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Proximate and mineral composition of some processed traditional and popular Indian dishes

N. Narayan Prasad, M. Siddalingaswamy, P.M. Parameswariah, K. Radhakrishna, R.V. Rao[1], K.R. Viswanathan, K. Santhanam*

Biochemistry and Nutrition Discipline, Defence Food Research Laboratory, Siddarthanagar, Mysore 570 011, India

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Abstract

Proximate and mineral composition of 30 different traditional and popular Indian foods, categorised as either ready-to-eat or easy-to-reconstitute or freeze dried products have been evaluated. Of the 30 products, the proximal score of eleven and mineral composition of two items have been reported recently, elsewhere. The various products employed for the present study include vegetable pulav, dehydrated pulses/curries, upma, mutton/chicken curry, which form part of main meals, and certain fruit beverage powders of pineapple, mangoes and grapes. All the products, tested for their shelf stability (minimum of 6–12 months at ambient conditions) and microbiological safety, have been found to provide approximately 350–660 kcals 100 g^{-1} (on moisture-free-basis), depending on the type of product. The pulse, meat/chicken items were found to be protein-rich. Fat content in all the products varied, depending on the amount of hydrogenated oil used in their preparations. However, the fruit-based products contained negligible amounts of both protein and fat. The various minerals and trace elements analysed, include sodium, potassium, calcium, magnesium, phosphorus, iron, zinc, copper, manganese, aluminium and lead. The elemental composition of each of the products varied with the different ingredients going into their preparation. However, it is noteworthy, that contaminants such as lead and aluminium are present in quantities well below the limits prescribed by standard institutions such as PFA and ASC. The nutrient database generated hitherto, while suggesting that the products are nutritionally good/safe, also enables nutrient-labelling of the products. Further, it helps the nutritionists and food planners to formulate different diets to meet the varied needs of the consumer.

Keywords: Proximal score; Minerals; Trace elements; Processed foods

1. Introduction

A wide range of traditional and popular Indian foods (cereal-, legume-, vegetable-, fruit- or meat-based), in ready-to-eat (RTE) or easy-to-reconstitute (ETR) form, has been developed in our laboratory employing state of the art techniques of food processing. These products have been found to be microbiologically safe and organoleptically acceptable for periods ranging from 3 months to 1 year. Although specifically meant for consumption by the Armed Forces personnel during combat and special missions, they are also being consumed by participants of rowing and mountaineering expeditions, motor rallies, antarctica expeditions etc. Moreover, urbanisation has generated a considerable interest amongst the civil population in such processed foods since these foods could easily be cooked, add variety and are available during off-seasons.

There is paucity of information with respect to macro and micro nutrient contents of these foods. In the late sixties, some of the products, heretofore, developed had been evaluated for their proximal score (Ramanuja, Susheela, Valli Devi, Sarma, Rao & Vijayaraghavan 1967) and vitamins content (Ramanuja, Rao, Vaidya, Rao, Rao & Vijayaraghavan, 1969). In view of the considerable advancement in technological processes, adoption of modified recipes and development of several new products to provide variety in the diet, based on the consumer demand, it is necessary to update the existing database with respect to both macro and micro nutrient contents. The proximal score and mineral content of some of these products have already been evaluated and published earlier (Prasad, Khanum,

* Corresponding author.
[1] Rare Metals Project, No. 1, Yelwal, Mysore, India.

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Siddalingaswamy & Santhanam, 1995; Semwal, Murthy & Arya, 1995). In the present study, several other products have been evaluated for their proximate composition, macro mineral and trace element contents, with a view to preparing compendium of the nutrient contents of various foods. This would in turn enable formulation of different rations to meet the nutritional requirements of the individuals, based on their physiological needs, clinical status and environmental/climatic conditions. Since the technologies and products developed by our laboratory, are ready for commercialisation, the nutrient database generated helps to meet stringent regulations (Rosenberg, 1992; FDA, 1993) and consumer acceptance.

2. Materials and methods

The raw materials used in the preparation of various ration items, together with their botanical names, are listed in Table 1. The quantities of various ingredients used in the processing of the different products employed in the present study are given in Table 2.

Table 1
List of ingredients used in the preparation of various products and their botanical names

S. No.	Ingredients used	Botanical names
1.	Wheat	*Triticum aestirum*
2.	Peanut	*Arachis hypogaee*
3.	Potatoes	*Solanum tuberosum*
4.	Bengal gram	*Cicer arietinum*
5.	Mangoes	*Mangifera indica*
6.	Gooseberries/Amla	*Emblica officinalis*
7.	Lemon	*Citrus limon*
8.	Ginger	*Zingiber efficinale*
9.	Chiranji	
10.	Tomato	*Lycopersicon esculentum*
11.	Onion	*Allium Cepa*
12.	Chillies	*Capsicum annum*
13.	Turmeric	*Curcuma domestica*
14.	Cumin/Jeera	*Cuminum cyminum*
15.	Pepper	*Piper nigrum*
16.	Peas	*Pisum Sativum*
17.	Rice	*Oriza sativa*
18.	Carrot	*Daucus carota*
19.	French beans	*Phaseolus coccmum*
20.	Garlic	*Allium sativum*
21.	Cinnamon	*Cinnamomum Zeylanicum*
22.	Cloves	*Syzgium aromaticum*
23.	Cardamom	*Elettaria Cardamomum*
24.	Curry leaves	*Murraya Koenigin*
25.	Rajma	*Phaselous vulgaric*
26.	Dhania/Corriander	*Coriandrum sativum*
27.	Green gram/Moong	*Phaselous aureus Roxb*
28.	Red gram/Arhar	*Cajnus Cajan*
29.	Mustard	*Brassica nigra*
30.	Black gram/Urd	*Phaseolus mungo Roxb*
31.	Pineapple	*Ananus comosus*
32.	Grapes	*Vitis vinifera*

The references cited against each of the items elucidate the processing techniques adopted and their method of reconstitution and use. In addition, items such as flavoured chapathy, spiced-potato chapathy, chikki, pickle, precooked dehydrated (PD) kichidi, PD vegetable pulav, PD green gram dal curry, instant halwa mix and instant upma mix were also employed for the analysis of various parameters. The raw materials used in the preparation of these products have been published earlier (Prasad et al., 1995). A brief description of the process, in the case of some of the listed products whose methodologies have not been published, is given below.

2.1. Ready to eat (RTE) foods

2.1.1. Canned mutton or chicken curry

Meat obtained from goat, sheep or chicken, slaughtered by the method of *halal*, was washed thoroughly under running water, deboned and dressed and cut into nearly uniform chunks of size $1–1^1/_2''$. The excess water was drained off by placing the chunks in a stainless steel wire-mesh basket for 10–15 min. The chunks were fried in about half the quantity of the hydrogenated oil until they turned hard. The peeled and shredded onion was separately fried in the remaining quantity of hydrogenated oil, to a golden yellow colour. The sliced tomato and ground garlic and ginger were added to it and frying continued for another 5–10 min. The spice or masala mix was then added with constant stirring followed by proportionate quantity of water and boiled for 15–20 min to obtain a gravy of desired consistency. The mutton or chicken chunks were added to the gravy, mixed well and removed from the heat. The curry thus obtained was filled into lacquered aluminium cans of size 83×80 mm, taking care to see that the chunks and the gravy were uniformly distributed in all the cans. The lids were just placed above the cans and exhausted in a steam exhaust chamber for about 15 min. The cans were double-seamed and retort-processed at 10 psi, to an F_o value of 6.5. This process took about 45 min. The cans were removed, cooled in a water tank and stored at room temperature. Samples were drawn at random for analysis.

2.1.2. Canned upma

Wheat semolina was fried in about 0.5 kg of hydrogenated oil, to a golden yellow colour. Sliced ginger, chillies and curry leaves together with bengal gram dhal, depodded green peas (or blanched, soaked dry peas) were fried in the remaining quantity of hydrogenated oil, by adding these ingredients sequentially with constant stirring. Finally, on adding measured amounts of water, lemon juice and roasted semolina, the mixture, while being stirred constantly, was boiled until it turned semi-solid. The material was removed from the flame

Table 2
List of various RTE, ETR and freeze-dried foods and their major ingredients

Sl. No.	Items	Major ingredients	Ref.
Ready-to-eat (RTE) foods			
1.	Sooji halwa (sweet semolina pudding)	Wheat semolina (Bansi variety) 5 kg; cane sugar 10 kg; hydrogenated oil 3 kg; chiranji 0.15 kg; cardamom whole 0.07 kg	Ghosh, Krishnappa, Srivalsa, Eapen and Vijayaraghavan, 1980 Krishnappa, Srivasta, Ghosh, Eapen and Vijayaraghavan, 1982
2.	Alu cholay	Dry bengal gram whole (Kabuli variety) 1 kg; hydrogenated oil 2 kg; potatoes 4 kg; garlic whole 100 g; ginger fresh 100 g; tomato (Madanapalli variety) 1.5 kg; onion fresh 1.5 kg; chilli powder 50 g; turmeric powder 50 g; jeera powder 25 g; white pepper powder 25 g; salt 150 g	Ghosh et al., 1980 Krishnappa et al. 1982
3.	Potato-peas-curry	Same as above (alu cholay) except for the use of dry peas instead of bengal gram whole	Ghosh et al., 1980 Krishnappa et al. 1982
4.	Canned vegetable pulav	Rice, good/fine quality 3 kg; hydrogenated oil 1 kg; onion 1.5 kg; carrot dressed 2 kg; depodded green peas or dry peas soaked overnight in water 2 kg; beans dressed 2 kg; garlic 75 g; ginger 75 g; cinnamon 10 g; cloves 10 g; cardamom 10 g; green chillies 85 g; salt 100 g	Jayaraman, Subramanian, Gopinathan, Babu Rao, Parameshwariah and Sharma, 1988 Srivatsa et al., 1993
5.	Canned upma (savory semolina pudding)	Wheat semolina (Sooji) 5 kg; hydrogenated oil 1.5 kg; bengal gram dal 350 g; depodded green peas or dry peas soaked in water overnight 1 kg; green chillies 120 g; curry leaves 200 g; ginger fresh 60 g; salt 200 g; lemon juice 800 ml; water 7 litres	Jayaraman et al., 1988 Srivatsa et al., 1993
6.	Canned baked beans (Rajma in sauce)	Soaked beans (Rajma) cooked in tomato puree	Srivatsa et al., 1993
7.	Canned mutton curry	Mutton dressed 5 kg; hydrogenated oil 1 kg; onion 2.5 kg; tomato 2.5 kg; ginger fresh 500 g; garlic 350 g; dhania powder 100 g; turmeric powder 50 g; white pepper powder 50 g; chilli powder 150 g; jeera powder 750 g; cardamom 10 g; cinnamon 20 g; clove 10 g; salt 200 g	See text
8.	Canned chicken curry	Chicken dressed 5 kg; hydrogenated oil 1 kg; onion 3 kg; tomato 3 kg; garlic 500 g; ginger fresh 600 g; chilli powder 100 g; turmeric powder 20 g; jeera powder 50 g; dhania powder 100 g; white pepper powder 25 g; cinnamon 20 g; cloves 20 g; salt 200 g	See text
9.	Mango bar	Mango (Badami variety) product yield 26% on fresh fruit weight basis	Mathur, Anthony Das, Jayaraman and Bhatia, 1972
Easy-to-reconstitute (ETR) items			
10.	PD Arhar Dal curry	PD Arhar dal 66%; hydrogenated oil 15%; fried onion 10%; curry powder 4.5%; salt 4.5%	Bhatia, Ramanathan, Prasad and Vijayaraghavan, 1967
11.	Instant spiced red gram dal	Red gram dal flakes 65%; fried onion 10%; masala/spice mix 4.5%; hydrogenated oil 15.0%; mustard 0.5%; cumin seeds 0.5% and salt 4.5%	Patki and Arya, 1994
12.	Instant spiced bengal gram dal	Same as red gram dal except for the use of bengal gram dal instead of red gram dal	Patki and Arya, 1994
13.	Instant spiced black gram dal	Same as red gram dal except for the use of black gram dal instead of red gram dal	Patki and Arya, 1994
14.	Insta Nutro Cereal mix	PD rice 4 kg; PD red gram dal 4 kg in hydrogenated oil 2.4 kg; fried peas 320 g; fried potatoes 240 g; fried onion 160 g; dehydrated carrot 320 g; dehydrated curry leaves 80 g; masala/spice mix 640 g; salt 400 g	Arya, Vidyasagar and Premavalli, 1989 Premavalli, Vidyasagar and Arya, 1991
Freeze dried Items			
15.	Chicken pulav	Deboned broiler chicken cut into uniform chunks 7.5 kg; rice 2.5 kg; hydrogenated oil 500 g; curds 1 l; lemon juice 250 ml; ginger 150 g; garlic 100 g; spice mix 200 g and salt 150 g	Sharma et al.
16.	Chicken masala	Deboned broiler chicken cut into uniform chunks 13 kg; curds 4 l; ginger 500 g; spice mix 225 g; garlic 300 g and salt 150 g	Sharma et al. Radhakrishna, Vijaya Rao, Jayathilakan, Joyce D'Souza and Sharma, 1988
17.	Lemon rice	Rice 3.5 kg; hydrogenated oil 350 g; lime juice 750 ml; green chilli 50 g; seasoning materials 210 g; turmeric powder 15 g and salt 200 g	Sharma et al.
18.	Peas pulav	Rice 3 kg; hydrogenated peanut oil 750 g; depoded fresh green peas 5 kg; pepper powder 10 g and salt 200 g	Sharma et al.

(continued)

Table 2 (*continued*)

Sl. No.	Items	Major ingredients	**Ref.**
19.	Peas paneer	Depodded fresh green peas 5 kg; paneer 4 kg; hydrogenated oil 500 g; jeera 40 g; pepper powder 40 g; lime juice 500 ml; salt 100 g	Sharma et al.
20.	Rice pudding (Kheer)	Rice 1 kg; milk 10 l; sugar 1.2 kg; saffron 1 g	Vijaya Rao et al., 1994
21.	Wheat porridge (Dhalia)	Broken wheat 1 kg; hydrogenated oil 100 g; milk 10 l; sugar 2 kg; cardamom powder 2 g	Vijaya Rao et al.
22.	Pineapple juice powder	Pineapple pulp; sucrose	Phanindra Kumar, Jayathilakan and Vasundhara, 1991
23.	Mango juice powder	Mango pulp; sucrose	Ammu, Radhakrishna, Subramamian, Sharma and Nath, 1977
24.	Grape juice powder	Grape pulp; sucrose	Vasundhara, Phanindra Kumar and Jayathilakan, 1992

and distributed in lacquered aluminium cans in appropriate quantities and processed as in the case of mutton or chicken. The process took about 55 min.

2.1.3. Canned vegetable pulav

Good quality rice was washed initially with water and the excess water was drained off. The rice was fried using 1/5th the quantity of hydrogenated oil along with ground cinnamon, cloves and cardamom, just to maintain the rice free flowing. The vegetables were diced into small, uniform size and blanched. Garlic and ginger were ground to a fine paste. Shredded onions were fried to a golden yellow colour in the remaining 4/5th of the hydrogenated oil. The chillies were cut into small bits and pastes of garlic and ginger were added and frying continued with constant stirring. Now the blanched vegetables, fried rice and salt were added followed by water, and cooking was continued until the mass turned into a semi-solid form. The pulav thus obtained was distributed into lacquered aluminium cans and processed as in the case of upma.

2.2. Easy-to-reconstitute (ETR) and freeze dried (FD) foods

All the products were developed according to the processes described in the respective references cited against each (Table 2).

2.2.1. Chemical analysis

The individual products were thoroughly pulverised in a Waring blender without allowing the material to heat up. The moisture content was estimated either by the hot air or vacuum oven method, depending on the product involved, as described by the Association of Official Analytical Chemists [AOAC] (1984). The dried materials were analysed for proximal components viz. ether-extractable residues (crude fat), crude protein, ash and crude fibre, by the AOAC (1984) methods. All the analyses were carried out in triplicate. The carbohydrate values were obtained by difference. The calorific value was calculated by using the Atwater energy conversion factors, i.e. 4 for protein and carbohydrates and 9 for fat.

The samples of ash obtained during the course of the above analysis were dissolved in a known volume of 2 N hydrochloric acid, evaporated to dryness and redissolved in another known volume of 1 N hydrochloric acid. Suitable dilutions were subsequently made using deionised distilled water for the determination of various minerals and trace elements. The elements, sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), aluminium (Al) and lead (Pb) were determined using an Atomic Absorption Spectrophotometer Model GBC-902.

3. Results and discussions

3.1. Proximate composition of foods

In total, 30 different products have been analysed for their proximate composition, of which data for eleven products have been reported earlier (Prasad et al., 1995; Semwal et al., 1995). The values for the products evaluated in the present study are given in Table 3. The products have been grouped under three different categories i.e. ready-to-eat foods, easy-to-reconstitute foods and freeze-dried foods. The moisture contents of RTE foods are generally very high (57.4–76.6%) except mango bar and IPS sooji halwa which had the lower moisture contents, i.e. 13.6 and 20.7% respectively.

The protein content was lowest in the case of mango bar (1.4%) as expected, while it ranged between 2.7 and 8.5% for others and depended on the protein content of the raw materials used. The ether-extractable solids have been found to be the lowest in the case of mango bar (0.2%) and IPS baked beans (0.4%). The values in the case of other products ranged between 3.2 and 17.8%. These variations are, however, due to the different quantities of hydrogenated oil used for processing. The calories provided by these products ranged between

Table 3
Proximate composition (g 100 g FW[c]) of processed foods

Sl. No.	Product	Moist	Prot	Fat	CHO	Ash	Fibre	kcals 100 g	kcals[b] 100 g
Ready-to-eat foods									
1.	IPS Sooji halwa[a]	29.7	2.7	8.5	58.0	0.3	0.9	319	454
2.	IPS Alu cholay	76.4	3.3	5.2	12.4	1.6	1.1	110	466
3.	IPS potato peas curry	72.0	4.3	3.2	16.8	1.8	1.9	113	403
4.	IPS baked beans	59.9	9.5	0.4	25.9	2.8	1.5	145	361
5.	Canned veg. pulav	66.3	3.1	4.4	23.8	1.3	1.1	147	436
6.	Canned upma	57.7	3.7	11.8	23.8	1.9	1.1	205	485
7.	Canned veg. curry	75.4	2.7	7.9	10.2	3.0	0.8	115	467
8.	Mango bar	13.6	1.4	0.2	82.4	1.2	1.2	337	
9.	Canned mutton curry	76.6	6.7	10.9	3.5	1.3	1.0	139	594
10.	Canned chicken curry	68.3	8.1	17.8	3.9	1.3	0.6	209	659
Easy-to-reconstituted foods									
11.	P.D. Arhar Dal curry	4.5	14.8	18.1	51.5	4.1	2.5	428	449
12.	Insta Nutro cereal mix	7.0	17.4	19.1	47.7	6.9	2.3	432	464
13.	Instant sp. arhar dal	3.3	18.4	20.3	47.8	5.8	4.4	448	453
14.	Instant spiced urd dal	7.6	16.4	18.7	48.0	7.4	1.9	345	483
15.	Instant sp. channa dal	6.7	15.7	22.6	46.2	6.4	2.4	451	373
Freeze-dried products									
16.	Lemon rice	0.4	8.7	17.2	67.8	5.1	0.8	461	463
17.	Peas pulav	0.7	11.1	15.9	61.9	5.8	4.7	435	438
18.	Peas paneer	0.4	24.9	38.7	23.4	7.2	5.5	541	543
19.	Chicken pulav	1.7	29.2	16.9	45.7	4.5	2.0	452	460
20.	Chicken masala	1.6	63.2	16.7	9.9	7.4	1.2	443	450
21.	Pineapple juice powder	1.6	0.7	0.1	96.3	0.7	0.7	389	395
22.	Mango juice powder	0.8	1.3	0.1	95.8	0.7	1.4	389	392
23.	Grape juice powder	0.6	1.4	0.02	96.5	0.9	0.7	392	394

[a] IPS, In-pack sterilised.
[b] On moisture-free basis.
[c] FW, fresh weight.

110 and 337 kcal/100 g^{-1} (361 and 659 kcal/100 g^{-1} on a moisture-free basis).

The ETR foods (dehydrated),on the other hand, contained moisture in the range of 3.3–6.7%. These foods are protein-rich and calorie dense (346–461 kcal/100 g^{-1}) because they are pulse-legume-based and large amounts of hydrogenated oil have been used in their preparation. The freeze-dried products are unique in their quality with respect to their rehydration properties. The various juice powders, as expected, are low in all the proximate components except carbohydrates and supply nearly 400 kcal/100 g^{-1}. Thirty grammes each of these juice powders are used per serving of 150 ml of the beverage which is equivalent to nearly 130–140 kcal. Of the other FD products, the chicken masala had the highest protein content (63.2%). On the other hand, chicken pulav had a protein content of only 29.2%, because of the dilution effect exerted by the use of rice and other ingredients. Similarly, between peas pulav and peas *paneer*, the latter had a higher protein value (11.1 vs 24.9%) which is contributed by *paneer*. Lemon rice, being a purely cereal- or rice-based product had the lowest protein content of 8.7%. The fat content, in all cases, was more or less similar except peas *paneer* (38.7%), which is again contributed by the *paneer*. Peas *paneer* being rich in protein and fat, supplies nearly 540 kcal/100 g^{-1}. The other constituents did not indicate any appreciable variation.

3.2. Mineral composition of foods

The mineral compositions of the various products are given in Table 4. The concentration of sodium is the highest in almost all the products studied and is attributed to the incorporation of salt (sodium chloride) during their preparation for the sensory attribute of taste. The sodium concentration is low in the case of the sooji halwa, mango bar and the fruit beverages wherein no salt was added. The exact amount of sodium required in a tropical country like India is not known with certainty, although it is estimated to be as high as 20 g as sodium chloride; the average being around 15 g/adult. In view of the association of hypertension with high salt intake, a lower intake of 8–10 g/day may be advisable. Larger intakes may be necessary under conditions of excessive sweating, as in a tropical summer or for those who work in a hot environment. Sodium present in foods, as well as that added as common salt

Table 4
Mineral composition[a] of processed foods

Items	Na	K	Ca	Mg	P	Fe	Zn	Cu	Mn	Al	Pb
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
I. Ready-to-eat (RTE) foods											
Fresh chapathy[b]	–	–	–	800	1000	–	–	–	–	0.20	0.9
Spiced potato chapathy[b]	–	–	–	600	800	–	–	–	–	0.11	1.2
IPS sooji halwa	300	200	200	200	300	30.0	7.8	1.7	4.5	0.20	1.0
IPS alu cholay[b]	–	–	–	1775	2718	–	–	–	–	0.38	0.14
IPS potato peas curry	17100	603	380	1755	2789	25.4	11.8	0.21	7.8	0.13	0.20
IPS baked beans	22400	5200	1400	1300	1800	40.0	17.3	18.8	12.7	0.32	1.6
Canned veg. pulav	16900	4700	400	900	1300	60.0	24.3	4.8	8.4	50	1.4
Canned upma	19200	2200	570	800	120	150.0	25.1	4.9	16.2	50	1.3
Canned veg. curry	57000	5000	2600	2000	2100	23.0	24.7	8.9	17.9	31	1.8
Canned mutton curry	31400	7935	1125	1810	2660	24.8	33.5	0.27	2.5	25	0.25
Canned chicken curry	23500	486.0	2245	1710	3270	43.0	40.8	0.10	3.6	30	0.14
Canned peas in brine	30100	3600	1200	1700	2200	40.0	47.6	16.6	12.6	40	0.00
Mango bar	7315	4861	484	167	NA	22.0	1.2	3.0	NA	NA[d]	1.9
II. Easy-to-reconstitute (ETR) foods											
PD kichidi	23000	6105	78	1680	3597	20.5	10.8	0.23	11.2	0.16	0.19
Instant halwa mix[b]	–	–	–	645	153	–	–	–	–	0.18	0.39
Instant upma mix[b]	–	–	–	1435	217	–	–	–	–	0.05	0.03
Instant sp. arhar. dal[b]	–	–	–	1885	3539	–	–	–	–	0.12	0.13
Instant sp. channa. dal[b]	–	–	–	2220	4821	–	–	–	–	0.2	0.20
Instant sp. urd. dal[b]	–	–	–	2000	1900	–	–	–	–	0.21	0.26
III. Freeze-dried foods											
Lemon rice	9651	1528	6092	732	3156	24	8.3	2.3	7.9	0.08	0.38
Peas pulav	11074	4239	484	271	1870	28	18.7	2.2	12.1	0.12	3.3
Peas paneer	7126	4127	4940	472	2182	21	35.0	3.0	8.6	0.2	5.3
Chicken pulav	13711	2314	459	251	1028	25	10.9	2.2	3.9	0.16	2.9
Chicken masala	1599	11161	1895	543	3129	44	21.6	2.6	3.1	0.38	3.0
Kheer[c]	–	–	–	274	–	–	–	–	9.1	0.25	0.28
Dhalia[c]	–	–	–	296	–	–	–	–	4.3	0.18	0.20
P.J. powder	1920	1602	1387	252	890	25	2.4	1.3	3.6	0.22	1.8
M.J. powder	4997	1859	1595	222	760	22	3.2	1.8	2.9	0.28	1.6
G.J. powder	2586	3320	616	81	510	16	1.3	2.0	4.2	0.16	1.2

[a] Values expressed as mg/kg, are on moisture-free basis.
[b] Values for content of Na, K, Ca, Fe, Zn, Cu and Mn have been reported earlier (Semwal et al.,1995).
[c] Values for Na, K, Ca, P, Fe, Zn & Cu have been reported earlier (Vijaya Rao et al., 1994).
[d] NA—values not available.

during preparation of dishes, is sometimes not adequate to meet the requirements. Hence, it is a practice among desert dwellers to add salt to drinking water while taking meals, in order to compensate for the sweat loss, although the rationale has been contested.

Large variation is observed in the concentration of potassium in foods which is attributed to the original levels of the mineral present in the various ingredients used in the preparation of different products. In plant foods, potassium is present in higher concentrations than sodium by nearly ten-fold. The exact requirement of potassium is not known. But potassium present in vegetable food is probably adequate to meet the daily requirement. Dietary potassium deficiency is not known to occur in man, because it is well absorbed and abundantly present in natural foods. Raw vegetables are generally high in potassium (Gopalan, Rama Shastri & Balasubramanian, 1985; Narasinga, Deosthala & Pant, 1989). The sodium content of vegetables is often increased during processing procedures, while the potassium content is generally depleted, which is probably due to leaching. Similarly, other major minerals, such as calcium, magnesium and phosphorus also showed wide variations, which again are naturally seen in the raw materials per se (Gopalan et al.; Narasinga Rao et al.).

Compared to the other nutrients, mineral losses as a result of processing are relatively low. Therefore, the processed products also exhibit a parallel wide variation in their concentration. Altogether, six major elements (sodium, potassium, calcium, magnesium, phosphorus and chloride) and 15 trace elements (iron, zinc, copper, iodine etc.) form the main electrolyte system in the body which in turn is related to the maintenance of home-

ostasis with respect to ionic strength, volume relationships and electrical gradients. Although 14 trace elements have now been recognised to meet the criteria of essentiality, it cannot be suggested that actual nutritional problems due to their deficiency are likely to occur in man under ordinary dietary conditions (Walter, 1986). Four trace elements, i.e. iron, copper, zinc and manganese were analysed. Lead and aluminium were determined to assess the contamination in foods. As seen from Table 4, the variation in the concentration of the trace elements is minimal unlike the major minerals. For example, in case of iron, all the products except canned upma contained between 16 and 60 mg/kg. The value obtained for canned upma which is the highest (150 mg/kg), agrees well with the values reported earlier (Semwal et al., 1995) with respect to instant upma mix prepared out of practically similar ingredients. The second highest amount of iron is present in canned vegetable pulav (60 mg/kg). Chicken curry and chicken masala have similar iron content whereas chicken pulav has lower amounts due to rice forming the major portion of the product. Although vegetable pulav contained more amounts of iron than the chicken products, the latter is considered to be more bioavailable since it is present in heme form, unlike in cereal products in which it is present as inorganic salts.

Zinc concentration ranged between 7.8 and 40.8 mg/kg, the largest amounts being present in curried meat and chicken and peas paneer. Zinc concentration, which according to ASC should be <20 mg/kg, is relatively higher in almost all the products except IPS potato peas curry, IPS baked beans, PD Kichidi, lemon rice, peas pulav, chicken pulav and the FD fruit beverages.

The National Institute of Nutrition (NIN 1976 and 1978) has reported higher zinc concentration in meat, followed by pulses and cereals. The vegetables contribute lowest amounts while considerable quantities are derived from condiments and spices. Similar to iron, the bioavailability of zinc from the plant sources, such as cereals and vegetables, is limited because of the presence of phytate, calcium, oxalate and dietary fibre (O'Dell, 1984).

The copper content was found to be highest in the legume based products, i.e. IPS baked beans, canned peas in brine and canned vegetable curry. Higher concentrations of copper have been reported earlier (Semwal et al., 1995) in pulse-based products, such as instant spiced red gram dal, black gram dal and bengal gram dal. The values ranged from 0.2 to 5 mg/kg in the other products. The concentration of copper in IPS baked beans and canned peas in brine were marginally higher than the limits prescribed by Army Service Corps (<15 mg/kg: [ASC] 1956 and 1991). Manganese also showed similar variation in its concentration in different products. The legume- or pulse-based products had higher concentrations of manganese.

The aluminium concentration was less than 1 mg/kg in all cases except for the products canned in aluminium cans, which contained 30–50 mg/kg aluminium. The Joint FAO/WHO Expert Committee (FAO/WHO, 1989) have found that levels of aluminium intake up to 110 mg/kg body weight/day do not induce any toxicological effects. In view of this, our products canned in aluminium cans are quite safe for consumption.

In processed foods, lead is generally estimated to assess the degree of contamination. Except for the FD products, i.e. peas pulav, peas paneer, chicken pulav and chicken masala, which had relatively a high concentration, all the products had more or less similar concentrations of lead. However, all are well within the maximum limits prescribed by either PFA (1954) or ASC (1956), i.e. >10 mg/kg and >5 mg/kg, respectively.

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References

A compendium of ASC specifications for food stuffs 1956 (1991). DGST, Army Hqrs, HHQ PO New Delhi.

Ammu, K., Radhakrishna, K., Subramanian, V., Sharma, T. R., & Nath, H. (1977). Storage behaviour of freeze dried fruit juice powder. *Journal of Food Technology, 12*, 541–554.

Association of Official Analytical Chemists (1984). *Official methods of analysis* (14th ed.), Washington DC: Association of Official Analytical Chemists

Arya, S. S., Vidyasagar, K., & Premavalli, K. S. (1989). Studies on the development, storage stability and acceptability of Insta Nutro Cereal Mix. DFRL Tech. Rep. No. SL-P1-84/DFR-179.

Army Service Corp. (1956). *Army Service Corps Specification*. The limits of heavy metals in processed food stuffs, Appendix L, pp. 517.

Bhatia, B. S., Ramanathan, L. A., Prasad, M. S., & Vijayaraghavan, P. K. (1967). Use of papain in the preparation of quick cooking dehydrated pulses and beans. *Journal of Food Technology, 21*, 105–107.

FAO/WHO (1989). Joint Expert Committee 33rd Meeting. Report on Food Additives 21–30 March.

FDA (1993). Mandatory Nutrition labelling — FDA's final Rule. *Nut. Rev., 51*, 101–105.

Ghosh, K. G., Krishnappa, K. G., Srivatsa, A. N., Eapen, K. C., & Vijayaraghavan, P. K. (1980). Pilot plant production of thermo-stabilized ready-to-eat pouch foods. *Research and Industry, 25*, 140–145.

Gopalan, C., Rama Shastri, B. V., & Balasubramanian, S. C. (1985). *Nutritive value of Indian foods*. Hyderabad, India. National Institute of Nutrition, ICMR.

Jayaraman, K. S., Subramanian, V., Gopinathan, V. K., Babu Rao, N., Parameshwariah, P. M., & Sharma, T. R. (1988). Studies on the suitability of aluminium containers for canning of some ready-to-eat Indian dishes for defence uses. In *Food study group symposium, Common Wealth Defence Science Organisation, Kuala Lumpur, Malaysia*. pp. 101–110.

Krishnappa, K. G., Srivatsa, A. N., Ghosh, K. G., Eapen, K. C., & Vijayaraghavan, P. K. (1982). Heat processing of foods in flexible pouches — development and future trends in India. *Indian Food Packer, 36*, 11–17.

Mathur, V. K., Anthony Das, S., Jayaraman, K. S., & Bhatia, B. S. (1972). Preparation of fruit bars for use in combat rations. *Indian Food Packer, 26*, 62–65.

Narasinga, R., Deosthala, Y. G., & Pant, K. C. (1989). *Nutrient composition of Indian foods*, Hyderabad, India: National Institute of Nutrition, ICMR.

National Institute of Nutrition (1976). Trace element composition of Indian foods. In *Annual Report of National Institute of Nutrition*, Hyderabad, India: ICMR.

National Institute of Nutrition. (1978). Trace element composition of common Indian foods. In *Annual Report of National Institute of Nutrition*, pp. 43–49. Hyderabad, India: ICMR.

O'Dell, B. L. (1984). Bioavailability of trace elements. *Nut. Rev., 42*, 301–308.

Patki, P. E., & Arya, S. S. (1994). Studies on development and storage stability of instant dhals. *Indian Food Packer, 45*, 31–39.

PFA (1954). Prevention of Food Adulteration Act. Central Law Agency, University Road, Allahabad.

Phanindra Kumar, H. S., Jayathilakan, K., & Vasundhara, T. S. (1991). Factors affecting the quality of freeze dried pineapple juice powder. *Indian Food Packer, 45*, 5–11.

Prasad, N. N., Khanum, F., Siddalingaswamy, M., & Santhanam, K. (1995). Proximate composition and dietary fibre content of various foods/rations processed to suit the Indian palate. *Food Chemistry, 52*, 373–378.

Premavalli, K. S., Vidyasagar, K., & Arya, S. S. (1991). Effect of oils and packaging materials on the storage of Insta Nutro Cereal Mix. *Indian Food Packer, 45*, 24–32.

Radhakrishna, K., Vijaya Rao, D., Jayathilakan, K., D'Souza, J., & Sharma, T. R. (1988). Studies on the freeze drying of rehydratable poultry product as large pieces. *Indian Food Packer, 42*, 41–52.

Ramanuja, M. N., Rao, T. S. S., Vaidya, P. D., Rao, M. V. R. K., Rao, N. A. N., & Vijayaraghavan, P. K. (1969). Vitamin content of some processed military rations. *J. Nutr and Dietet, 6*, 295–300.

Ramanuja, M. N., Susheela, B. A., Valli Devi, A., Sarma, M. L., Rao, N. A. N., & Vijayaraghavan, P. K. (1967). Proximate and mineral composition of some processed military rations. *J. Nutr. and Dietet, 4*, 311–317.

Rosenberg, I. H. (1992). The food label as nutrition policy. *Nut. Rev, 50*, 58–59.

Semwal, A. D., Murthy, M. C. N., & Arya, S. S. (1995). Metal contents in some of the processed foods and the effect on the storage stability of precooked dehydrated flaked bengal gram dal. *J. Fd. Sc. Technol, 32*, 386–390.

Sharma, T. R., Vijaya Rao, D., Vasundhara, T. S., Radhakrishna, K., Anthony Das, S., Bhagirathi. B., Gopala Rao, K. R., Phanindra Kumar, H. S., Jayathilakan, K. & Srihari, K. A. Formulation of Quality standards for Freeze-dried food items. DFRL Tech Tep. No. SL-P1-85/DFR-199.

Srivatsa, A. N., Ramakrishna, A., Gopinathan, V. K., Nataraju, S., Leela, R. K., Jayaraman, K. S., & Santhanam, K. (1993). Suitability of indigenously fabricated aluminium cans for canning of Indian foods. *J. Fd. Sc and Technol, 30*, 429–434.

Vasundhara, T. S., Phanindra Kumar, H. S., & Jayathilakan, K. (1992). Effect of relative concentration of different sugars on the freeze drying properties of grape juice. *J. Fd. Sc. and Technol, 29*, 45–47.

Vijaya Rao, D., Radhakrishna, K., Jayathilakan, K., Vasundhara, T. S., Bhagirathi, B., Gopala Rao, K. R., Srihari, K. A., & Siddalingaswamy, M. (1994). Manufacture of freeze dried breakfast and dessert foods. *J. Fd. Sc. and Technol, 31*, 40–43.

Walter, M. V. (1986). *Trace elements in human and animal nutrition* (Vol. 2). New York: Academic Press Inc.