan, P. K., 'Development of some ready-to-eat and instant foods for use in combat rations'. Proceedings of papers presented at the CDSO Food Study Group Meeting, Australia, April 1969, Paper No. FSG/P (69) 4, p. 22.
26. Jayaraman, K. S., Anthony Das, S., Ramanathan, L. A. & Bhatia, B. S., *J. Fd. Sci. Technol.*, **7** (1970), 200.
27. Compressed meat and vegetable bars—ready-to-eat type, Project report No. DFRL/36/72, Jan. 1972.
28. Jayaraman, K. S., Goverdhanan, T., Sankaran, R., Bhatia, B. S. & Nath, H., *J. Fd. Sci. Technol.*, **11** (1974), 181.
29. Jayaraman, K. S. & Bhatia, B. S., 'Development of some ready-to-eat food formulations for use in combat rations', Proceedings of papers presented at the CDSO Food Study Group Meeting, Mysore, Dec. 1975, Paper No. FSG/75/S-1/6.
30. Jayaraman, K. S., Goverdhanan, T., Anthony Das, S., Mathur, V. K., Bhatia, B. S. & Nath, H., *Indian Fd. Packer*, **28** (1974), 42.
31. Compressed meat and vegetable bars – Ready-to-eat type, Project report No. DFRL/55/76, Aug. 1976.
32. Ration for submarine crew, Report No. DFRL/38/72.
33. Jayaraman, K. S., Bhatia, B. S. & Nath, H., 'Food systems for the submarine'. Proceedings of papers presented at the CDSO Food Study Group Meeting, U.K., March 1973.
34. Jayaraman, K. S., Bhatia, B. S. & Vijayaraghavan, P. K., *J. Fd. Sci. Technol.*, **1** (1964), 72.
35. Nath, H. P., *Def. Sci. J.*, **8** (1959), 258.
36. Malhotra, M. S., Rai, R. M., Sharma, G. D. & Nath, H. P., Defence Science Organisation Report No. 7/59 (1959).
37. Development of survival ration for the Navy, Project report No. DFRL/28/68, Aug. 1968.
38. A ration for human survival on land and sea, Indian Patent No. 102120.
39. Comparative suitability of soft bar and boiled sweets as survival ration for Navy—user trials, Report No. DFRL/60/77, Aug. 1977.
40. Comparative suitability of soft bar and boiled sweets as survival ration for Navy—user trials, Report No. DFRL/65/82, Oct. 1982.

The discovery of a new dish does more for the happiness of mankind than the discovery of a star.