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Dietary protein quality and lysine adequacy among urban casual labour households in Ludhiana City of Punjab, India

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Abstract

Protein quality, determined by indispensable amino acid composition and digestibility, is crucial for efficient utilization, with lysine being the primary limiting amino acid in cereal-based diets. In India, predominantly plant-based diets rely heavily on cereals for protein, which, despite meeting energy needs, often provide low-quality protein due to inadequate lysine and poor digestibility. Therefore, to identify major food sources contributing to protein and lysine intake and assess dietary protein quality in terms of lysine intake among fifty casual labour households of urban areas of Ludhiana City, Punjab, India, including construction and factory workers. An occupational group-based cross-sectional study was conducted using a household-level dietary assessment. Protein quality was evaluated using total protein intake, lysine intake, protein-energy ratio, protein-CHO ratio, food group contribution analysis, and nutrient adequacy indicators. Diets of urban casual labour households were predominantly cereal-based, with cereals contributing the largest share of total protein intake. However, cereals contributed a disproportionately lower share of lysine intake (1383.86 mg/d per capita). Although, total protein intake levels were low (25.68 g/d per capita) in several households, lysine intake was frequently adequate (76.3 to 95.0%) relative to reference requirements. Pulses, milk and milk products, and animal-source foods contributed a higher proportion of dietary lysine despite overall adequate consumption. Nutrient adequacy assessment revealed that lysine adequacy was more prevalent than total protein adequacy. Differences between construction and factory labour households were modest, with both groups exhibiting similar dependence on the same-quality protein sources. The study integrates lysine-based protein quality assessment with household-level dietary analysis in an understudied urban labour population, revealing a critical mismatch between protein quantity and amino acid adequacy in cereal-dominated diets, highlighting its novelty. Nutritional interventions and national food programmes should go beyond calorie adequacy and address protein quantity by improving access to lysine-rich foods such as pulses and dairy products to improve nutritional adequacy among vulnerable socio-economic populations.

1. Introduction

Adequate dietary protein intake is essential for the maintenance of muscle mass, metabolic health, and overall physiological function (Wolfe *et al*., 2017; Phillips, 2017). Beyond total protein quantity, the quality of dietary protein, assessed by its indispensable amino acid composition and digestibility, plays a critical role in ensuring efficient protein utilization (FAO, 2013; Food and Agriculture Organization, 2020). Among all indispensable amino acids, lysine is of paramount importance because it is typically the first limiting amino acid in cereal-based diets commonly consumed in low- and middle-income countries like India (Garg *et al*., 2018).

In India, dietary patterns are predominantly plant-based, with cereals contributing nearly half of total protein intake in both rural and urban populations (Indian Council of Medical Research-NIN, 2020; National Sample Survey Office, 2019). Although, such diets may fulfil energy requirements, they often provide protein of suboptimal quality due to low lysine content and reduced digestibility (ICMR-NIN, 2020). Previous estimates suggest that a large proportion of the Indian population remains vulnerable to protein quality deficiency despite adequate total protein intake (Swaminathan *et al*., 2012; Ritchie *et al*., 2018). This risk is particularly pronounced among socioeconomically vulnerable groups who rely heavily on inexpensive staple foods and have limited access to high-quality protein sources such as milk and animal-derived foods (Headey and Alderman, 2019).

Urban casual labourers represent one such nutritionally vulnerable population, characterized by irregular employment, low and unstable income, and physically demanding work (International Labour Organization, 2021). Casual labour households allocate a substantial proportion of their income to food, yet their diets are often cereal-dominated (NSSO, 2019). The combination of high occupational energy expenditure and poor dietary protein quality may increase the risk of lysine inadequacy, leading to inefficient protein metabolism, loss of lean body mass, and reduced work capacity (Pasiakos *et al*., 2015; FAO, 2013). Despite their economic and social importance in rapidly urbanizing settings, these populations remain underrepresented in nutrition research, particularly with respect to dietary protein quality and indispensable amino acid intake (Haddad *et al*., 2020).

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Lysine has multiple physiological roles beyond protein synthesis. It is involved in collagen and elastin formation, carnitine synthesis, calcium absorption, and immune function (Kalhan and Hanson, 2012; Brosnan and Brosnan, 2020). Suboptimal lysine intake has been associated with impaired muscle growth and maintenance, compromised bone health, and reduced nitrogen retention (FAO, 2013). Since excess intake of other amino acids cannot compensate for lysine deficiency, diets meeting recommended protein levels may still fail to support optimal health if lysine intake is inadequate.

Assessment of dietary protein quality using indicators such as protein-energy ratio, indispensable amino acid intake, and food-group contribution analysis provides a more accurate evaluation of nutritional adequacy than total protein intake alone (FAO, 2013; Wolfe *et al*., 2017). However, only a limited number of studies in India have applied these approaches among adult urban labour populations. Most existing research has focused on children, women, or rural communities, leaving a significant evidence gap regarding protein quality among urban working households (ICMR-NIN, 2020; Haddad *et al*., 2020). In addition, emerging evidence from plant-based nutrition research highlights the dual role of traditional plant foods in providing essential nutrients along with bioactive compounds that support metabolic health and disease prevention (Sharma *et al*., 2021; Singh *et al*., 2022).

Therefore, the present study focuses on evaluating dietary protein quality in terms of lysine intake among urban casual labour households. Specifically, it assesses total protein and lysine intake, evaluates adequacy relative to recommended requirements, and identifies the major food sources contributing to dietary protein and lysine. Since the current study integrates lysine-based protein quality assessment with household-level dietary analysis in an understudied urban labour population, it reveals a critical mismatch between protein quantity and amino acid adequacy in cereal-dominated diets, highlighting its novelty. The findings are expected to inform nutrition-sensitive urban food policies and interventions that move beyond calorie sufficiency toward improving protein quality among vulnerable labour populations, while also recognizing the phytomedicinal potential of plant-based diets (Kaur *et al*., 2020; Verma *et al*., 2021; Patel *et al*., 2023).

2. Materials and Methods

2.1 Study design and setting

A community-based cross-sectional study was conducted among urban casual labour households in Ludhiana City, Punjab, India. The study targeted labour households engaged in informal employment, primarily construction and factory work, characterized by low and irregular income.

2.2 Study sample

A total of 50 households of urban casual labourers were selected using purposive sampling. These included 25 construction labour households and 25 factory labour households. The surveyed households comprised 73 adult men, 59 adult women, and 77 children, allowing assessment of household-level and per-capita dietary intake.

2.3 Data collection

Data were collected through face-to-face interviews using a pre-tested structured questionnaire. The questionnaire captured socio-demographic characteristics, dietary intake, and household food consumption patterns. Pre-testing was conducted in ten households, which were excluded from the final analysis.

2.4 Dietary assessment

Dietary intake was assessed using a food inventory method at the household level. All foods and beverages consumed by household members were recorded, including quantities and ingredients used. Standard household measures were converted into gram weights using standardized conversion factors. Household food intake data were converted to per-capita daily intake using consumption unit factors. Nutrient intake was computed using Indian Food Composition Tables (Longvah *et al*., 2017) and DietCal software (Kaur, 2018).

2.5 Assessment of protein and lysine intake

Total dietary protein intake (g/day) was calculated for households and expressed on a per-capita basis. Intake of lysine and other indispensable amino acids (mg/day) was estimated using amino acid composition values of commonly consumed foods. Dietary lysine adequacy was evaluated by comparing observed intake with recommended reference values for adults, expressed as mg lysine per g protein intake. Protein quality was further assessed using the protein-energy ratio, calculated as the proportion of total dietary energy derived from protein.

2.6 Food group contribution analysis

The contribution of major food groups (cereals, pulses, milk and milk products, animal foods, and others) to total protein and lysine intake was calculated as a percentage of total intake. This analysis was used to identify dominant dietary sources and assess dependence on low-quality protein sources.

2.7 Nutrient adequacy assessment

Nutrient adequacy was evaluated using the nutrient adequacy ratio (NAR), calculated as the ratio of observed intake to recommended dietary allowance. Values greater than one were truncated to one to avoid overestimation. Overall dietary adequacy was summarized using the mean adequacy ratio (MAR), computed as the mean of individual NAR values.

2.8 Statistical analysis

Data were entered into Microsoft Excel and analysed using SPSS software. Descriptive statistics, including means and standard deviations, were calculated for dietary variables. Comparisons between occupational groups were performed using independent sample t-tests. Statistical significance was set at $p<0.05$.

3. Results

3.1 Socio-demographic profile of households

A total of 50 urban casual labour households were included in the study, comprising construction labour households (n=25) and factory labour households (n=25). Most households were nuclear families, with an average family size of three to five members. The majority of household heads were adult males, reflecting the male-dominated nature of casual labour employment. The mean age of household heads was in the economically productive adult age group.

Table 1: Socio-demographic profile of the selected households

Variable	Group I (n = 25)	Group II (n = 25)	Total (n = 50)
Family size			
< 2 members	00 (000)	05 (20)	05 (10)
3 to 5 members	21 (084)	18 (72)	39 (78)
> 5 members	04 (016)	02 (08)	06 (12)
Sex of respondent			
Male	22 (088)	24 (96)	46 (92)
Female	03 (012)	01 (04)	04 (08)
Age of household head (years)	39.62 ± 12.70	36.72 ± 9.71	38 ± 11.31
Family type			
Nuclear	25 (100)	21 (84)	46 (92)
Joint	-	04 (16)	04 (08)
The education level of the head			
Illiterate	05 (020)	01 (04)	06 (12)
Primary school	03 (012)	06 (24)	09 (18)
Middle school	09 (036)	07 (28)	16 (32)
High school	05 (020)	08 (32)	13 (26)
Intermediate/diploma	03 (012)	03 (12)	06 (12)
Religion			
Hindu	24 (096)	15 (60)	39 (78)
Sikh	01 (004)	08 (32)	09 (18)
Muslim	-	01 (04)	01 (02)
Christian	-	01 (04)	01 (02)
Caste			
General	05 (020)	07 (28)	12 (24)
Other Backward Classes	09 (036)	08 (32)	17 (34)
SC	11 (044)	10 (40)	21 (42)

Group I: Factory labour, Group II: Construction labour. Values in parentheses indicate percentage.

3.2 Household and per-capita energy and macronutrient intake

Mean household energy intake differed significantly between occupational groups, with factory labour households reporting higher intake (6653 ± 1155 kcal/d) than construction labour households (5899 ± 1366 kcal/d; $p<0.05$). However, at the per-capita level, construction labour households consumed significantly more energy (1674 ± 379 kcal/d) than factory labour households (1398 ± 228 kcal/d; $p<0.01$).

Per-capita protein intake was significantly higher among construction labour households (27.76 ± 6.10 g/d) compared with factory labour households (23.60 ± 4.10 g/d; $p<0.01$). Despite these differences, protein-energy ratios remained low and comparable across groups (6.7-6.9 g/100 kcal), indicating carbohydrate-dense dietary patterns. Per-capita fat and carbohydrate intake exceeded recommended levels in both groups.

3.3 Individual-level daily macronutrient intake of adults based on consumption unit

The individual-level daily intake of macronutrients and energy among adult males and females from factory labour (Group I) and construction labour (Group II) households, adjusted for consumption units, is presented in Table 3. Overall, construction labour adults showed marginally higher mean intakes of protein, fat, carbohydrates, and energy than factory labour adults; however, most intergroup differences were not statistically significant, except among females.

Among adult males, mean protein intake was slightly higher in Group II (35.74 ± 8.67 g/d) compared with Group I (33.33 ± 8.08 g/d). Similar non-significant trends were observed for fat, carbohydrate, and energy intake. Mean energy intake remained inadequate in both groups, with values of 2002 ± 459 kcal/d in Group I and 2084.94 ± 510.78 kcal/d in Group II. The protein-energy ratio was comparable between groups, indicating similar macronutrient distribution patterns.

Table 2: Household and per capita daily macronutrient intake

Household				
Nutrients (g/d)	**Group I (n=25)**	**Group II (n=25)**	**Total (n=50)**	**t values**
Protein	0113.2 ± 0025.2	0110.2 ± 0030.8	0111.7 ± 0028.2	1.62^{NS}
Carbohydrates	0855.2 ± 0135.7	0754.0 ± 0165.6	0804.6 ± 0151.4	2.36**
Fat	0308.9 ± 0081.7	0275.6 ± 0074.7	0292.3 ± 0078.3	1.52^{NS}
Energy (kcal)	6653.4 ± 1154.8	5898.8 ± 1365.9	6276.1 ± 1264.8	2.10**
Protein energy ratio (g per 100 kcal)	0006.9 ± 0001.2	0006.7 ± 0001.1	0006.8 ± 0001.1	0.73^{NS}
CHO/protein ratio	0007.7 ± 0000.9	0007.8 ± 0001.7	0007.8 ± 0001.3	0.30^{NS}
Per capita				
Protein	0023.6 ± 0004.1	0027.8 ± 0006.1	0025.7 ± 0005.6	2.82***
Carbohydrates	0179.6 ± 0027.1	0215.1 ± 0053.0	0197.3 ± 0045.4	2.98 ***
Fat	0065.0 ± 0016.7	0077.9 ± 0019.2	0071.5 ± 0018.9	2.52**
Energy (kcal)	1398.3 ± 0228.1	1673.7 ± 0379.3	1536.0 ±0339.2	3.11***
Protein energy ratio (g per 100 kcal)	0006.9 ± 0001.2	0006.7 ± 0001.1	0006.8 ± 0001.1	0.73^{NS}
CHO/protein ratio	0007.7 ± 0000.9	0007.8 ± 0001.7	0007.8 ± 0001.3	0.30^{NS}

Group I: Factory labour, Group II: Construction labour; Values are expressed in Mean ± SD; NS-Non -significant, *represents statistically significant at ($p<0.01$) level, **statistically significant at ($p<0.05$), ***statistically significant at ($p<0.1$), RDA 2024.

Among adult females, more pronounced differences were observed. Construction labour women had higher intakes of protein (25.76 ± 6.52 g/d), fat (74.82 ± 23.60 g/d), carbohydrates (199.48 ± 57.24 g/d), and energy (1574.48 ± 446.39 kcal/d) compared with factory labour women. Fat intake and energy intake were significantly higher among Group II females ($p<0.01$). The protein-energy ratio was significantly higher among factory labour women than construction labour women ($p<0.05$).

Per cent adequacy analysis revealed persistent inadequacy of energy intake across both occupational groups and sexes. Protein adequacy was lower among females, particularly factory labour women, while fat adequacy exceeded recommended levels in all groups. Despite higher macronutrient intake among construction labour adults, both groups, especially women, failed to meet recommended energy requirements, indicating suboptimal dietary adequacy even after adjustment for consumption units.

Table 3: Individual-level daily macronutrient intake on the basis of consumption units of adults

	Group	**Protein (g/d)**	**Fat (g/d)**	**Carbohydrates (g/d)**	**Energy (kcal/d)**	**Protein-energy ratio**	**CHO-protein ratio**
Adult Male	Group I (n=39)	0033.3 ± 008.1	0093.5 ± 029.9	0257.2 ± 054.7	2002.0 ± 459.1	0006.8 ± 001.2	0007.9 ± 000.9
	Group II (n=34)	0035.7 ± 008.7	0097.3 ± 024.5	0266.5 ± 073.4	2084.9 ± 510.8	0006.9 ± 001.2	0007.5 ± 001.6
	Total (n=73)	0034.5 ± 008.4	0095.3 ± 027.4	0261.5 ± 063.8	2041.0 ± 482.2	0006.8 ± 001.2	0007.7 ± 001.3
	t values	1.12^{NS}	0.59^{NS}	0.61^{NS}	0.72^{NS}	0.99^{NS}	0.30^{NS}
	RDA	54.0	40	130	2720	8.00	-
Adult Female	Group I (n=26)	0023.8 ± 004.0	0064.1 ± 017.6	0181.4 ± 034.9	1393.1 ± 275.2	0006.8 ± 001.1	0007.7 ± 001.0
	Group II (n=33)	0025.8 ± 006.5	0074.8 ± 023.6	0199.5 ± 057.2	1574.5 ± 446.4	0006.6 ± 001.3	0007.8 ± 001.5
	Total (n=59)	0024.9 ± 005.6	0070.1 ± 021.7	0191.5 ± 049.3	1494.5 ± 388.4	0006.6 ± 001.0	0007.8 ± 001.3
	t values	1.36^{NS}	1.93*	1.41^{NS}	1.81*	1.54^{NS}	0.57^{NS}
	RDA[1]	45.7	40	130	2110	8.6	-

Group I: Factory labour, Group II: Construction labour. Values are expressed in Mean ± SD; NS-Non -significant, *represents statistically significant at ($p<0.01$) level, **statistically significant at ($p<0.05$), *****statistically significant at ($p<0.1$), (RDA 2024).

3.4 Household and per capita daily intake of lysine and other indispensable amino acids

Mean household-level and per-capita daily intake of lysine and other indispensable amino acids are shown in Table 2. Lysine intake was consistently lower relative to other indispensable amino acids, reflecting its role as the limiting amino acid in cereal-dominated diets. When evaluated against reference requirements, a substantial proportion of households exhibited inadequate lysine intake, despite meeting or approaching total protein intake recommendations. This indicates compromised dietary protein quality rather than absolute protein deficiency.

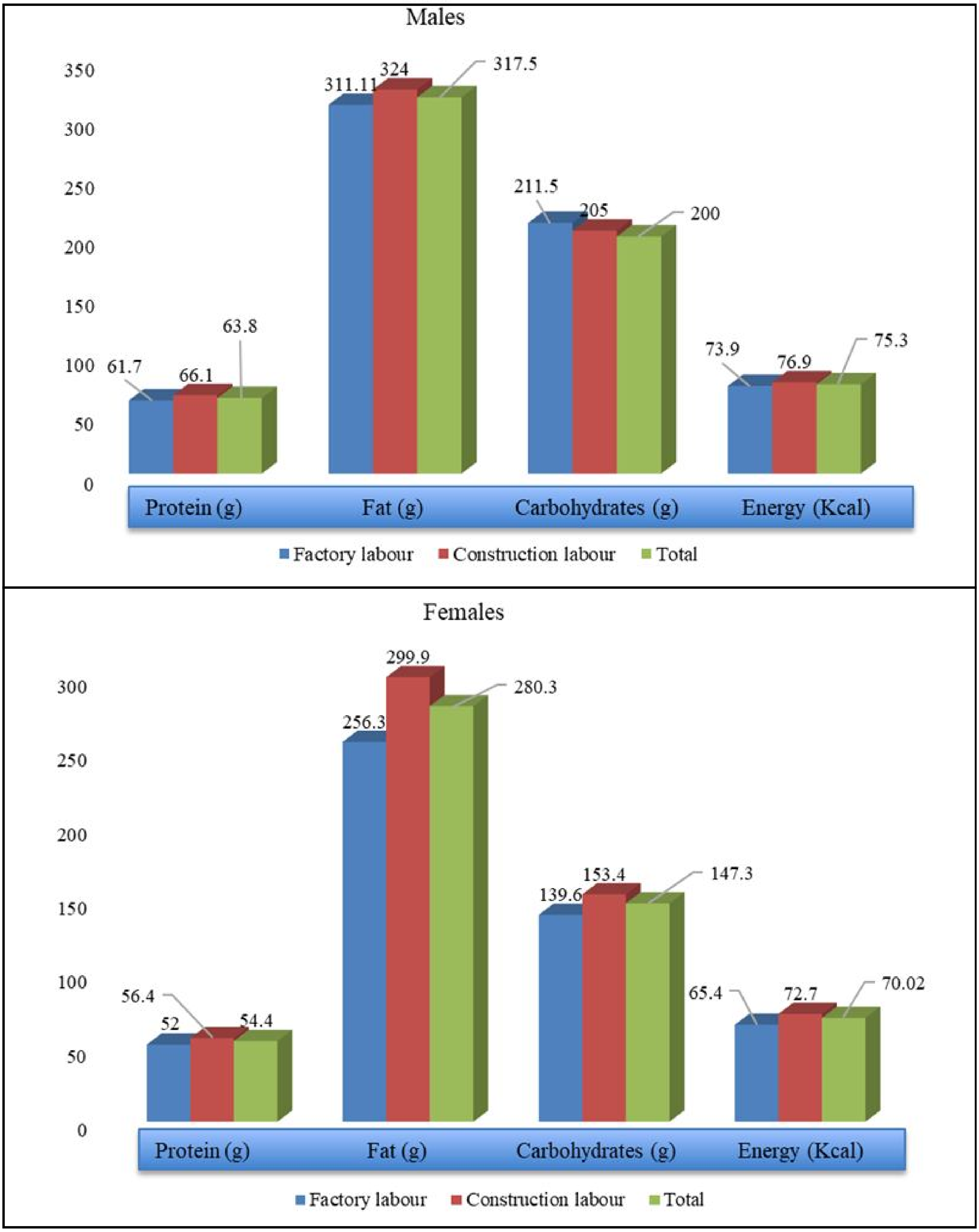

Figure 1: Per cent adequacy of individual-level daily macronutrient intake on the basis of consumption unit of adults.

Table 4: Household and per capita daily intake of indispensable amino acids (mg/d)

Amino acid(mg/d)	Group I (n = 25)	Group II (n = 25)	Total (n = 50)	t values
Household				
Lysine	05895.1 ± 01828.2	05622.4 ± 01971.3	05758.7 ± 01886.6	0.507NS
Histidine	03276.0 ± 01948.1	03143.7 ± 02297.7	03209.9 ± 02109.3	0.220NS
Leucine	06515.2 ± 02566.4	06420.1 ± 02389.5	06467.7 ± 02454.6	0.136NS
Isoleucine	03559.6 ± 01337.5	03240.2 ± 01044.0	03399.9 ± 01198.4	0.941NS
Methionine	02736.9 ± 01335.2	02460.8 ± 01392.4	02598.9 ± 01357.3	0.716NS
Threonine	02966.3 ± 01133.4	03189.0 ± 00982.5	03077.7 ± 01055.8	0.743NS
Tryptophan	00568.3 ± 00199.1	00546.1 ± 00206.4	00557.2 ± 00200.9	0.388NS
Valine	04091.6 ± 01552.9	03887.0 ± 01243.2	03989.3 ± 01396.1	0.514NS
Cystine	01568.4 ± 00891.3	01346.3 ± 00855.8	01457.4 ± 00872.0	0.899NS
Tyrosine	05280.9 ± 02222.7	05181.9 ± 01709.1	05231.4 ± 01962.9	0.177NS
Methionine + cystine	04305.4 ± 02083.8	03807.2 ± 02187.2	04056.3 ± 02129.2	0.825NS
Phenylalanine + tyrosine	09961.5 ± 03846.5	09494.8 ± 03374.4	09728.2 ± 03588.8	0.456NS
Total EAA	41707.3 ± 15582.2	39896.5 ± 14991.3	40801.9 ± 15160.4	0.419NS
Per capita				
Lysine	01227.7 ± 0353.0	01540.0 ± 0284.0	1383.9 ± 0354.4	3.445***
Histidine	00666.1 ± 0363.8	00807.1 ± 0352.0	0737.2 ± 0361.5	1.39NS
Leucine	01353.8 ± 0502.6	01762.1 ± 0409.4	1558.3 ± 0498.5	3.155***
Isoleucine	00756.7 ± 0327.5	00907.2 ± 0236.4	0831.9 ± 0292.8	1.863*
Methionine	00581.9 ± 0317.9	00655.5 ± 0217.6	0618.7 ± 0272.1	0.954NS
Threonine	00620.0 ± 0231.7	00894.5 ± 0255.4	0757.3 ± 0278.3	3.979***
Tryptophan	00119.0 ± 0041.4	00151.6 ± 0042.8	0135.3 ± 0044.9	2.738***
Valine	00854.8 ± 0307.9	01087.1 ± 0275.4	0970.9 ± 0312.0	2.812***
Cystine	00325.4 ± 0188.4	00352.4 ± 0172.4	0338.9 ± 0179.2	0.528 NS
Tyrosine	01093.2 ± 0426.5	01443.2 ± 0354.9	1268.2 ± 0426.6	3.153***
Methionine + cystine	00907.4 ± 0476.3	01007.8 ± 0350.2	0957.1 ± 0416.8	0.849 NS
Phenylalanine + tyrosine	02073.7 ± 0764.3	02625.1 ± 0641.4	2349.4 ± 0751.8	2.763***
Total EAA	08698.6 ± 3130.3	10935.3 ± 2490.2	9816.9 ± 3018.7	2.796***

Group I: Factory labour, Group II: Construction labour. Values are expressed in Mean ± SD; NS-Non -significant, *represents statistically significant at (p<00.1) level, **statistically significant at (p<0.05), ***statistically significant at (p<0.1).

3.5 Individual-level daily indispensable amino acid intake by adults on the basis of the consumption unit of adults

The individual-level daily intake of indispensable amino acids among adult males and females from factory labour (Group I) and construction labour (Group II) households, adjusted for consumption units, is presented in Table 4. Overall, construction labour adults exhibited consistently higher intake of most indispensable amino acids compared with factory labour adults, with several differences reaching statistical significance.

Among adult males, lysine intake was significantly higher in Group II (2023.67 ± 452.47 mg/d) than in Group I (1751.92 ± 565.27 mg/d) (p<0.05). Group II males also showed significantly higher intake of leucine, threonine, and total essential amino acids (EAA) (p<0.05), while tryptophan, valine, and phenylalanine + tyrosine showed marginal significance (p<0.01). No significant intergroup differences were observed for histidine, isoleucine, methionine, cystine, or methionine + cystine.

Among adult females, indispensable amino acid intake was uniformly lower than that of males; however, construction labour women consistently demonstrated significantly higher intake than factory labour women for most amino acids. Lysine intake showed the most pronounced difference (1470.48 ± 297.25 mg/d vs. 1191.10 ± 312.44 mg/d; p<0.01). Significant differences were also observed for histidine, leucine, isoleucine, methionine, threonine, tryptophan, methionine + cystine, phenylalanine + tyrosine, and total EAA (p<0.05-0.01). Cystine intake did not differ significantly between groups.

Per cent adequacy analysis (Figure 2) revealed higher lysine adequacy among construction labour adults compared with factory labour adults across both sexes. However, lesser adequacy was observed among factory labour women, identifying lysine as the primary limiting amino acid in this population. Despite higher overall amino acid adequacy among construction labour households, shortfalls persisted for tryptophan and valine, indicating selective indispensable amino acid gaps.

Table 5: Individual-level daily indispensable amino acid intake by adults on the basis of the consumption unit of adults

Male					
Amino acid	**GROUP 1 (n=39)**	**GROUP II (n=34)**	**TOTAL(n=73)**	**t test**	**RDA**
Lysine (mg/d)	01751.9 ± 0565.3	02023.7 ± 0452.5	01878.5 ± 0530.2	2,24**	01975
Histidine (mg/d)	00970.8 ± 0507.1	01142.2 ± 0428.6	01050.6 ± 0520.8	1.14NS	00975
Leucine (mg/d)	01943.9 ± 0746.3	02343.7 ± 0575.7	02130.1 ± 0697.3	2.53**	02535
Isoleucine (mg/d)	01098.4 ± 0506.8	01173.4 ± 0323.9	01133.2 ± 0430.2	0.74NS	01300
Methionine (mg/d)	00852.1 ± 0480.2	00872.9 ± 0330.5	00861.8 ± 0414.6	0.24NS	00655
Threonine (mg/d)	00880.1 ± 0354.5	01171.3 ± 0360.7	01015.8 ± 0383.1	3.47***	00975
Tryptophan (mg/d)	00170.2 ± 0063.3	00197.3 ± 0056.2	00182.8 ± 0061.2	1.92*	00260
Valine (mg/d)	01219.7 ± 0467.9	01426.5 ± 0412.3	01315.9 ± 0451.9	1.98*	01690
Cystine (mg/d)	00476.6 ± 0269.1	00475.4 ± 0206.3	00476.0 ± 0240.3	0.20NS	00260
Methionine + Cystine (mg/d)	01328.6 ± 0706.3	01348.4 ± 0503.9	01337.8 ± 0616.2	0.13NS	00975
Phenylalanine + Tyrosine (mg/d)	02974.7 ± 1153.6	03463.2 ± 0921.8	03202.3 ± 1073.3	1.97*	01625
Total EAA (mg/d)	12508.7 ± 4699.3	14486.9 ± 3562.8	13430.1 ± 4296.5	2.00**	119600
Female					
Lysine (mg/d)	1191.1 ± 0312.4	01470.5 ± 0297.3	1347.4 ± 0332.3	3.5***	01767
Histidine (mg/d)	0639.8 ± 0332.5	00835.5 ± 0217.8	0749.2 ± 0363.9	2.11**	00825
Leucine (mg/d)	1304.6 ± 0426.1	01687.9 ± 0415.6	1519.1 ± 0458.7	3.47***	02145
Isoleucine (mg/d)	0688.7 ± 0208.4	00853.4 ± 0217.8	0780.8 ± 0227.4	2.93***	01100
Methionine (mg/d)	0512.2 ± 0191.1	00658.5 ± 0218.2	0594.0 ± 0217.7	2.69***	00550
Threonine (mg/d)	0597.9 ± 0174.5	00839.4 ± 0245.6	0733.0 ± 0247.1	4.23***	00825
Tryptophan (mg/d)	0113.9 ± 0034.5	00145.3 ± 0040.3	0131.5 ± 0040.8	3.31**	00220
Valine (mg/d)	0819.9 ± 0271.9	01014.1 ± 0256.4	0928.6 ± 0278.5	2.81*	01430
Cystine (mg/d)	0304.7 ± 0175.3	00358.6 ± 0170.4	0334.9 ± 0222.1	1.11NS	00220
Methionine + Cystine (mg/d)	0816.9 ± 0338.7	01071.2 ± 0351.1	0928.9 ± 3058.1	2.20**	00825
Phenylalanine + Tyrosine (mg/d)	1982.1 ± 0671.6	02501.9 ± 0633.2	2272.9 ± 0695.3	3.04***	01375
Total EAA (mg/d)	8296.0 ± 2595.1	10510.6 ± 2496.8	9522.8 ± 2757.2	3.36**	10120

Group I: Factory labour, Group II: Construction labour, Values are expressed in Mean ± SD; NS-Non -significant, *represents statistically significant at (p<0.01) level,**statistically significant at (p<0.05), ***statistically significant at (p<0.01),[1]RDA 2024.

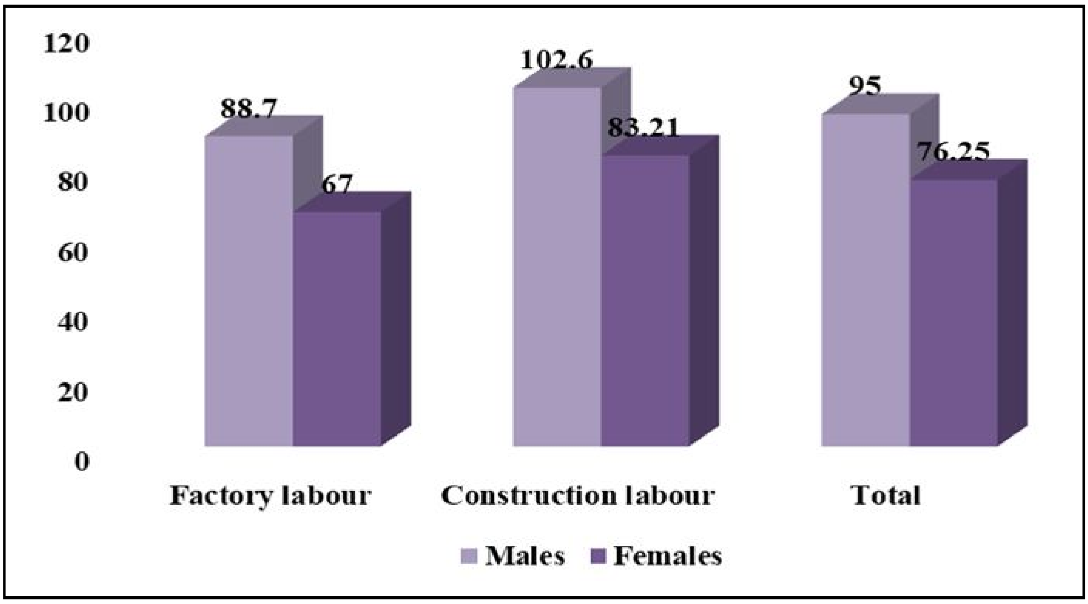

Figure 2: Per cent adequacy of lysine intake on the basis of consumption unit of adults and females.

3.6 Contribution of food groups to protein and lysine intake

The relative contribution of major food groups to total protein and lysine intake is presented in Table 3. Cereals emerged as the dominant source of dietary protein, contributing more than half of total protein intake across households. However, cereals contributed a disproportionately lower share of lysine intake. In contrast, pulses, milk and milk products, and animal-source foods, though consumed in smaller quantities, contributed a higher proportion of dietary lysine relative to their protein contribution. This highlights the importance of these food groups in improving dietary protein quality.

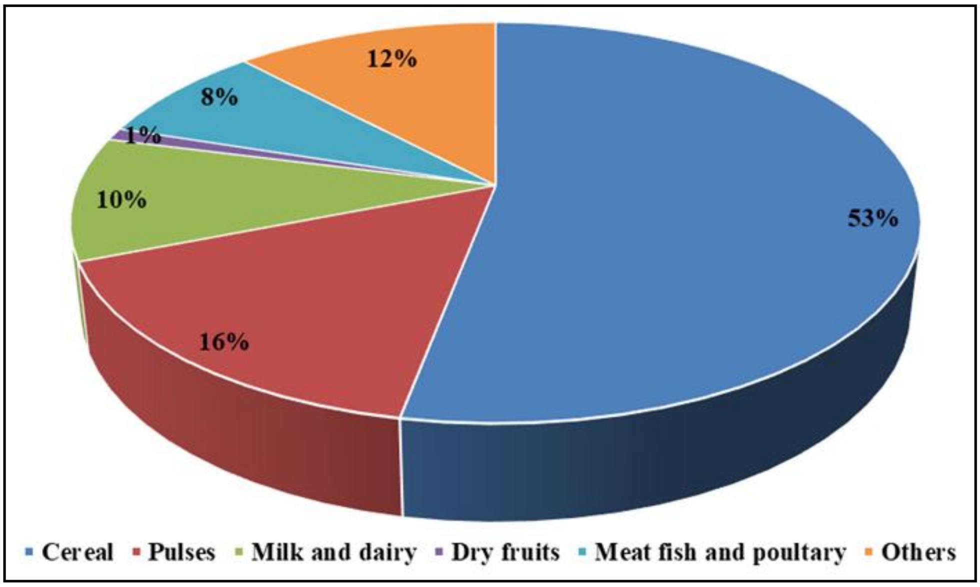

Figure 3: Per cent contribution of food groups to protein.

3.7 Nutrient adequacy assessment

The distribution of households according to nutrient adequacy ratio (NAR) categories is shown in Table 5. While adequacy for total protein intake was moderate in several households, lysine adequacy was markedly lower, with a significant proportion of households falling into the marginally inadequate or inadequate categories. The mean adequacy ratio (MAR) values reflected overall optimal dietary quality, driven primarily by adequate intake of indispensable amino acids.

3.8 Occupational differences in protein and lysine intake

Comparisons between construction and factory labour households revealed differences in dietary intake patterns. Factory labour households tended to have marginally higher protein and lysine intake than construction labour households; however, reliance on cereals as the primary protein source remained high in both groups.

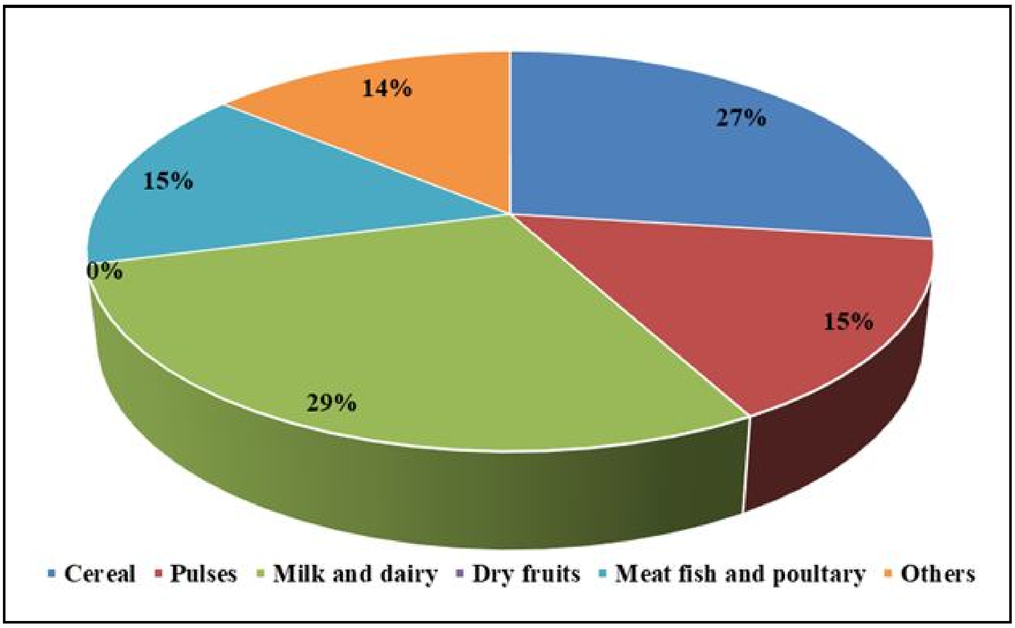

Figure 4: Per cent contribution of food groups to lysine.

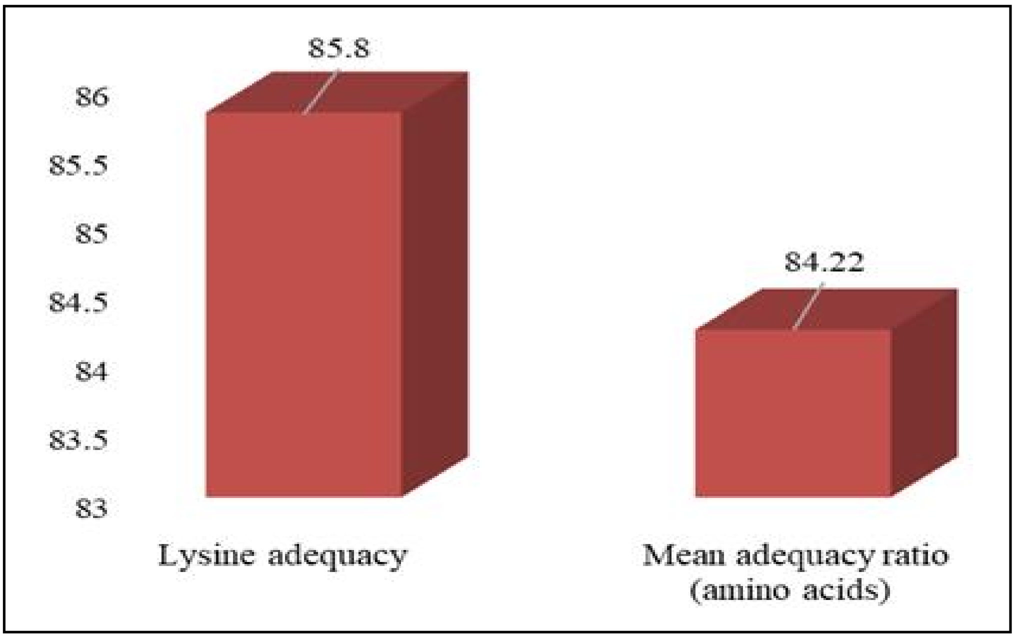

Figure 5: Protein quality among urban casual labourers.

4. Discussion

The present study examined dietary protein quality among urban casual labour households, with particular emphasis on lysine intake as the principal limiting indispensable amino acid in cereal-based diets. The findings demonstrated that although total protein intake approached recommended levels in several households, dietary protein quality remained suboptimal, but lysine intake remained adequate. This observation reinforces earlier evidence indicating that low protein quantity cannot ensure nutritional adequacy when indispensable amino acid balance is normal (FAO/WHO/UNU, 2007).

A dominant reliance on cereals as the primary protein source was evident across both occupational groups. While cereals contributed substantially to total dietary protein, their contribution to lysine intake was disproportionately low, reflecting the inherent amino acid profile and lower bioavailability of cereal proteins (Gilani *et al*., 2005; Rutherfurd *et al*., 2012). This explains why households with near-adequate protein intake still exhibited lysine inadequacy, supporting the concept of "hidden protein malnutrition" reported in Indian and other plant-based dietary contexts (Minocha and Kurpad, 2019).

Construction labour households demonstrated relatively higher per-capita protein and lysine intake compared with factory labour households; however, the overall protein-energy ratios remained low in both groups, indicating persistent carbohydrate-dense dietary patterns. These findings suggest that occupational category alone did not substantially mitigate poor protein quality when dietary diversity remained limited. The consistently lower lysine intake observed among women, particularly factory labour women, is nutritionally concerning, as lysine inadequacy has been associated with impaired nitrogen retention, reduced muscle maintenance, and diminished work capacity in physically active populations (Millward and Jackson, 2004; Lemon, 1996).

Food-group contribution analysis highlighted the nutritional significance of pulses, milk and milk products, and animal-source foods, which provided a disproportionately higher share of dietary lysine despite lower consumption quantities. Similar patterns have been documented in Indian diets, where modest inclusion of lysine-rich foods markedly improves overall protein quality (FAO, 2013; Minocha *et al*., 2017). However, economic constraints, irregular income, and rising food costs likely restricted access to these foods among urban casual labour households, reinforcing dependence on low-cost cereal staples (Darmon and Drewnowski, 2008).

Overall, the findings underscored a critical gap in urban nutrition strategies. While food subsidy programmes and dietary guidelines have traditionally prioritised calorie sufficiency, the present study highlighted the need to explicitly incorporate protein quality and indispensable amino acid adequacy into nutrition policies. Improving access to affordable lysine-rich foods may contribute to better protein utilisation, enhanced functional capacity, and improved nutritional resilience among urban casual labour populations (Aggarwal and Bains, 2020).

5. Conclusion

The study concludes that urban casual labour households are at significant risk of poor dietary protein quality, primarily due to inadequate lysine intake, despite near-adequate total protein consumption. Cereal-dominated diets contribute substantially to protein intake but fail to provide sufficient lysine, limiting effective protein utilization. Improving access to lysine-rich foods such as pulses, milk, and other high-quality protein sources is essential to address this form of hidden protein malnutrition. Nutrition policies and urban food programs should move beyond calorie-based approaches and explicitly incorporate protein quality and indispensable amino acid adequacy as core objectives. Targeted interventions aimed at improving dietary diversity and affordability of high-quality protein foods may contribute to better health, work capacity, and nutritional resilience among urban casual labour populations.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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