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Traditional Indian Foods—Some Recent Developments

S. S. ARYA
Defence Food Research Laboratory, Mysore-570011

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Abstract. Considerable progress has been made in the preservation of traditional Indian foods in ready-to-eat form and products like *chapaties*, stuffed *parothas*, *halwa*, *upma*, *kheer*, *idli*, *avial*, *pullav*, precooked dehydrated *dhals*, precooked dehydrated instantised *pullav* and *alu-chholay* have been preserved for periods ranging from 6 months to one year under ambient conditions either by thermal processing in cans and flexible retortable pouches or by the use of preservatives and dehydration. Processes have also been developed for freeze drying of tropical Indian fruits like mango and pineapple in the form of fruit juice powders. Preserved products have been utilized extensively during mountaineering expeditions, Antarctica expeditions and feeding of cosmonauts in space programmes. Some of the critical parameters in the process development and their role in the sensory quality of preserved foods have been highlighted.

1. Introduction

Armed Forces have to subsist mainly on pack rations containing ready-to-eat foods during combat operations. Apart from ready-to-eat nature, long shelf life, easy commercial availability and nutritional adequacy, their suitability to troops' palate and dietary habits have to be taken into consideration in designing these pack rations. Prior to independence most of the pack rations for allied forces were designed to suit western palate. Troops of Indian origin had to subsist mainly on puffed rice or bengalgram and jaggery. After independence, attempts were made to design pack rations based on beaten rice, canned rice and canned curried vegetables and *dhals*. But these pack rations, besides being too heavy and bulky, were not liked by troops because of monotony and poor organoleptic quality of the products. Major hindrance in the design of these pack rations had been the non-availability of popular Indian foods preserved in ready-to-eat form. With the establishment of Defence Food Research Laboratory, Mysore in 1961, considerable attention was directed to develop suitable technology for preserving the traditional Indian foods in light weight flexible packages so that the pack rations could be designed to meet the nutrient requirements of troops under combat situations and also to suit their taste. This paper reviews the progress made in the development of ready-to-eat traditional Indian foods in our country and the problems encountered to attain these objectives. Emphasis has been laid on the relative merits and demerits of various preservation techniques like use of antimicrobial compounds, thermal processing in cans, plastic films and their laminates and the use of ionizing radiations, that have been tried in the preservation of *chapaties*, *parothas*, stuffed *parothas*, *idlis*, *halwa*, rice and *pulav* and certain vegetable curries (Table 1) in ready-to-eat form and the physico-chemical and sensory changes that take place during processing and storage of these products and which influence the acceptability of the stored products.

2. Chapaties

2.1. *Preservation*

More than 80% of the wheat produced in our country is consumed in the form of *chapaties*. When preserved in ready-to-eat form, *chapaties* can be consumed as such along with pickles etc. and, therefore, these are ideally suited for combat rations.

Moisture content in freshly baked *chapaties* varies from 25–35% and the product equilibrates to 88–92% RH. The pH of *chapaties* varies from 5.8 to 6.0 and spoilage is mostly brought about by growth of moulds, moisture loss and development of stale odour and hard texture. Initial attempts to preserve *chapaties* by adding propionates for arresting mould growth mostly remained unsuccessful[1]. Subsequently, Rao, et al.[2] reported that *chapaties* can be preserved for six months by incorporating sorbic acid (0.48 per cent) and salt (2 per cent) in the dough and by packing them in paper/Al foil/polyethylene laminate pouches immediately after baking. Despite encouraging results in the laboratory acceptability tests, the *chapaties* preserved by this method did not receive wide acceptance from the troops mainly because of being slightly bitter after taste. This was found to be related to the sorbic acid concentration in *chapaties*, and became more pronounced during storage. Also, the concentration of sorbic acid in *chapaties* (0.25 per cent as basis) was higher than the level (0.15 per cent) permitted by P.F.A. Efforts were, therefore, directed towards reducing the concentration of sorbic acid and to improve the flavour and texture of preserved *chapaties*. Arya, et al.[3] reported that effective concentration of sorbic acid for the preservation of *chapaties* can be reduced from 0.48 to 0.20 per cent (both on wheat flour basis) by adding citric acid (0.1 per cent) and sugar (3 per cent) along with sorbic acid and by subsequent inpack pasteurisation of *chapaties* at 90°C. Both citric acid and sugar are known to suppress the dissociation of sorbic acid in aqueous solutions. Since only undissociated sorbic acid has antifungal action, inclusion of citric acid and sugar in *chapaties* formula proved highly beneficial in preventing mould spoilage with low levels of sorbic acid.

Attempts have also been made to preserve *chapaties* using gamma radiation. Sevagaon, et al.[4] have claimed that *chapaties* could be stabilized against mould

Table 1. Some of the traditional Indian foods preserved in ready-to-eat or instantised form

Sl No	Item	Description	Method of preservation	Shelf life (months)
1	*Chapati*	Unleavened pancake made from whole wheat meal.	a) By incorporating sorbic acid, salt, sugar, citric acid and cumene oleoresin in dough and subsequent inpack pasteurisation at 90°C. b) Irradiation (1 Mrad).	6 2
2	Stuffed *parothas*	*Chapaties* with vegetable or meat stuffing.	a) By thermal processing in polypropylene pouches at 115°C b) By thermal processing in cans under inert atmosphere.	4 12
3	*Halwa*	Sweet, semi-solid pudding prepared from wheat semolina, fat and sugar.	a) By thermal processing in cans. b) By thermal processing in polypropylene pouches.	12 5
4	*Upma*	Savoury preparation from wheat semolina, vegetables, fat and spices.	By thermal processing in cans.	12
5	*Kheer*	Sweet preparation from milk, rice and sugar.	By thermal processing in cans.	6
6	*Idli*	Prepared by steam cooking of rice and blackgram fermented batter.	By thermal processing in cans.	6
7	Whole meal	*Chapaties*, *puries*, vegetable curries and *halwa* etc.	Packed individually in cellophane pouches and thermally processed in cans.	12
8	Avial	Savoury preparation from vegetables, curd, spices and coconut gratings.	a) By thermal processing in cans. b) By spray drying and HTST hot air drying.	12 9
9	Peas-*Paneer*	Peas and fried cottage cheese curry.	By thermal processing in cans.	9
10	*Pulav*	Rice and vegetables or meat seasoned with fat and spices and cooked.	a) By thermal processing in cans. b) By thermal processing in polypropylene pouches.	6 4
11	*Rajma*	Beans in sauce.	a) By thermal processing in polypropylene pouches.	4
12	*Alu-chholay*	Potatoes-gram curry.	By thermal processing in polypropylene pouches.	4
13	Pineapple juice powder	Freeze dried juice + sugar.	By accelerated freeze drying.	6
14	Mango juice powder	Freeze dried mango pulp + sugar.	By accelerated freeze drying.	6
15	Dehydrated instantised pulav	——	By hot air drying.	6
16	Dehydrated *dals* curried	Precooked dehydrated *dals* (pulses) and spiced.	By hot air drying.	12

spoilage by a radiation dose of 1 Mrad and these were acceptable organoleptically for about two months. Mathur, et al.[5] have attempted to preserve *chapaties* and *parothas* by thermal processing in cans. These workers have claimed, that *chapaties* and *parothas* could be preserved in acceptable condition for more than a year by processing at 116°C for 100 minutes. However, the quality of irradiated and thermally preserved *chapaties* has been found to be far inferior to the one preserved by sorbic acid. This is mainly because of excessive caramelisation and the resultant hard and leathery texture of canned *chapaties*. Irradiation and subsequent storage, on the other hand, result in very pronounced off-odours probably due to the radiolytic degradation of amino acids and fatty acids. Addition of antioxidants has not proved effective in retarding the development of off-odours in irradiated *chapaties*. But irradiation at very low temperatures (frozen state), which has proved effective in retarding the off-odours in beef, may prove beneficial in improving the acceptability of irradiated *chapaties*.

2.2. *Flavouring Compounds in Chapaties*

Despite major use of wheat being in the form of *chapaties*, very little information is available on the factors that affect the flavour of *chapaties*. High sugar and diastatic activity definitely increase the sweetish taste in *chapaties*[6], whereas high tyrosinase activity, has been reported to influence the darkening in whole wheat meal dough, and thereby the colour of *chapaties*[7]. Arya, et al.[8] have reported that carbonyls are the most important components of aroma fraction in *chapaties*, and these are generated mostly during baking operation from sugar-amino acids interactions, and thermal degradation of polyunsaturated fatty acids. Relatively, wheat flour lipids seem to exert a more pronounced effect on carbonyl composition of *chapaties*, in not only generating a large number of additional aldehydes, but also retaining the volatile carbonyls formed by other reactions by exerting a solvent action.

Among the carbonyls identified from *chapaties* are diacetyl, acetoin, glyoxal, formaldehyde, acetaldehyde, propanal, acetone, crotonaldehyde, ethyl methyl ketone, valeraldehyde, isovaleraldehyde, hexanal, nonenal and 2, 4-decadienal. During storage, proportions of 2, 4-decadienal, valeraldehyde, isovaleraldehyde, formaldehyde and acetone decreased, whereas the proportions of glyoxal, diacetyl and crotonaldehyde increased significantly. Also, the proportion of α, β-unsaturated aldehydes increased, while that of saturated aldehydes and ketones decreased to a significant extent[9]. It has been postulated by Arya & Parihar[10] that increase in α, β-unsaturated carbonyls results from the aldol condensation of saturated aldehydes. This reaction is catalysed by amino compounds and is mainly responsible for the development of stale aroma in stored *chapaties*. Attempts to arrest the amino-carbonyl interactions in *chapaties* have not been very successful, but encouraging results have been obtained in improving the organoleptic characteristics of *chapaties* by adding cumene oleoresin[3]. *Chapaties* flavoured with cumene oleoresin have received high acceptance in user's trials. About 50–95 per cent of the participants among variousr egiments have liked these *chapaties* after six months storage under field conditions, and these *chapaties* are being continuously supplied to troops as well as to expeditions. The process has also been released to industry for regular marketing of the product in civil sector.

2.3. *Textural Changes in Preserved Chapaties*

Freshly baked *chapaties* are soft, pliable and elastic but on storage they develop hard and brittle texture. Same problem has been observed in case of bread, wherein the crumb becomes hard and dry, followed by crumbliness, harshness and a dry sawdust type taste. The changes are generally referred to as crumb staling. Despite considerable work, the mechanism of crumb staling is not completely understood but it is generally believed to result from conformational changes in starch. During baking operations, as a result of gelatinization of starch granules both amylose and amylopectin molecules acquire random conformation. With gradual cooling and during storage, amylose and amylopectin chains slowly reorient themselves into regular helical structure leading to crystallinity and release of water molecules which are absorbed by gluten proteins[11]. This slow crystallization of starch molecules generally known as retrogradation is associated with the loss in solubility of starch, which has been found to be true both in case of bread and *chapaties*. Both total soluble solids and soluble polysaccharides in *chapaties* have been shown to decrease during initial 48 hours of storage[1]. X-ray diffraction studies have also revealed increase in crystallinity in starch molecules on storage of *chapaties*[12].

Though many attempts have been made to arrest the development of staling both in bread and *chapaties*, but only marginal improvements in texture have been achieved so far. Addition of hydrogenated oil in the dough or when applied at the time of baking definitely improves the texture of preserved *chapaties* and *parothas*[2,3]. Beneficial effects of surfactants like glycerol monostearate, polyoxyethylene sorbitan monostearate and sodium steaoryl lactylate when incorporated along with hydrogenated oil were appreciable only during first few days of storage. On the other hand, addition of pectin, gluten, milk powder and yeast leavening exerted more pronounced effect on the texture of *chapaties* and *parothas* upto six months storage. Some studies had also been undertaken to understand the mechanism of improving action of hydrogenated oil and other lipids on *chapaties* texture. It has been observed that added hydrogenated oil does not bind with proteins or with starch in *chapaties* but forms a loose hydrophobic coating over starch granules in baked products (Table 2). This loose hydrophobic coating acts as a barrier for moisture redistribution between starch and protein molecules, and thus retards the rate of retrogradation. Studies on gelatinization behaviour of *chapaties* having different levels of hydrogenated oil (2.5 to 10 per cent) support these conclusions[3].

Polar wheat flour lipids, on the other hand, exert their improving action by binding with wheat proteins and starch during dough mixing and baking. Arya has reported that major portion of phospho and galacto lipids become inextractable (Table 3) during *chapaties* baking and the wheat varieties having higher levels of polar lipid retain relatively softer texture during storage[13].

Table 2. Effect of dough mixing and baking on lipid binding during *chapati* preparation

Product	Free lipids (%)	Bound lipids (%)
Atta	1.91	0.53
Dough (2.0)	0.79	1.60
Dough (5.0)	0.52	1.92
Dough (10.0)	0.50	1.93
Chapati	0.41	2.00
Chapati with 2 per cent oil hydrogenated	2.47	1.97
Chapati with 2 per cent groundnut oil	2.45	2.02
Chapati with 2 per cent butter oil	2.31	2.08

Values in brackets indicate the mixing time in minutes in a Farinograph mixer.

Table 3. Composition of free lipids of *atta*, dough and *chapaties* (g/100 g flour)

Product	Neutral lipids	Glycolipids	Phospholipids
Atta	0.60	0.16	0.14
Dough (2.0)	0.76	0.02	0.01
Dough (5.0)	0.51	0.01	0.01
Dough (10.0)	0.48	0.01	0.01
Chapati	0.41	0.02	0.00

Values in brackets indicate the mixing time in minutes in a Farinograph mixer.

3. Stuffed Parothas

There has been a consistent demand from the Armed Forces for supply of stuffed *parothas* in pack rations because these can be consumed as such without any additional curry or pickle. Secondly, stuffings can be varied e.g., vegetables, pulses, meat, eggs etc. to suit different palates and to provide variety in meals. Initial attempts to preserve stuffed *parothas* by incorporating sorbic acid or *p*-hydroxy benzoates were not successful mainly because of development of surface sliminess due to bacterial growth. Moisture content in stuffed *parothas* varies from 40–45 per cent, which was considered sufficient for bacterial proliferation. Kannur, et al.[14] attempted to preserve stuffed *parothas* by thermal processing at 120°C in indigenously available paper/Al foil/polyethylene laminate pouches. Though the method gave very encouraging results in laboratory studies, the process could not be scaled up because of high rate of pouch failures during subsequent handling and transportation. Subsequent studies by Ghosh, et al.[15] revealed that use of polyethylene based foil laminate was not safe for thermal processing of foods as polyethylene suffered distinct thermal damage during processing. Despite all precautions, spoilage rate could only be brought down to a level of five per cent which was thought to be rather too high especially for foods meant for combat situations. Considerable efforts have been made in this laboratory in standardisation of processing conditions for thermal processing of stuffed *parothas* and other conventional Indian foods for their long term preservation with the commencement of indigenous production of polypropylene film. Ghosh, et al.[16] have reported that polypropylene film does not soften at processing temperatures but it undergoes certain physical changes which detract from its physical properties. This along with the delicate nature of the film necessitates outer protective packaging for safe transportation and storage. The system developed by them has undergone extensive trials both in the laboratory and under field conditions and has been found to keep food materials microbiologically safe and organoleptically acceptable for about four months. The major problem in further extending the shelf life of stuffed *parothas* is redistribution of moisture in *parothas* and stuffing portion leading to hardening of edges and excessive sogginess in the central region, besides the characteristic problem of staling. Further improvements in the quality of stuffed *parothas* seem to be interlinked with the understanding of the mechanism of staling which is by far the greatest hindrance in freshness retention in cereal products.

Attempts have also been made to preserve stuffed *parothas* by thermal processing in cans at 116°C for 100 minutes[5]. The product, however, undergoes extensive thermal damage leading to browning and texture hardening. The quality of the canned *parothas* is, therefore, inferior to the ones processed in polypropylene pouches. Besides, the original shape of the *parothas* is not retained during canning.

4. Other Traditional Foods Preserved by Processing in Polypropylene Pouches

Besides stuffed *parothas*, a number of other foods both sweet and savoury preparation like *halwa*, *alu-chholay curry*, mutton *kofta* curry and beans in sauce (*Rajma*) have been preserved successfully for a period of 4-6 months in polypropylene pouches by thermal processing[16]. Though no data are available on the physico-chemical and nutritional changes that may be taking place during processing and storage of these foods, the products seem to remain in good conditions as evidenced by good response from troops in consumer acceptability trials. Inadequate barrier properties of polypropylene against oxygen, flavouring compounds and water vapour seems to be the major hindrance in further extending the shelf life of these products as well as in its more wider use in the preservation of oxygen sensitive products.

5. Canned Products

5.1. *Canned Halwa and Upma*

Considerable attempts have been made in preserving traditional Indian foods by conventional canning technique. Excellent quality canned *halwa* and *upma* have been developed at DFRL, Mysore and these products have undergone extensive testing in various user acceptability trials. Some basic data have also been collected about the type of physico-chemical changes that take place during roasting of semolina. Though both these products are generally flavoured with spices, carbonyls and pyrazines formed during roasting have been shown to influence their characteristic aroma[17]. Canned *avial* and *peas-paneer* curry have also been liked by troops in various pack rations.

5.2. *Idli*

Idli, a popular South Indian breakfast food seems to have been maximally investigated. Desikachar, et al.[18] and Steinkraus, et al.[19] have standardised the composition of dry *idli* mix and investigated the overall physico-chemical changes brought about during fermentation of the *idli* batter and their effect on organoleptic characteristics. It has been established that *S. faecalis* appears in the beginning, followed by *L. mesenteroides* in the useful stage of fermentation whereas during later stages *P. cerevisiae* was most predominant[20]. Among the various constituents of the mix, black gram proteins seem to control the textural characteristics in idlies. These studies have resulted in the development of dry mixes for preparing *idlies* which are being commercially marketed by a number of firms. These *idli* mixes though useful for regular army kitchens, are not suitable for combat rations. Nagarathnamma Krishnamurthy & Siddappa[21] have developed a method for heat processing of *idli* batter in cans. The method provides a means to preserve *idlies* in ready-to-eat form for more than six months. Subsequently, Kadkol, et al.[22] attempted to can ready-to-eat *idlies* along with *sambhar* by giving a surface coating of fried blackgram powder. By this technique discrete shape of individual *idlies* could be retained and the product remained stable for six months under ambient conditions.

5.3. *Whole Meal*

In order to meet certain logistic needs Mathur, et al.[5] have attempted to preserve conventional whole meals containing *chapaties, puries, parothas*, different types of curries (both vegetarian and non-vegetarian types) and sweet dishes like *halwa* and *kheer* by thermal processing at 116°C for 100 minutes in a single 401 × 300 plain sanitary can. Individual products were packed in MST cellophane pouches and arranged in such a way to preclude intermixing. Though the thermal processing conditions were found to be adequate and the products remained stable for more than a year, moisture redistribution in individual dishes led to excessive changes in texture and flavour which were not considered desirable. Secondly, though data were not collected on nutrient changes during canning, such lengthy processing periods are bound to have adverse effects on nutrient availability. Nevertheless, this method provided a means to preserve a composite meal in a single pack for more than a year.

5.4. *Canned Pulav*

Canning of white rice has posed many problems in the past because of formation of congealed mass of pasty grains after retorting[23]. Attempts in improving the quality of canned rice have not been very rewarding but Bhatia, et al.[24] have successfully developed a process for canning of conventional *pulav* (*Biriyani*) based on vegetarian and non-vegetarian receipes. Because of high fat content in *pulav*, rice grains remain discrete and formation of congealed mass is avoided. Addition of tomato *puree* and 10 per cent fat and equilibration of rice to 35 per cent moisture before cooking seems to improve the texture and flavour of the stored product.

6. Dehydrated Convenience Foods

Dehydrated foods though not exactly in ready-to-eat form provide many advantages especially long shelf life, and savings in transportation cost. Many innovative methods have been developed during last two decades which have enabled many traditional Indian dishes to be prepared in ready made form. Prominent among these are precooked dehydrated rice, dehydrated *khichdi* and *pulav*, dehydrated avial mix, *lassi* powders, mango and pineapple juice powders, dehydrated curried *dhals* and vegetables. These products require simple reconstitution with boiling water and can be made in ready-to-eat form within 5-15 mintutes. Considerable amount of basic and applied research work[25-30] has gone-in to develop these products and a detailed description of the same will not be attempted here. Technological advances that have been made during the last three decades have enabled many of the traditional foods to be preserved in either ready-to-eat form or in instantised form in light weight flexible packages. Commercial production of these preserved and processed foods is still in infancy but industry has started giving some attention to these technological advances in exploiting their potential in commercial market. Unlike two decades back, today military planners have the choice of selecting the type of foods of their liking for pack rations which will suit different palates and provide necessary convenience under different types of combat operations.

One of the major constraints in the commercial production and marketing of the processed traditional Indian foods is the lack of easy availability of suitable packaging materials and machineries needed in upscaling these processes. At present many of the food processing and packing machineries are being imported, which besides being not suitable for some of Indian products, require high investment and their maintenance and availability of spare parts becomes a major problem. Indigenous fabrication and production of these processing and packaging equipments, therefore, needs immediate attention. Secondly, though many of the traditional Indian foods have been preserved in ready-to-eat or instantised form, the nature of physico-chemical changes and their role on nutritional and sensory properties of the processed and preserved products is not known. In order to bring out further improvements in their sensory and functional properties, it is of utmost importance to understand the nature and mechanism of these changes resulting from processing and storage.

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Condiments are like old friends—highly thought of, but often taken for granted.