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Assessment of Ration Scales of the Armed Forces Personnel in Meeting the Nutritional Needs at Plains and High Altitudes–I

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ABSTRACT

Adequate nutrition is very essential, especially for the Armed Forces, to buildup their nutritional reserves while deriving maximum benefits of training/peak performances in operational situations by keeping their morale high. The present study reviews/examines the adequacy of the existing ration scales of the Armed Forces personnel stationed under different terrain conditions of the country/recruits at various training centres. Food samples were collected from different strategic locations during different seasons of the year and analysed for their nutrient composition like proximal constituents, vitamins A, E, B_1, B_2, C, and dietary fibre. Based on the data generated, the daily nutrients/energy consumption by the soldiers/recruits, were calculated separately both for personnel in plains and at high altitudes. Soldiers in plains, on an average consumed protein 124.2 $\pm$ 13.0 g, fat 98.8 $\pm$ 29.6 g and energy 3632$\pm$317 kcal/person/day, while their counterparts at high altitudes consumed protein 120.4 $\pm$ 11.2 g, fat 120.1 $\pm$ 31.1 g, and energy 3906 $\pm$ 423 kcal/person/day. The study clearly indicate that the present ration scales for the Service personnel, both in plains and at high altitudes (9000 ft to 15000 ft) is adequate wrt their nutrient density. It is however suggested to ensure adequate supply of good quality fresh vegetables, fruits, and meat, which inturn would not only help to keep the morale of the soldiers, high and cheerful, especially at high altitudes, but will also enable adequate micronutrient availability. The fibre levels in the diets of these soldiers have also been found to be well within the limits (20 -35 g/ person/ day) recommended for optimal health.

Keywords: Ration scales, Armed Forces personnel, military personnel, nutritional requirments

1. INTRODUCTION

Of the three basic requirements of man, viz., food, clothing, and shelter, food plays a vital role, especially in the case of military personnel, as they have to be always in a fighting fit condition. The vigour/vitality as well as the zeal and enthusiasm with which a soldier discharges his duties, together with his body resistance to combat diseases, if any, or speedy recovery from injury/illness, depend on his nutritional status. Adequate nutrition is very essential to derive maximum benefits of training, during peak performances in operational situations, by keeping their morale high. The axiom that Army marches on its stomach is as good today as it has ever been. It is only now that the classical stomach rides in airplanes, ships, tanks, submarines, and jeeps in every terrain and climate of the world. But this does not imply that the problems of the Army stomach have entered the age of specialisation, which is increasingly evident as the story of the Army subsistence unfolds itself from early simplicity to the contemporary complexity of the military feeding programme.

Military nutrition has to be viewed differently from the civilian one, although the basic principles governing both are the same, since the former relates to soldiers, sailors, and airmen, who are exposed to different stressful situations like environmental-heat, cold, hypoxia, etc, and always lead a regimental and directed life. A uniform standard in the nutrient supplies/uptake is required to be ensured, be it during peace time/operational areas, to build up the physiological nutritional reserves, since the military personnel, especially in operational terrains, are often forced to subsist for days together on inadequate quantities of food or processed rations depending on logistics of the situation. In several instances, the soldier may have to forego his ration in preference to arms and ammunition into survive and discharge his duties, the efficiency of which depends on his body's nutritional reserves.

The ration scale formulated in as early as 1943 and modified subsequently in 1945, is being continued as the basic ration scale for soldiers at peace stations, with slight modifications off and on[1, 2, 24, 25 & 52]. Although the Indian Armed Forces pay considerable attention and accord high priority to feed their soldiers, sailors, and airmen, it is strongly felt that no sincere efforts have been put in to comprehensively review the existing food, nutrition, and dietary services, despite rapid advances made in this field over the past four decades.

In view of this, a detailed study was undertaken jointly by DIPAS, Delhi, and DFRL, Mysore, to assess the calorie requirements / nutritional status of Armed Forces personnel

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stationed at different terrains of the country and recruits at various training centres to examine the adequacy or otherwise of the existing ration scales and recommend modifications, if found necessary. Energy and nutrient requirements in plains and at high altitudes have been summarised in this study.

2. STUDY DESIGN AND METHODS

2.1 Volunteers and their Scale of Ration

The physical/physiological characteristics of the volunteers together with their dietary habits and lifestyles are given in Table 1.

2.1.1 In Plains

One hundred and twenty seven soldiers were randomly chosen from different Army Units representing all trades of the Army and belonging to 2 Infantry (20 Sikh and 18 Grenadiers) and 2 Support Groups (307 Field Ambulance –a Medical Unit and 118 Engineers) stationed at Ferozepur. The authorised ration scale of Army personnel of these units is given in Table 2.

2.1.2 At High Altitudes

One hundred and five soldiers chosen from Army units, including both Infantry (14 Mechanical Infantry, 9 Sikh, 2 Kumaon, and 13 Punjab) and Support Troops (802 Field Workshop, 202 Engineers) stationed at different locations (3500-4500 m above mean sea level, MSL) were selected for the study, and data were collected at Karu (3650 m above MSL) near Leh. The authorised ration scale of Army personnel stationed at altitudes ranging between 2700-4500 m is given in Table 3.

Written consent was obtained from each of the volunteers from plains/high altitudes after explaining the experimental protocol in detail and with an option to quit the study at any point of time.

2.2 Weather/Climatic Conditions

The studies were conducted from May to October 2003 at different locations, for three months at each site. The weather at Ferozepur was hot with the temperature ranging between 15.5 °C - 42.5 °C and relative humidity (RH) ranging between 79 per cent to 88 per cent. At Karu, it was cold with high velocity winds and cloudy atmosphere, which warranted a need for heavy clothing round the clock. The maximum temperature during the study period ranged between 10 °C–29 °C with the minimum not going below –4 °C.

2.3 Experimental Protocol

Several physical, physiological, biochemical, and nutritional investigations were carried out initially, to obtain baseline data, and again at the end of three month of the experimental period, to evaluate the associated changes in the various traits identified for the purpose. The scientific team from DIPAS, Delhi, stayed at the site with the volunteers/ troops during initial 10 days, and for another 10 days after three months of experimental period for evaluating the various parameters. However, the food intake record during the study period, in the absence of the scientific team, was maintained by the Medical Officer of the Unit assisted by the Mess Hawaldar.

3. ASSESSMENT OF FOOD / NUTRIENT INTAKE

The present study confines only to the study related to the various nutritional aspects. The food intake was evaluated by the inventory method, as described by Malhotra[2] *et al*. No separate kitchen arrangement was made for the volunteers. Instead, the *lungar* (Mess) to which the subjects were attached was monitored for the entire study period of three months and the mean daily food intake was computed, taking into account the total strength of the *lungar*. All raw food ingredients were weighed and issued. Wastage at this stage of issue was duly accounted for. Weighed quantities of the prepared meals–breakfast (B/F), lunch (L) and dinner (D) – were issued to the volunteers. Plate wastage was recorded. With these various figures, the quantity of food intake, in terms of raw ration, per person per day, was calculated. This value represented the average food intake of a soldier from the Unit as a whole.

Table 1. Food/living habits, and physical/physiological characteristics of the volunteers: in plains and at high altitudes

Total number of Soldiers	Food/living habits						Physical/physiological characteristics						
	Veg (%)	Non-Veg (%)	Alco-holic (%)	Non Alco-holic (%)	Smokers (%)	Non-Smokers (%)	Age (yr)	Body Mass Index (kg/m ^{2})	Mean body wt. kg	Mean blood pressure (mmHg) Systolic	Mean blood pressure (mmHg) Diastolic	Mean heart rate (beats/ min)	Physical fitness*
In Plains													
127	33	67	35	65	9	91	29.2 ± 6.8	22.8 ± 2.32	65.0 ± 7.5	116 ± 12	68± 10	72 ± 10	109± 14
At high altitudes-I													
105	29	71	37	63	24	76	27.5 ±5.7	22.8 ±2.2	64.5 ±11.0	127 ±12	78 ± 7	81 ±12	94± 13

* Physical fitness is a score obtained by Harward Step Test, wherein the person steps up and down on an 18" high wooden stool for five minutes or until exhaustion (whichever is earlier) and recovery heart rate is measured taking radial pulse. The test scores are always low at high altitude even for well acclimatised persons.

Table 2. Authorised/existing ration scale* for Army personnel stationed in plains [valid up to 9000 ft (SAI 7/S/74)]

Items	Quantity(g)
Aata *Aata + Rice* In lieu of items: biscuits + maida	620 220 + 400 490 + 60
Dal (Split legumes) or *Besan* + *Dal*	90 40 + 50
Oil hydrogenated or Refined oil	80
Milk fresh/blended/standard or milk tinned or Whole milk powder	250 ml. / 100 ml. / 36 g
Onion fresh or garlic once a week (if demanded) In lieu of onion spring green or vegetables fresh or onion dehydrated	60 / 20 100 / 90 / 7
Potatoes fresh or sweet potatoes / vegetables fresh / *arvi* / potatos tinned / vegetables tinned / dried peas / *dal* / flour / yam / dehydrated potatoes	110 110 /110 /110 /80 /60 /60 /60 /30 /110 /24.
Vegetables fresh or Vegetables tinned curried /*dal* for germinating / peas or beans dried / gram whole (white *kabuli*) / whole gram / beans dried (*lobia*)/ *rajma* or soyabean chunks	170 90 / 90 / 90 / 90 / 90 / 90 / 60.
Sugar or gur	90 / 110
Salt rock or salt evaporated	10 / 20
Tea or coffee	9 / 4
Condiments powder	16
For Non-vegetarians Meat fresh with bone or meat on hoof or Fish fresh / eggs / dahi / milk fresh / cheese / nutramul / meat tinned / fish tinned / milk tinned / skimmed milk powder / fowl (chicken live wt.) / fowl (chicken dressed) / pork fresh / whole milk powder / fish tinned curried / tuna chunks curried	 110 / 275 OR 3 / 170 / 220 ml. / 25 / 30 / 85 / 90 ml. / 60 / 156 / 78 / 90 / 32 / 85 / 85.
For Vegetarians Milk For Ovo-vegetarians: Eggs	 220 ml 3 Nos. (3 times/week)
Fruits fresh citrus/non-citrus or Fruits dried / fruits tinned / apple juice concentrate	110 / 230 or 28 / 90 / 35 ml

* 1. Although the ration scale comprised a variety of items, during the study period, the soldiers were given only the items/quantities highlighted above.

2. The ration provides-
   a. Macronutrients: Protein 136.7 g [(523 kcals or 12.8 % kcals.) For non-vegetarians 27 g is derived from the animal source]; Fat 117.8 g [1060 kcal or 25.9 % kcal.]; Carbohydrates 626.3 g [2505 kcal or 61.3 % kcal.]; Total Energy 4088 kcal.
   b. Micronutrients: Vitamin A–772 µg; Vitamin C–100 mg; Vitamin B_1–1.97 mg; Vitamin B_2–1.78 mg; Vitamin B_3–37.0 mg; Iron–49.0 mg; and Calcium–1365 mg.

The proximate composition of the ration issued/consumed was calculated using the standard literature values for various ingredients[2, 3]. To determine the actual intake of nutrients, the food samples of breakfast, lunch, and dinner were collected in duplicate from different volunteers separately but individually. Known quantities of samples thus obtained were homogenised individually and portioned into two to three fractions and stored in frozen condition with thymol as preservative, until analysed for various nutrients. One representative sample of each individual/group/category, totaling to about 100, was provided to DFRL, Mysore, in the frozen state for nutrient analysis.

Table 3. Authorised/existing ration scale* for Army personnel stationed at high altitudes [9000 ft. to 15000 ft. (SAI 2/S/72)] and their observed intake

Items	Qty. authorised (g)	Observed intake (g) (Mean ± SD)
Aata *Aata* + rice In lieu of *aata*, *papad* can be issued	570 140 + 430 28	257 ± 13 259 ± 14
Dal (split legume) Substitute (twice a week) Beans dried (*rajma*, red *channa*) / white *kabuli* / gram whole / peas dried	85 85 85 / 85 / 85 / 85	81 ± 5
Dal / *Besan*	30	
Oil hydrogenated or refined groundnut oil	80 (50 : 50)	84 ± 2
Butter tinned or butter fresh or oil hydrogenated	14 14	15 ± 3
Sugar	140	97 ± 26
Tea / coffee	14 / 6	14
Condiments powder	16 or cash allowance	
Salt evaporated	21	
Meat dressed AFD meat / meat tinned / fish tinned / fowl (chicken live wt.: two issues of daily ration / week) / fish tinned curried / tuna chunks curried / fowl (chicken dressed) / eggs / whole milk powder / skimmed milk powder / meat on hoof / cheese / nutramul	110 18 / 85 / 85 / 156 / 85 / 85 / 78 / 3Nos. / 32 / 32 / 275 / 25 / 30.	20.3 ± 17 11 ± 6
Eggs fresh In lieu of egg powder / fish tinned / meat tinned/ /skimmed milk powder For vegetarians: vegetables fresh / vegetables dehydrated / vegetables tinned / whole milk powder / milk tinned	1 No. 10 / 38 / 38 / 15. 60 / 7 / 30 / 15 / 40 ml.	½ 11
Milk tinned (evaporated / condensed: sweetened / unsweetened) in lieu of whole milk powder / cow's milk / standard milk / reconstituted milk / concentrated milk	100 ml. 36 / 250 ml. / 36.	467 ± 44
Whole milk powder milk tinned / concentrated milk / sweet milk powder	28 78 ml / 195 / 28	
Onion fresh In lieu of onion dehydrated / garlic (once weekly if demanded) / vegetables fresh	60 12 / 20 / 90	56 ± 3
Potato fresh In lieu of potato tinned / potato dehydrated / vegetable tinned.	140 90 / 30 / 70	114.8 ± 8 2.8 ± 1.0
Vegetable fresh In lieu of vegetables tinned / vegetables dehydrated / soybean chunks / kabuli chana / chana whole / beans dried (rajma) / lobia dried	170 90 / 20 / 60 / 90 / 90 / 90 / 90.	146 ± 19 19
Fruits fresh (citrus) In lieu of fruits tinned / fruits dried / apple juice concentrate.	60 50 / 15 / 15.	49
Copra (dried coconut) In lieu: cashew nut	4 4	
Raisins In lieu of cashew nut / chikki / walnut with shell / rewadi / dried dates / jam tinned.	4 4 / 10 / 15 / 25 / 15 / 13.	3.6 ± 0.3
Jam In lieu of golden syrup / sugar	14 14 ml. / 9	14 ± 0.5
Pickles / pickles without vinegar	15 / 15	20.3 ± 17 11 ± 6
Vitamin C tablet / orange powder	100mg / 17	½ 11

* 1. Although the ration scale comprised a variety of items during the period of study the soldiers were given only the items/quantities highlighted above.

2. The ration provides-
   a. Macronutrients: Protein 143.0 g [(572 kcal or 12.3 % kcal) For non-vegetarians 35 g is derived from the animal source]; Fat 144.0 g [1296 kcal or 27.7 % kcal]; Carbohydrates 699.0 g [2796 kcal or 60.0 % kcal]; Total Energy 4664 kcal.
   b. Micronutrients: Vitamin A–1658 µg; Vitamin C–93+100 mg; Vitamin B_1–2.15 mg; Vitamin B_2–2.41 mg; Vitamin B_3–37.0 mg; Iron–55.0 mg; and Calcium–1508 mg.

4. ASSESSMENT OF ENERGY EXPENDITURE/ REQUIREMENT

Indirect calorimetry based on oxygen consumption in different activities was used to compute energy expenditure. The daily activities of 24 h for seven days (24 x 7) were recorded by the soldiers in the time and motion proforma issued for the purpose. The mean time for different types of activities was computed. The energy cost of similar activities of Indian soldiers determined at DIPAS, under well controlled conditions were employed, and with the data generated in the field area, the energy expenditure was calculated. The energy requirement was determined on the basis of energy expenditure by making an allowance of 10 per cent for digestion, absorption, and kitchen/plate wastage.

4.1 Analysis of Food Samples

All the samples of food were analysed for various nutritional parameters, both at DIPAS, Delhi, and at DFRL, Mysore.

Energy values of the samples were evaluated using a computer-controlled bomb calorimeter (M/s Toshniwal Bros. Pvt Ltd, India). An automated nitrogen analyser (M/s Pelican Equipments, India) working on the principle of micro Kjeldhal method, was used for the determination of the protein content. Fat content was measured by the standard Soxhlet extraction method. The different vitamins content were analysed by the standard techniques[5] while mineral contents except phosphorous were evaluated using atomic absorption spectrophotometer (M/s Analytikjena, Germany), the facility available at DFRL, Mysore.

The samples received from DIPAS, Delhi, were analysed at DFRL, Mysore, for their proximal scores by the standard methods[6] of AOAC. Vitamins A, E, B_1, B_2, and C contents were estimated using the standard methods described[7-11] by Bureau of Indian Standards (BIS). Dietary fibre was estimated by the enzymatic-cum-gravimetric method of Asp[12], *et al*. as described by Prasad[13] *et al*. Phosphorous content was determined by the method of Gupta[14].

5. RESULTS AND DISCUSSIONS

The number of volunteers studied, both in plains and at high altitudes, their food habits and lifestyle, such as vegetarian or non-vegetarian, alcoholic or non-alcoholic, smoker or a non-smoker, and their physical/physiological characteristics are given in Table 1. The total numbers of volunteers in plains were 127 with 33 per cent vegetarians, 35 per cent alcoholic as per their entitlement, and 9 per cent smokers. On the other hand, the total numbers of volunteers at high altitudes were 105 with 29 per cent vegetarians, 37 per cent consumed liquor and 24 per cent smokers. The number of smokers was quite high at high altitudes, probably because of the prevailing low temperatures and non-conducive weather/climatic conditions. The mean age, bodyweight, body mass index (BMI), blood pressure, heart rate, and the physical fitness index of the volunteers of both the regions were similar except the physical fitness, which was found to be marginally low in case of the high altitude group. This is attributable to the low availability of oxygen at tissue level due to hypobaric hypoxia, although the volunteers were fully acclimatised.

The existing ration scales of the Army personnel stationed in plains (valid up to 2700 m) and at high altitudes (valid for heights between 2700 m to 4500 m above MSL) are given in Tables 2 and 3.

5.1 Nutritional Status in Plains

The macronutrients and micronutrients intake of soldiers as obtained by calculations using standard tables and based on the raw ration provided/entitled together with the actual analytical values of plate samples, are given in Table 4. Marginal differences were observed in the macronutrient data between the calculated values and the analytical values, which would be a result of the unavoidable errors creeping in while collecting/measuring the plate wastages and the analytical/experimental errors. Kitchen and plate wastages were minimum 0.5 per cent, and in some cases, as high as 4.0 per cent, especially in the case of vegetariens for vegetables and *chapati*, which was noticed to be due to hardening. The seven days plate samples collected during breakfast, lunch and dinner were pooled separately and analysed for their proximal score and the results obtained thereof are given in Table 4. The contents of each of the constituents including energy, expressed as per cent of

Table. 4 Proximal score of various food samples both in plains and at high altitude

Nature of meals	Moisture (%)	Total fat (%)	Total protein (%)	Crude fibre (%)	Total ash (%)	Carbohydrates (%)	Energy value (kcal/100 g)
In plains							
B-fast	63.4±8.5	7.4±1.6	5.2 ± 1.4	0.4± 0.1	1.2 ± 0.2	23.6± 5.9	182.5±41.4
Lunch	70.2±3.0	3.3 ± 0.9	4.6 ± 0.7	0.6 ± 0.3	0.8±0.0	20.3±2.11	130 ±16.02
Dinner	71.2±2.7	2.8 ±1.6	4.4 ± 0.8	0.4 ±0.2	0.8 ± 0.1	20.2 ±1.8	123.8 ±15.2
At high altitude							
B-fast	58.6±7.1	7.0±1.4	5.6±1.3	0.6 ±0.23	1.3±0.2	26.5 ± 4.6	192.8 ±33.4
Lunch	69.1±1.9	4.5±1.8	4.2 ± 0.3	0.6 ±0.1	0.9± 0.2	20.5± 2.3	139.7 ±14.4
Dinner	67.8±7.6	4.0±1.3	4.5 ± 0.5	0.8 ±0.3	0.9±0.3	1.8±5.5	141.5±32.8

Table 5. Macronutrients and micronutrients intake* per day of soldiers in plains

Nutrients	Intake	
	Calculated (values based on raw ration)	Actual values**
Energy (kcal)	3854 ± 344 @	3632 ± 317
Protein (g)	118 ± 41	124.2 ± 13.02
Fat (g)	115 ± 62	98.8 ± 29.6
Carbohydrates (g)	586 ± 23	565.6 ± 29.1
Vitamin A (µg)	575 ± 130	34.3 ± 9.0
Vitamin C (mg)	65 ± 22	15.0 ± 3.3
Thiamine (mg)	1.6 ± 0.3	2.03 ± 0.43
Riboflavin (mg)	1.5 ± 0.3	1.08 ± 0.19
Niacin (mg)	-	26.8 ± 6.4
Iron (mg)	-	34.7 ± 7.6
Calcium (mg)	-	1474 ± 318
Phosphorous (mg)	-	3190 ± 121
Sodium (mg)	-	8189 ± 180
Potassium (mg)	-	2679 ± 250
Zinc (mg)	-	13.58 ± 1.20
Copper (mg)	-	3.31 ± 0.5
Total dietary fibre # (g)	-	80.9± 4.2 (27.5± 1.5)

@ Energy contribution from carbohydrates 61%; fat 27%; and protein 12% .

** Obtained from analysis of plate samples

The values are on moisture-free basis. The insoluble soluble fractions are 62.2 ± 3.9 and 18.7 ± 2.7, respectively. The figure in parenthesis indicates the value on fresh weight basis.

the specific meal, are found to be comparatively higher during breakfast, both in plains as also at high altitudes.

5.2 Protein Intake

The World Health Organisation (WHO) recommends the total proteins to contribute 15 per cent of the dietary energy as the upper limit and 10 per cent as the lower limit. As per the recommendations for the Indian population, it is suggested that the energy derived from proteins should range between 8 per cent and 12 per cent to meet the needs of the biological system of any group. As seen, the average protein intake was 118 g/day (Table 5) which works out to be 1.8 g/kg/bodyweight contributing 12.3 per cent of the total energy.

It is believed that in the case of Army population, the protein intake from animal sources need not be hiked to maintain and buildup muscle mass and to combat with the stress of physical training[4]. Consumption of larger quantities of animal proteins in a single meal or in the usual dietary regimen is bound to induce higher losses of calcium ions in urine compared to the losses due to a diet containing minimal amounts of animal protein[16, 17]. The higher losses of calcium are attributable to increased acid or hydrogen ion generation arising from the amino acids present relatively in higher concentrations in the animal proteins or increased secretion of glucose- regulating hormones, including insulin and glucagons, following the consumption of protein-rich diet[18, 19]. Further, several, studies indicate that excessive consumption of proteins especially of animal origin are related to certain non-communicable diseases like bowel cancers, ischemic heart disease (IHD) and hypertension[1]. The animal proteins consumed by non-vegetarians as evaluated in the present study represents nearly 40 per cent of the total proteins, which appear to pose no concern.

On the other hand, proteins from the vegetarian (plant) sources are normally considered to be of inferior quality when consumed singly due to their deficiency in one or more of the essential amino acids such as lysine/threonine/ methionine/tryptophan. The relative biological value of a mixed protein of plant origin is 65 compared to 100 of standard egg protein. Several nitrogen-balance studies reported wrt Indian adults indicate that a minimum average intake of protein of good quality/mixed protein for nitrogen equilibrium ranges between 0.5–0.66 g/kg body weight. If the loss of nitrogen through sweat is also taken into account, the requirement works out to be 0.7 g/kg bodyweight. However, the corresponding safe level of consumption will be 0.88 g / kg bodyweight[15].

The quantity and quality of the protein consumed hitherto by the vegetarians is good and adequate since it is derived largely from cereals and a variety of pulses and legumes. The intake of proteins by non-vegetarians, with 40 per cent being derived from animal sources, is not only safe but also adequate. However, in view of stronger evidences building up in favour of vegetable foods and Vitamin A, Vitamin C and Vitamin E, *vis a vis,* proteins, the medical services should gradually work on the possibility of recommending changes whereby the protein allowances to some extent could be replaced by more of fresh yellow vegetables and citrus fruits, which will give more of antioxidant vitamins and vegetable fibre, now known to protect against ageing as well as a number of chronic diseases.

The consumption of meat and its substitutes was found to be less at different units while vegetables and milk were more than the authorised quantities. Our observations in the field area indicate that this shift in consumption of vegetarian items was probably due to the poor quality/ appearance of meat provided/received at the user end.

5.3 Fat Intake

Fat is well understood to be responsible for making the diet/ration of an individual not only calorie-dense but also enhances the palatability while increasing the bioavailability of lipid-soluble vitamins. The intake of fat (Table 5) in the present study was around 115 g/person/day (26.9 per cent of the total calories), which is well within the globally accepted limits of < 30 per cent of the total calories[20,21]. Presently, naturally occurring refined edible oils are being issued to/used by the Services, in view of the importance of their containing poly unsaturated fatty acids (PUFA) in relation to health. To maintain a well established and a desired ratio of saturated fatty acids to PUFA of 0.8 to 1.0 in the diets of the Army personnel, it is suggested the use of oils containing moderate amounts of linoleic acid (peanut oil, sesame oil, etc) or oils rich in PUFA (safflower, sunflower, cotton seed, corn oils) in conjunction with other oils having lower PUFA levels (palm oil). Alternatively, soybean/mustard

Table 6. Energy intake and energy expenditure of soldiers in different units in plains

Energy	307 Field Ambulance	20 Sikh	118 Engineers	18 Grenadiers	Mean
Intake (kcals/day)	3430 ± 210	4074 ± 156	4007 ± 250	4084 ± 195	3854 ± 344
Expenditure (kcal/day)	3078 ± 442	4034 ± 449	3660± 619	4017± 148	3511± 601

oil could also be used with other oils to derive the benefits of α-linolenic (n-3) fatty acid, which is known for its cardiac-protective property. However, this does not necessarily mean that the oils should be blended for the purpose, but the effect could be achieved using a wide variety of refined oils instead of being monotonous on a particular type/ brand[15].

5.4 Carbohydrate Intake

Carbohydrates are a more efficient energy/fuel source for a living organism. In the present scale, the energy derived from carbohydrates is about 2344 k cals/ person/day (586 g), which is equivalent to about 61 per cent of the total calories (Table 5).

Dietary fibre, which was all along considered to be an inert ingredient in food, is presently valued for its wide variety of therapeutic roles. The quantity of dietary fibre consumed by the subjects per day on an average is 80.9 ± 4.2 g on moisture-free basis, and is adequate as per the recommendations of the United States Food and Drug Administration and the National Advisory Committee in Great Britain, who suggest an intake[22, 23] of 20 – 35 g/day.

5.5 Energy Intake

The total mean energy intake of soldiers of various units together with their energy expenditure is shown in Table 6. The energy intake by various units ranged between 3430 kcals/person/day and 4084 kcals/person/day, the lowest being of 307 Field Ambulance Unit while the highest being of 18 Grenadiers. The energy expenditure was however not found to be proportional to the intake except in the case of 307 Field Ambulance Unit which was the lowest. The mean energy expenditure of the soldiers from all the units is 3511 ± 601 kcal/person/day as against the intake of 3854 ± 344 kcal/ person/day. On the basis of energy expenditure, the calculated energy requirements, taking into account losses through metabolic processes (6 per cent) and plate/kitchen wastages (4 per cent), works out to be 3862 kcals/person/day, with a range of 3385 to 4437 k cals/person/day. In earlier studies[24, 25] the mean expenditure of different units was found to be 3936 k cals/ person/day which indicates that there is no marked difference in the energy output of soldiers despite revolutionary modernisation/ mechanisation of the systems prevailing in the Army units, over a period of three decades. As per the recommendations of the ICMR[15] the energy requirement of men engaged in heavy work/activity is 3933 kcal/day and the same being applicable to our soldiers also, since they are engaged in rather strenuous activities throughout the year, the existing ration scale for plains contributing 4088 kcal, appears to be adequate wrt its protein, fat, and energy contents/values.

5.6 Micronutrients Intake

The intakes of micronutrients are given in Table 5. The vitamin A intake was 575 ± 130 µg retinol equivalents (RE)/ day, which is marginally lower than the RDA of 600 µg/day. Vitamin C intake was more than the RDA; 65 ± 22 vs 40 mg/ day. However, riboflavin and niacin intakes were found to be as per RDA suggested for heavy activity group[15]. Iron intake of 34.7 mg/day was slightly lower than the RDA levels, while zinc intake was high (19.8 Vs 15 mg/day). The lower intake of iron poses no concern since its bioavailability is higher due to the presence of larger amounts of vitamin C. However, calcium intake was 2.5-fold greater than the RDA levels. Since the bioavailability of calcium from Indian diets being poor due to the presence of large amounts of phytates and oxalates, which are known to reduce absorption and bioavailability of minerals[26-32], the higher intakes of calcium may not have any adverse effect.

Green leafy vegetables and fruits are the main sources of various vitamins and minerals, and hence, these are suggested to be supplied regularly on a varietal basis. In order to include variety in the supply of vegetables frozen peas, mushroom, etc. could be thought of, since these are available throughout the year due to the advancements made in the agricultural sciences/sector. The intake of fruits was observed to be nearly half the authorised quantity, probably because of poor supply due to the then prevailing higher costs. Condiments which were all along thought to be an important constituent of the Indian cuisine for their contribution towards taste and flavour, are now considered essential because of their antioxidant/ antimutagenic potential due to the presence of polyphenolics and aromatic compounds[33-38].

5.7 Nutritional Status at High Altitudes

The existing ration scale for soldiers stationed at high altitudes (9000 to 15000 ft above MSL) depicted in Table 3 provides 4664 kcals of which 60 per cent is derived from carbohydrates, 27.7 per cent from fats, and 12.3 per cent from proteins. The actual intake of energy through this ration was found to be 4180 ± 290 kcals/person/day (Table 7). The average energy requirement of ration on the basis of current energy expenditure is estimated to be 4268 k cals/ day, which is nearly identical to the observed energy intake during the study (Table 8).

5.8 Carbohydrates

High carbohydrate diets are generally recommended/ considered beneficial[39] for high altitudes since the Respiratory quotient (RQ) for carbohydrates is 1.0 as against 0.7 for fat. Carbohydrates provide higher yield of energy per mole of oxygen. The energy equivalent of oxygen for carbohydrates

Table 7. Macronutrients and micronutrient intake* per day of soldiers at high altitudes

Nutrients	Intake values*	
Energy (kcal)	4180 ± 290**	(3906 ± 423)
Protein (g)	104.4 ± 15.4	(120.4 ± 11.2)
Fat (g)	138.0 ± 12.4	(120.1 ± 31.1)
Carbohydrates (g)	630.0 ± 40.4	(581.4 ± 79.7)
Vitamin A (µg)	961.0 ± 184.0	(34.3 ± 9.0)
Vitamin C (mg)	117.0 ± 93.0	(15.0 ± 3.3)
Thiamine (mg)	1.5 ± 0.2	(2.03 ± 0.43)
Riboflavin (mg)	1.5 ± 0.2	(1.08 ± 0.19)
Niacin (mg)	25.5 ± 8.1	
Iron (mg)	24.07 ± 6.9	
Calcium (mg)	1303 ± 370	
Phosphorous (mg)	2360 ± 800	
Sodium (mg)	9876 ± 3206	
Potassium (mg)	10391 ± 3049	
Zinc (mg)	21.32 ± 3.78	
Copper (mg)	8.89 ± 1.9	
Total dietary fiber# (g)	77.2 ± 6.6	(25.5 ± 2.2)

* Based on 90 days data for macronutrients and 7 days Plate samples analysis for micronutrients.

** Energy contribution from carbohydrates 60.3 % (59.5 %); fat 29.7 % (27.6 %); and protein 10 % (12.3 %). Figures in parenthesis are the values obtained at DFRL, Mysore, while others at DIPAS, Delhi.

\# The values are on moisture-free basis. The insoluble and soluble fractions are 60.5 ± 4.2 and 16.7 ± 3.4 respectively. The figure in parenthesis indicates the value on fresh weight basis.

is 5.06 kcals/L as against 4.7 for fat, and 4.48 for protein[40]. Diets rich in carbohydrates have been proved to enhance glucose metabolism at high altitudes[41]. Studies on Indian residents at high altitude wrt their dietary habits reveal that nearly 60 per cent of their energy is derived from carbohydrates[42]. The dietary fibre, which is an important non-nutrient constituent in the diet of persons especially stationed at high altitudes consumption per day on an average is 77.2 ± 6.6 g on moisture-free basis, and appears adequate [RDA 20 – 35 g/day[22, 23]].

5.9 Fats

The observation indicates that fat intake is 138 ± 12.4 g as against the authorised quantity of 144 g/day (Tables 3 and 7). Higher fat intake at high altitudes is believed to pose problems in digestion since the metabolic processes require higher amounts of oxygen. One earlier studies[43] with acclimatised subjects have clearly indicated that fat content upto the level of 232 g/day is liked and well tolerated at altitudes between 3500 m to 4700 m. Several other controlled studies have also indicated no adverse effects of high fat diets on digestion[39, 44, 45]. The only disadvantage of high fat at altitudes is the cleaning problem of the vessels used for cooking because of its solidification/stickiness in the cold weathers. On the other hand, fat being calorie-dense, the total weight of ration to be provided remains considerably reduced. Due to logistic reasons, hydrogenated oil is the major source of fat even to date for high altitude regions. This needs to be replaced with refined oils as has been done in plains in view of the deleterious effects of long-term consumption of the trans-fatty acids contained by these[46-51].

5.10 Proteins

Protein intake of 1.6 g/kg bodyweight was found sufficient to maintain nitrogen balance. Soldiers expressed their dislike for both eggs and egg powder. Meat consumption was found to be low because of the poor quality resulted due to transport problems. For similar reasons, even vegetables supplied appeared to be of inferior quality. Milk intake, mainly in the form of tea due to cold weather conditions, was higher than the

Table 8. Energy intake and energy expenditure of soldiers in different units at high altitude

Energy	Unit 5						
	14 Mechanical Infantry	802 Field Workshop	202 Engineers	13 Punjab	2 Kumaon	9 Sikh	Mean
Intake kcal/day	4351 ± 280	4175 ± 390	4370 ± 245	4160 ± 350	3990 ± 520	3730 ± 215	4180±290
Expenditure kcal/day	3964 ± 342	3588±290	3803± 496	4011±285	4099±435	3825±474	3880±474

Table 9. Opinion of soldiers/ volunteers about the existing ration scale

Characteristics	Plains			High Altitudes		
	Satisfied (%)	Dissatisfied (%)	Neutral (%)	Satisfied (%)	Dissatisfied (%)	Neutral (%)
Quantity	33	62	5	38	60	2
Quality	29	69	2	41	55	4
Taste	16	79	5	38	57	5
Hygienic condition of *lungar*	57	39	4	65	33	2

authorised scale since the same was preferred for meat and meat products. Intake of pulses, hydrogenated oil, butter/ *desi ghee*, sugar, onion, jam, and fruits was as per the authorised scale. The fluid intake, which was low due to cold climatic conditions, could be improved by including tetra-pack juices and soups in the ration.

6. OPINION OF PARTICIPANTS

The opinion of the subjects, both in plains and at high altitudes, has been summarised in Table 9. It is observed from the present investigation that the existing ration scales for soldiers, both in plains and at high altitudes, are adequate wrt the nutrient density. However, the personal opinion of the soldiers regarding quantity/quality, etc indicate that a majority of them are dissatisfied. This opinion appears to be only psychological because, whenever any scientific team visits the Army units for trails of similar type, they are afraid that the team would recommend pruning of the ration scales. They also have a feeling that if they express their dissatisfaction, the ration scales would be improved. On the other hand the dissatisfaction could also be due to the monotonous nature of cuisines/dishes served everyday at the *lungars*. Hence, it is suggested to include variety in the menu by supplying different types of vegetables/ pulses/legumes/meat, etc. to keep the soldiers happy and cheerful.

7. CONCLUSIONS

This study clearly indicates that the present ration scales for the Service personnel, both in plains and at high altitudes (9000 to 15000 ft), are adequate wrt their nutrient density. It is, however, suggested that adequate supply of good quality fresh vegetables, fruits, and meat be ensured, which in turn would help to keep the morale of the soldiers, especially at high altitudes, still high and cheerful. In the present scenario of proven health benefits of natural antioxidants, their consumption could be increased through inclusion of herbal-based products in the ration. Replacement, partial if not total, of hydrogenated oils with refined edible oils in the high altitude ration scales should be considered on top priority.

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