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Nutrient Intake Optimization in Karnataka: A Linear Programming Approach§

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Abstract

The present study has analysed the food consumption pattern in the rural and urban areas of Koppal district of Karnataka. The study has assessed the present nutritional status and has suggested the optimal food-mix. The monthly per capita expenditure (MPCE) on both food and non-food items together has been found almost double in urban areas than in rural areas. In the rural areas, the MPCE is higher on food items than on non-food items, while in the urban areas, it is the reverse. The urban people consume less cereals and more pulses than their rural counterparts. Further, the expenditure on non-food items, especially on education, healthcare, insurance, etc. in the rural area has been found far from satisfactory. The consumption per capita per day of all the food items is higher (2750 g) in optimal food consumption plan as compared to the existing food consumption plan (860 g); the corresponding food expenditures were ₹ 45.18 and ₹ 28.19, respectively. At a cost of ₹ 45.18 per day per capita, the optimal plan ensures the dietary requirements in terms of energy (2425 kcal), protein (80.2 g), fats (61.5 g), carbohydrates (366.1 g), minerals (15.0 g) and fibres (26.6 g), through the consumption of jowar, greengram, groundnut, palm oil, sugar, milk, brinjal, methi, pomegranate, potato and dry chilli. Given the forced post-harvest sale of farm produce by the farmers for their cash needs, the study has suggested the need of educating them on the 'nutrition aspect', so that they appropriately use their farm produce for food and nutritional security. The study has also suggested that the policy aiming at achieving nutritional security should have different strategies for different income categories of households.

Key words: Nutrient intake, food consumption, linear programming, Karnataka

JEL Classification: D12

Introduction

India has achieved self-sufficiency in foodgrains production and has also improved its capacity to cope with year-to-year fluctuations in their production, but has yet to solve the problem of chronic household nutritional insecurity. Extremely high levels of malnutrition continue to exist, particularly in rural population. Women and children are most vulnerable to nutrient deficiency disorders. The optimal nutrition demands intake of a wide range of food items and a judicious combination of essential nutrients (Raghavendra *et al.*, 2014). As per the results of the 66th NSSO round, the proportion of chronically hungry households (not getting enough to eat during any month of the year) at the all-India level, was about 0.5 per cent in the rural areas and 0.1 per cent in the urban

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areas. To have food security and be adequately nourished, it is necessary to understand as to what constitutes an appropriate diet for healthy condition as well as the resources, skills and motivation to make good food choices. Developing policies and interventions to increase food security therefore requires an understanding of each of these factors, their inter-relationships and their relevance to particular groups of people.

The analysis of trends in the supply of dietary energy can help in assessing the adequacy of food supply, from which inferences about nutritional status can be drawn. Developing optimal food plan for the food insecure households may be needed to reduce the problems associated with the ignorance on nutritious and low cost food items faced by the poor rural households. The present study has analysed the food consumption pattern in the rural and urban areas of the Koppal district of Karnataka, has assessed the present nutritional status of the people in relation to the recommendations, and has suggested the optimal food-mix for minimizing food expenditure given the minimum nutrient requirements.

Data and Methodology

Data

Both primary and secondary data were used for the study. The secondary data were mainly collected from various published reports of the National Sample Survey Office (NSSO) during the period 1993-94 to 2009-10. The primary data pertaining to the year 2010-11 were collected through personal interview of sample respondents by using a well-structured and pre-tested schedule. The data on general information about the respondents, family size, age, education, occupation, sources of income, items of food purchased along with the frequency and quantity, money spent on different food items, place of purchase and such other details were obtained from them.

Multistage random sampling technique was employed for the selection of sample respondents. At the first stage, Koppal district was selected purposively. At the second stage, one village was selected from each of the four taluks of Koppal district. Finally, 15 respondents were selected from each selected village making 60 rural respondents. For selecting urban respondents, the city or the taluk headquarter was chosen and 15 respondents were selected randomly from each taluka, making a total of 60 urban respondents. Thus, in all, the study sample consisted of 120 households (60 rural and 60 urban).

The Model

Linear and non-linear programming models have been used to develop the optimum food consumption plans in human beings (Nicole *et al*., 2002). The present study has used linear programming model to develop the optimal food plan for rural and urban households of the Koppal district in Karnataka. The objective was to minimize per capita per day food expenditure subject to the constraints of energy requirement, the recommended dietary allowances (RDA) (as recommended by ICMR) and the desirable dietary pattern (as recommended by FAO). Further, in line with the United States Department of Agriculture (USDA, 2007), food items consumed by at least twenty-five per cent of the sample households were included in this analysis. Using FAO's specification for minimum requirements by quantity, protein, fats, carbohydrates and calories for 32 food commodities, a set of 15 constraints were formulated.

The final linear programming model used for estimating the minimum food expenditure to meet the recommended dietary needs of households was:

$$\text{Min } Z = P_j X_j \quad \ldots(1)$$

Subject to:

$$\Sigma a_{ij} X_j \geq b_i \quad (b_i = 2425 \text{ kcal for energy, 60 g for protein, 20 g for fat and 250 g for carbohydrates}) \quad \ldots(2)$$

$$\Sigma d_{gk} X_k = 970 \text{ kcal } (k = 1,2,\ldots,m), \text{ where, m= Number of cereals} \quad \ldots(3)$$

$$\Sigma d_{gk} X_k = 121 \text{ kcal } (k = m+1,\ldots,n, \text{ where, n–m= Number of pulses} \quad \ldots(4)$$

$$\Sigma d_{gk} X_k = 243 \text{ kcal } (k = n+1,\ldots,p, \text{ where, p–n= Number of oilseeds \& nuts} \quad \ldots(5)$$

$$\Sigma d_{gk} X_k = 73 \text{ kcal } (k = p+1,\ldots,q, \text{ where, q–p= Number of fats \& oils} \quad \ldots(6)$$

$\Sigma d_{gk} X_k$ = 194 kcal (k = q+1,…,r, where, r–q= Number of sugars & sweeteners) …(7)

$\Sigma d_{gk} X_k$ = 485 kcal (k = r+1,…,s, where, s–r= Number of animal products) …(8)

$\Sigma d_{gk} X_k$ = 41 kcal (k = s+1,…t, where, t–s= Number of vegetables in set-1) …(9)

$\Sigma d_{gk} X_k$ = 20 kcal (k = t+1,…,u, where, u–t= Number of vegetables in set-2) …(10)

$\Sigma d_{gk} X_k$ = 60 kcal (k = u+1,…,v, where, v–u= Number of fruits) …(11)

$\Sigma d_{gk} X_k$ = 121 kcal (k = v+1,…,w, where, w–v= Number of roots & tubers) …(12)

$\Sigma d_{gk} X_k$ = 97 kcal (k = w+1,…,x, where, x–w= Number of other items including beverages, spices, etc.) …(13)

Also,

$X_j \geq 0$ [Non-negativity restrictions] …(14)

where,

Z = Per capita per day food expenditure (₹),

X_j = Decision variable, namely average per capita per day consumption of food items (j=1,…,n),

P_j = Average market price per unit of food item consumed computed by the ratio of total expenditure on that item to total quantity consumed (j=1,…,n),

a_{ij} = The i^{th} nutrient content of the j^{th} food item,

b_i = Recommended dietary allowance of the i^{th} nutrient,

i = Corresponds to 4 nutrient constraints (energy, protein, fats, and carbohydrate)

j = 1,…,32 food items,

d_{gk} = The energy content of the k^{th} food item,

k = 1,2…,m; m+1,…,n; n+1,…,p; p+1,…,q; q+1,…,r; r+1,…,s; s+1,…,t; t+1,…,u; u+1,…,v; v+1,…,w; w+1,…,x; indicating number of food items in each food group, viz. cereals, pulses, etc.

The RHS of the constraint equations [namely, Equation (2) to Equation (13)] are the desirable contributions from various food items/groups to the energy intake (kcal), as suggested by the Desirable Dietary Pattern of FAO. For example, FAO suggests that nearly 40 per cent of the total energy intake of 2425 kcal/capita/day, that is about 970 kcal/capita/day, should come from cereals in the diet.

Results and Discussion

Changes in Monthly Per Capita Food Consumption in Karnataka

The data on food consumption in terms of physical quantity at two points of time (1993-94 and 2009-10) for rural and urban areas of Karnataka were available only for cereals and pulses. Between 1993-94 and 2009-10, the monthly per capita cereals consumption declined by 23.88 per cent in rural areas and 15.73 per cent in the urban areas (Table 1). Thus, the consumption of cereals has declined across all households in Karnataka. Such a phenomenon is explained by Murthy (2000) in terms of negative effect of taste and preferences more than offsetting the positive effect of income on cereals consumption in both rural and urban areas. The perusal of the composition of cereals group by individual commodities revealed that rice and jowar were the major cereals consumed in the state. Among these two, consumption of jowar has declined significantly, more so in rural (55.3%) than in urban (47.1%) areas.

The consumption of rice has declined in the urban areas (-13.32%), but has increased in the rural areas (3.86%). The wheat consumption has increased across both the groups — 29.41 per cent in rural and 10.26 per cent in urban areas. Bajra and maize constituted a negligible portion of the total cereals consumed in the state.

Between 1993-94 and 2009-10, the monthly per capita consumption of pulses increased from 0.78 kg to 1.39 kg in the rural areas and from 0.88 kg to 3.03 kg in the urban areas, depicting a rise of 78 per cent and 244 per cent in pulses consumption, respectively. Bengal gram, red gram and green gram are the three major pulses consumed in Karnataka. The red gram consumption has increased by 141 per cent in urban areas, and declined by 12 per cent in rural areas. Similarly, the consumption of Bengal gram has increased by 550 per cent in urban areas, and declined

Table 1. Food consumption pattern in rural and urban areas of Karnataka

(kg/capita/month)

Food items	Rural households			Urban households		
	1993-94	2009-10	Change, %	1993-94	2009-10	Change, %
Rice	5.44	5.65	3.86	6.38	5.53	-13.32
Wheat	0.85	1.10	29.41	1.56	1.72	10.26
Jowar	4.01	1.79	-55.36	1.72	0.91	-47.09
Bajra	0.11	0.03	-76.36	0.01	0.01	40.00
Maize	0.20	0.00	-100.00	0.04	0.00	-100.00
Other cereals	2.54	1.44	-43.31	1.16	0.99	-14.66
Total cereals	13.15	10.01	-23.88	10.87	9.16	-15.73
Bengal gram	0.10	0.07	-33.00	0.12	0.78	550.00
Red gram	0.32	0.28	-12.50	0.41	0.99	141.46
Green gram	0.09	0.28	211.11	0.10	0.35	250.00
Black gram	0.05	0.06	12.00	0.12	0.12	0.00
Other pulses	0.22	0.70	218.18	0.13	0.79	507.69
Total pulses	0.78	1.39	78.21	0.88	3.03	244.32

Source: NSSO Reports (various years)

by 33 per cent in rural areas. The green gram consumption has increased significantly in the state, more in urban (250%) than in rural (211%) areas.

A decline in the consumption of cereals was observed in both rural and urban areas of Karnataka (Pavithra, 2008). Wheat is the only cereal for which per capita consumption in urban areas exceeded that in rural areas of the state. Between 1993-94 and 2009-10, the per capita monthly consumption of wheat has increased from 0.85 kg to 1.10 kg in rural areas, and from 1.56 kg to 1.72 kg in urban areas. In addition to being rich in protein and low in fat content, wheat was available at PDS shops and had a lower price, and therefore, consumer choices shifted in favour of wheat. Higher per capita consumption of cereals in rural area was attributed to the factors like higher prices of milk, meat, vegetables, etc. Overall shift in terms of increased wheat consumption, green gram consumption and reduced coarse grain consumption during the study period was visible both in rural and urban areas. In the case of urban areas, consumption of bajra, bengal gram and red gram has slightly increased.

Share of Food Items in Total Food Expenditure in Koppal District

The share of different food items in total food expenditure in Koppal district is presented in Table 2 for the year 2009-10. The rural households spent maximum on consumption of cereals (35.51%), followed by milk and milk products (14.04%), edible oils (9.81%), eggs and meat (7.65%), fruits (5.08%), etc. In the urban areas also, cereals had the lion's share (32.80%) in the total food expenditure, followed by eggs and meat (13.38%), milk and milk products (11.37%), and vegetables (10.86%). The rural households spent least on spices, while urban households spent lowest on edible oils.

The percentage of total food expenditure on cereals and milk & milk products was found higher in rural than in urban areas. However, the percentage shares of total food expenditure on vegetables, and eggs and meat were higher in urban areas compared to in rural areas. Similar observations were made by Chourad and Kiresur (2013).

Share of Different Food Commodity Groups in Total Energy-intake of Households

The proportion of energy supplied by different commodity groups in the rural and urban areas of Koppal district is furnished in Table 3. In general, for the rural and urban households of Koppal district, cereals provided the highest energy (987 kcal/day/capita), followed by edible oils (214 kcal/day/capita),

Table 2. Share of different food items in total food expenditure of sample households in Karnataka, 2009-10

Food items	Rural households		Urban households	
	Consumption expenditure on food items (₹)	Percent of total food expenditure (%)	Consumption expenditure on food items (₹)	Percent of total food expenditure (%)
Cereals	380	35.51	387	32.80
Pulses	52	4.91	54	4.53
Oilseeds	26	2.33	15	1.23
Edible oils	105	9.81	102	8.63
Sugar and jaggery	54	5.03	46	3.86
Spices	16	1.51	23	1.91
Milk and milk products	150	14.04	134	11.37
Eggs and meat	82	7.65	158	13.38
Vegetables	148	3.88	128	10.86
Fruits	54	5.08	54	4.55
Others	3	0.25	81	6.88
Total	1069	100.00	1181	100.00

Source: Authors' analysis

Table 3. Share of different food commodity groups in total energy intake of sample households in Karnataka, 2009-10

Food items	Rural households			Urban households			All households		
	Energy derived (kcal/ day/ capita)	% to total	Rank	Energy derived (kcal/ day/ capita)	% to total	Rank	Energy derived (kcal/ day/ capita)	% to total	Rank
Cereals	975	51.56	1	1000	50.78	1	987	51.16	1
Pulses	67	3.53	7	73	3.69	7	70	3.61	7
Oilseeds	39	2.08	8	39	1.99	8	39	2.03	8
Edible oils	212	11.22	2	216	10.97	2	214	11.09	2
Sugar and jaggery	166	8.76	3	158	8.04	4	162	8.39	3
Spices	9	0.49	10	12	0.62	10	11	0.56	10
Milk & milk products	142	7.51	5	134	6.82	6	138	7.16	5
Eggs and meat	108	5.72	6	152	7.73	5	130	6.74	6
Vegetables	147	7.76	4	159	8.07	3	153	7.92	4
Fruits	26	1.37	9	25	1.29	9	26	1.33	9
Total	1891	100.00		1968	100.00		1930	100.00	

Source: Authors' analysis.

sugar and jaggery (162 kcal/day/capita), vegetables (153 kcal/day/capita), milk and milk products (138 kcal/day/capita) and eggs and meat (130 kcal/day/capita), pulses (70 kcal/day/capita), oilseeds (39 kcal/day/capita), fruits (26 kcal/day/capita) and spices (11 kcal/day/capita). In a similar study in Maharashtra, cereals were reported to be the major source of nutrients (Musebe and Kumar, 2002).

The ranks of commodities in terms of energy intake in rural areas exactly matched the overall district figures. However, in urban areas, the ranks 3 and 4 as well as 5 and 6 swapped each other when compared to overall district ranks. Thus, it could be seen that the total energy intake was much lower as compared to the recommended dietary allowances (RDA) suggested by the Indian Council of Medical Research. Further, it could also be seen that the pattern of energy sourcing did not completely satisfy the desirable dietary pattern (DDP) suggested by the Food and Agriculture Organisation (FAO).

Daily Intake, Prices and Consumption Expenditure of Selected Food Items

The daily intake per capita, mean prices and consumption expenditure of selected food items are presented in Table 4. The average price of a food item was computed by dividing the total expenditure on that item by the total quantity consumed of that item.

The food items consumed by all the households were wheat, red gram, sugar, tomato and onion in the urban areas and only onion in the rural areas. The per capita per day consumption of food items was slightly higher in urban areas (881 g) than in rural (845 g) areas, the district average being 862 g. The per capita per day expenditure was also higher in urban (₹ 31.07), than in rural (₹ 26.39) areas, the district average being ₹ 28.66. The per capita per day expenditure on individual food items varied from as low as ₹ 0.10 to as high as ₹ 4.83. The corresponding figures were ₹ 0.10 to ₹ 4.58 for rural areas and ₹ 0.11 to ₹ 5.09 for urban areas.

Shortfall in Energy Intake, Energy Derived per Rupee Spent and Nutritional Security Status

The present total energy intake per capita per day stood at 1891 kcal for rural households and 1968 kcal for urban households, the district average being 1930 kcal. These energy-intake levels accounted for 78 per cent and 81 per cent of the RDA, for rural and urban areas, respectively. The shortfall in energy intake was to the tune of 534 kcal for rural households and 457 kcal for urban households (Table 5). The food expenditure per day per capita of the sample households was ₹ 26.29 in the rural areas and ₹ 29.39 in the urban areas, the district average being ₹ 27.84. Now, let us find how much energy is derived from a rupee spent on food consumption in rural and urban areas? The energy derived per rupee spent was 69 kcal at the district level; the corresponding figure was slightly higher for rural areas (72 kcal) than for urban areas (67 kcal).

The nutritional-security status of the sample households was analysed in terms of 'Security Ratio', computed in terms of energy intake as a ratio of RDA. The household securing a ratio of > 1 was termed as 'Secured', while the household securing a ratio of < 1 was termed 'Insecured'. The insecure households were further classified into 'Moderately insecured', 'Mildly insecured' and 'Severely insecured' based on the security ratio falling in the range of 0.80 to 0.99, 0.50 to 0.79 and < 0.50, respectively.

In general, the majority of respondent-households (50%) were found mildly insecured, nearly 24 per cent were moderately insecured, nearly 8 per cent were severely insecured and about 17 per cent were secured. A similar pattern of nutritional security existed in the rural and urban areas of the district. The 'severely insecured' households mostly belonged to lower income groups. In a study on nutritional security of respondents across poverty categories in Karnataka, Kiresur *et al.* (2010) and Kiresur and Melinamani (2013) have observed that amongst the poverty categories, calorie intake was lower than the recommended calorie intake in the households falling in Below Poverty Line (BPL), poor- and middle-income categories, while it was higher in the case of rich categories.

Existing vs Optimal Food Consumption Plans

An 'optimal food consumption plan' meeting the RDA of ICMR and DDP of FAO was obtained by the linear programming model and the results, presented in Table 6, were compared with the 'existing food consumption plan'. In terms of quantity, the per capita

Table 4. Daily intake per capita, mean prices and consumption expenditure of food items

Items	% Households consuming			PCPDC*(g)			PCPDE*(₹)		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Cereals									
Rice	98	98	98	120.6	132.9	126.5	4.58	5.09	4.83
Wheat	97	100	98	48.6	62.3	55.2	1.71	2.48	2.08
Jowar	98	93	96	86.4	74.7	80.7	2.96	2.63	2.80
Pulses									
Redgram	98	100	99	11.6	12.3	11.9	0.88	0.96	0.92
Greengram	90	95	93	6.8	6.4	6.7	0.41	0.38	0.40
Oilseeds & nuts									
Groundnut	90	82	86	7.1	5.1	6.1	0.59	0.39	0.49
Fats & oils									
Palm oil	90	93	92	7.8	9.7	8.7	0.57	0.67	0.62
Groundnut oil	93	87	90	14.2	12.6	13.5	2.23	2.04	2.15
Sugars & sweeteners									
Sugar	97	100	98	33.1	29.4	31.3	1.08	0.96	1.02
Jaggery	95	98	97	7.1	8.5	7.8	0.22	0.28	0.25
Animal products									
Milk	93	88	91	101.8	104.5	103.1	3.37	3.40	3.38
Meat	50	58	54	7.1	10.3	8.6	1.63	2.27	1.92
Egg	37	42	39	63.6	91.5	77.1	0.30	1.35	0.81
Vegetables									
Tomato	98	100	99	24.8	22.7	23.8	0.65	0.53	0.59
Green chilli	97	90	93	8.4	8.0	8.2	0.31	0.29	0.30
Brinjal	90	87	88	23.6	20.9	22.3	0.42	0.39	0.41
Cucumber	87	82	84	11.9	12.5	12.1	0.38	0.37	0.37
Coriander	80	70	75	31.1	29.6	30.4	0.13	0.13	0.13
Curry leaves	80	70	75	24.3	28.9	26.5	0.10	0.12	0.11
Amaranthus	72	50	61	39.2	31.4	35.4	0.16	0.12	0.14
Methi	52	45	48	34.0	30.0	32.1	0.14	0.12	0.13
Palak	45	40	43	20.3	15.4	17.9	0.08	0.07	0.07
Clusterbean	27	48	38	3.2	6.4	4.7	0.10	0.20	0.14
Cabbage	23	30	27	3.9	5.3	4.6	0.11	0.15	0.13
Fruits									
Banana	95	90	93	21.6	20.6	21.1	0.93	1.09	1.01
Mango	97	90	93	1.6	2.7	2.1	0.09	0.13	0.11
Grapes	88	82	85	6.4	5.3	5.9	0.18	0.14	0.16
Pomegranate	55	62	58	4.2	4.8	4.5	0.10	0.11	0.10
Roots & tubers									
Onion	100	100	100	23.9	23.2	23.5	0.31	0.25	0.28
Potato	92	77	84	21.2	17.3	19.3	0.44	0.36	0.40
Garlic	80	65	73	5.9	5.3	5.6	0.18	0.13	0.15
Others									
Dry chilli	92	97	94	3.4	8.9	6.1	0.40	0.63	0.52
Grand total				**845.1**	**880.5**	**862.3**	**26.39**	**31.07**	**28.66**

*PCPDC = Per capita per day consumption; PCPDE = Per capita per day expenditure
Source: Authors' analysis.

Table 5. Shortfall in energy intake, food expenditure and nutritional-security status of respondents in Karnataka

	Particulars	Rural households	Urban households	All households
A	**Energy intake status**			
	• Present energy intake (kcal/day/capita)	1891	1968	1930
	• Percentage of RDA#	78.0	81.2	79.6
	• Shortfall from RDA (kcal/day/capita)	534	457	495
B	**Food expenditure**			
	• Food expenditure (₹ /day/capita)	26.29	29.39	27.84
	• Energy derived per rupee spent (kcal)	71.97	66.96	69.32
C	**Nutritional security status (% of households)**			
	• Secured (NSR*>1)	18.33	16.66	17.50
	• Moderately insecured (0.80<NSR<0.99)	26.67	21.67	24.17
	• Mildly insecured (0.50<NSR<0.79)	45.00	55.00	50.00
	• Severely insecured (NSR<0.50)	10.00	6.67	8.33

#RDA=Recommended dietary allowance
*NSR=Nutritional security ratio.
Source: Authors' analysis.

Table 6. Existing versus optimal food consumption plans by commodity groups

Food items	Food consumption	Daily per capita consumption		Nutrient contribution					
		Quantity (g)	Expen-diture (₹)	Energy (kcal)	Protein (g)	Fat (g)	Carbo-hydrate (g)	Minerals (g)	Fibres (g)
Cereals	Existing	262.4	9.63	906.30	23.67	3.10	195.82	3.54	2.59
	Optimal	277.9	9.64	969.87	28.90	5.28	201.76	4.45	4.45
Pulses	Existing	18.6	1.32	62.24	4.26	0.29	10.65	0.65	0.45
	Optimal	36.2	2.17	120.91	8.69	0.47	20.53	1.27	1.48
Oilseeds & nuts	Existing	6.1	0.49	34.59	1.54	2.45	1.59	0.15	0.19
	Optimal	42.9	3.43	243.24	10.85	17.20	11.20	1.03	1.33
Fats & oils	Existing	34.4	3.75	268.97	3.09	27.09	3.18	0.29	0.38
	Optimal	93.9	7.44	559.39	21.71	42.51	22.39	2.06	2.66
Sugars & sweeteners	Existing	87.0	7.17	544.92	3.15	40.60	41.71	0.37	0.38
	Optimal	142.6	9.03	753.21	21.76	42.51	70.80	2.11	2.66
Animal products	Existing	118.5	5.73	141.19	6.96	7.75	5.28	0.98	0.00
	Optimal	414.5	13.62	484.97	17.82	26.94	20.73	3.32	0.00
Vegetables	Existing	86.4	2.53	23.04	1.76	0.26	3.92	0.70	1.43
	Optimal	200.2	4.60	60.98	4.13	0.81	9.45	1.13	2.22
Fruits	Existing	36.8	1.47	35.45	0.44	0.09	8.24	0.26	0.34
	Optimal	92.3	2.11	60.00	1.48	0.09	13.38	0.65	4.71
Roots & tubers	Existing	46.3	0.83	35.79	0.83	0.05	8.05	0.25	0.25
	Optimal	124.7	2.67	120.96	2.00	0.12	28.18	0.75	0.50
Others (spices, etc.)	Existing	3.5	0.42	8.61	0.56	0.22	1.11	0.21	1.06
	Optimal	39.4	4.77	96.92	6.26	2.44	12.45	2.40	11.90
Grand total	Existing	865.0	28.19	1601.45	40.09	36.41	273.18	6.82	6.31
	Optimal	2750	45.18	2425	80.18	61.46	366.08	15.04	26.59

Source: Authors' analysis.

per day consumption of all food items was much higher (2750 g) in optimal food consumption plan than in the existing food consumption plan (865 g). The expenditure on each of the food items was also slightly higher in the optimal plan than in the existing plan. Hence, the per capita per day consumption expenditure on all the food items together was higher (₹ 45.18) in the optimal than in the existing plan (₹ 28.19).

At a cost of ₹ 45.18 per day per capita, the optimal plan ensures the dietary requirements in terms of energy (2425 kcal), protein (80.18 g), fats (61.46 g), carbohydrates (366.08 g), minerals (15.04 g) and fibres (26.59 g) as against the existing plan providing energy (1601 kcal), protein (40.09 g), fats (36.41 g), carbohydrates (273.18 g), minerals (6.82 g) and fibres (6.31 g). The optimal food consumption plan for sample-respondents includes jowar, greengram, groundnut, palm oil, sugar, milk, brinjal, methi, pomegranate, potato and dry chilli. The quantity suggested by the plan is highest in the case of milk (415 g), followed by jowar (278 g), brinjal (180 g) and potato (125 g), among others.

Conclusions

The study by conducting macro level analysis has indicated two things: (i) the monthly per capita expenditure (MPCE) on both food and non-food items together is much higher (almost double) in urban than in rural areas; and (ii) in the rural areas, the MPCE is higher on food items than on non-food items, while in the urban areas, it is the reverse. Thus, in the rural areas, the expenditure on non-food items, especially, education, healthcare, insurance, etc. needs to be enhanced through suitable measures including generation of awareness about quality of life. In physical terms too, the monthly per capita consumption was higher in the urban than in rural areas. The urban people consumed relatively slightly less cereals than their rural counterparts, while their intake of pulses was much more than in rural areas. Though the farmers produce these items, they sell their produce due to immediate cash needs; hence, they need to be educated on the 'nutrition front', so that they appropriately use their farm produce for balanced nutrition.

The decline in consumption of cereals during the past one decade coupled with steep rise in MPCE on cereals has indicated that rising prices of cereals, changing food preferences and life-style of households are the root cause of this phenomenon. The stability in food consumption and prices, especially in the rural areas, are of prime importance to ensure intake of a balanced diet. About four-fifths of the households have been food insecure to varying degrees. The nutritional security varies significantly across income groups. Therefore, the policies aiming at achieving nutritional security should have different strategies for different income categories of households. Compared with the desirable dietary pattern (DDP), the present nutrient-intake has been found short of the recommended dietary allowances. Insensitivity analysis has indicated that prices have a major role to play in determining the 'optimal food plan', given the nearly fixed nutrient content of food items. Hence, price stability and price policy conducive to attaining food security needs utmost attention.

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