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Analyzing Food Consumption Patterns in Rural Areas of Iran: Identifying Provinces with Standard and Homogeneous Consumption

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Abstract

Investigating food consumption patterns in rural areas of Iran is necessary to understand the state of food security and social health in the country. Identifying provinces with standard and homogeneous consumption patterns not only helps improve planning to meet food needs, but also can lead to the formulation of appropriate and effective policies to address issues related to nutrition and public health. This study examined: (i) the current food consumption patterns in rural areas of Iran in 2023, compared to the standard dietary pattern; (ii) the ranking of provinces based on the similarity of their dietary patterns to the standard; (iii) the identification of similar food consumption patterns across rural regions in different provinces; and (iv) the relationship between food consumption patterns and the infrastructural, economic, and social indicators of the provinces. The methodology of this study includes statistical analysis tools, such as TOPSIS method and k-means clustering technique. The results showed that the current dietary pattern of households in rural areas of Iran mainly consists of various types of cereals, providing more than 60% of an adult's daily calorie intake. Comparing, global scale, cereals provide 50% of daily calories intake, averagely, varying from 30% to 55% and 70% in high, middle, and low-income societies, respectively. We found that food consumption in rural areas of Iran does not necessarily align with the standard pattern, meaning 28.4% lower food items than required in the standard basket, and 16% less than standard energy requirements. For instance, the consumption of bread was more than recommended level while the share of dairy products, fruits, and red meat, was 64.4%, 52.1%, and 50% lower than the recommended amount, respectively. While the dietary patterns in rural areas of six provinces - Chaharmahal and Bakhtiari, Markazi, Isfahan, Hamedan, Zanjan, and Mazandaran - satisfied the standard dietary. The converse evidence was observed for Hormozgan, Semnan, Kerman, North Khorasan, Ilam, and Sistan-Baluchestan. Between comparison of provinces confirmed (i) a heterogenous consumption pattern, mostly, dominated by five types of behavioral patterns; (ii) non-significant effect between consumption pattern and geographical distribution; (iii) a more desirable consumption pattern depending on more suitable infrastructure, economic, and social indicators. To deal with the undesirable consequences of calorie shortage and non-standard consumption pattern, this study suggests a comprehensive plan regulating supportive policies, public awareness, sustainable agriculture, and educational programs about nutrition and market access. Nutrition in rural regions is influenced by economic, regional, social, cultural, and individual factors, and improving dietary health necessitates addressing these interconnected elements.

Keywords: Calorie intake, Dietary preferences, k-means clustering, Rural households, Standard food basket, TOPSIS method

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Introduction

Nutrition is closely related to health, and the type, quantity, and quality of food that people consume daily have a profound impact on their health status. Variety in dietary patterns is essential for providing the necessary micronutrients in sufficient quantities. A healthy diet can help reduce the risk of nutrition-related diseases and prevent illness and infection by supplying essential nutrients. To maintain the health of family members, it is recommended to consume 20 to 30 different types of food throughout the week (Wen *et al*., 2024). According to World Bank statistics, the world population is estimated to reach 2.8 billion in 2024. Of this amount, about 43 percent, or more than 3.5 billion people, live in rural areas. Given that a large portion of the population, especially in developing countries, resides in rural areas, improving and promoting their nutritional status and food security is a crucial goal (Sheibani *et al*., 2020).

The concept of food security is especially crucial in rural areas, as these areas play a significant role in food production. Rural areas are known as the main centers of agricultural production but often face the issue of poverty. Poverty rates among rural residents are nearly three times higher than urban residents, and over 80 percent of people living in extreme poverty reside in these areas (UNICEF, 2024). This situation can result in reduced access to food, malnutrition, and other health problems in rural communities. A healthy workforce possesses the physical and mental capabilities necessary to work effectively, ultimately increasing productivity. However, poor nutrition can lead to a decrease in the productivity of farmers in rural areas (Siddique *et al*., 2020). In 2019, 94.7 million deaths worldwide were attributed to poor diet, with a significant portion linked to low food intake in rural regions. Additionally, in low- and middle-income countries, a considerable number of smallholder farmers are at risk of malnutrition (Nandi *et al*., 2021). Given that the agricultural production process is generally labor-intensive, it is crucial to prioritize the health, diversity, and food security of households in rural areas to ensure the sustainability of production and meet growing demand (Weil *et al*., 2023).

It is often assumed that farmers in rural areas can improve their families' dietary diversity by growing a variety of crops and diversifying their farm produce. However, the relationship between farm product diversity and dietary diversity has not been conclusively confirmed in empirical studies (Snapp & Fisher, 2015; Hirvonen & Hoddinott, 2017; Sibhatu & Qaim, 2018; Zanello *et al*., 2019). While it is generally believed that growing different crops and raising livestock in smallholder households can provide essential micronutrients, there is limited empirical evidence on how agricultural production impacts the nutrition of farming families. This is because most smallholders sell their own produce and purchase food items from local markets. Furthermore, many researchers argue that productivity growth in the agricultural sector, particularly for smallholders, has not significantly improved the diversity and food security of farming families. Productivity improvements have mainly focused on staple crops like rice, wheat, and corn, which only offer a limited amount of essential vitamins and minerals. Food and nutritional security are influenced by food diversity, not just food quantity, and therefore, having access to healthy, diverse, and affordable food is crucial for household food security (Webb & Kennedy, 2014; Ruel *et al*., 2017; Usman & Callo-Concha, 2021).

Rural areas in Iran, with a population of over 24 million out of 83 million people, play a vital role in the country's social, economic, and cultural structure (Statistical Center of Iran, 2024). Traditionally, these areas have had their own unique patterns in terms of access to food resources, dietary habits, and local cultures. However, with the influence of economic and social changes, dietary habits in these areas have also significantly changed (Forouhesh & Soltani, 2024). Various studies have been conducted on food consumption in rural areas of Iran. These studies can be broadly divided into three groups. The first group of studies has

examined food consumption patterns. Literature have extensively contributed to food consumption patterns (e.g., Bakshoodeh, 2005; Rostami *et al.*, 2016; Amjadi & Barikani, 2020; Sheibani & Karbasi, 2020; Forouhesh & Soltani, 2024). The second group of studies has focused on factors influencing consumption, diversity, and food security (e.g., Shirani Bidabadi & Ahmadi Kaliji, 2013; Jamini *et al*., 2017; Charaghi *et al*., 2018; Okati *et al.*, 2020; Sheibani *et al*., 2020; Ghaderi, 2024; Galedarvand *et al*., 2024), Also Sharify (2020) and Shabanzadeh-Khoshrody *et al.* (2023) investigated the impact of government policies on consumption and food security.

A review of the history of studies reveals that there have been few studies conducted on food consumption patterns in rural areas of Iran. Most studies either focus on the past or cover the entire country or a specific province's rural areas. Furthermore, these studies did not analyze provinces with standard dietary patterns or those with similar consumption habits and explore the relationship between food consumption patterns and the economic, social, and climatic capacities of rural areas in different provinces. Understanding the nutritional status and content of the household consumption basket in various provinces and comparing it with the standard situation is crucial for governments. This information can serve as a valuable guide for future planning. Identifying provinces with homogeneous and standardized consumption patterns can help in developing strategies tailored to local needs and conditions.

Various variables affect the dietary diversity of households in rural areas, and the nutritional status of each individual depends on several factors, including physical, physiological, cultural, technological, economic, religious, and environmental factors (Ludwig, 2018). According to a study by Adelaja *et al.* (1997), economic factors, including household income, are important and determining factors in household nutritional patterns. Variyam's (2003) suggests that demographic variables such as household size, age, and race play a significant role in household consumption patterns. Streeter (2017) and Lourenção *et al.* (2021) have shown that cultural and economic variables are determinants of household consumption. In the studies by Facina *et al.* (2023) and Weil *et al*. (2023), the role of economic and social variables in determining household consumption patterns has been emphasized.

This article first analyzes the current pattern of food consumption in rural areas of Iran and compares this pattern with the standard pattern. Next, it identifies and ranks the provinces whose dietary patterns are closest to the standard pattern. Then, it identifies provinces with similar food consumption patterns and draws a map of food consumption patterns in rural areas of Iran. Finally, it examines the relationship between food consumption patterns and the infrastructural, economic, and social indicators of the provinces[۱].

Materials and Methods

The research methodology of the present study consists of four main parts including (i) the method used to identify the current food consumption pattern in rural areas of Iran; (ii) the method used to identify provinces with a food pattern close to the standard food pattern within the framework of the TOPSIS method; (iii) how the k-means clustering method was used to identify provinces with similar food consumption patterns, and (iv) the method used to examine the relationship between food consumption patterns and the infrastructural, economic, and social indicators of the provinces.

Identifying Household Consumption Patterns

۱- The provinces of Iran are characterized by a significant amount of ethnic, religious, linguistic, and cultural diversity. Since the cost-income design relies heavily on statistical samples, the chosen samples may not accurately reflect the various ethnicities and religions present. These differences, which pertain to cost and income data, are outside the researchers' control and could potentially impact the results, introducing bias to some extent.

To calculate the index for rural areas of Iran in 2023, we first used cost-income data from the Statistical Center of Iran to construct a nutritional performance matrix. This matrix is created by multiplying two matrices: one containing consumption amounts of items and the other containing calories received per hundred grams of food. The first matrix's rows represent household food items, while its columns show the amounts consumed by rural households. The second matrix's rows show calories, and its columns indicate nutrients obtained from food items per hundred grams. Information on nutrients from various items was sourced from the Iranian Institute of Nutrition and Food Industries. The nutritional performance matrix for rural households is determined by multiplying the aforementioned matrices. Under the assumption of a linear function, the calorie content model equation can be expressed as equation (1) (Smed *et al*., 2005; Akerele, 2011; Shabanzadeh-Khoshrody & Hosseini, 2021).

$$y_h^* = \sum_{j=1}^{n=k} \beta_j X_{hj} + \varepsilon_h \qquad (1)$$

Where, y_h^* represents the calorie intake level of the h^{th} household member, X_{hj} is the amount of the j^{th} food item consumed by the h^{th} household member, and β_j is the energy content of the j^{th} food item. It is worth noting that energy content coefficients have been calculated based on various geographical zones and climates. By dividing the matrix by the average number of household members, and, subsequently, by 30, we calculated the monthly and daily calorie per capita, respectively. Then, we followed the procedure of Adult Male Equivalents (AMEs) of calorie (Shabanzadeh-Khoshrody *et al*., 2024) to unify calorie intake across household members.

This procedure was repeated for all ten diet components, including bread and grains, red meat and poultry, fish and seafood, milk, cheese and eggs oils and fats fruits and nuts, vegetables and cereals, sugar and sweets, non-alcoholic beverages, and other food types.

TOPSIS Method

In the present study, the TOPSIS method was utilized to rank and identify provinces with food consumption patterns that align closely with the diet recommended by the Ministry of Health and Medical Education of I.R. Iran. The primary rationale for employing this method in the study was the presence of both negative and positive indicators used for comparison and ranking. Specifically, as some provinces in the country have food consumption levels above the standard while others fall below, the TOPSIS method allows for foods with higher consumption levels to be viewed as negative factors and those with lower consumption levels as positive factors for ranking purposes. The TOPSIS method for ranking is predicated on the idea that the chosen option should have the shortest distance to the positive ideal solution and the longest distance from the negative ideal solution. In this method, a total of 31 provinces were evaluated based on the average daily per capita consumption of various food items including bread, rice, Macaroni, legumes, potatoes, vegetables, fruits, red meat, poultry, eggs, dairy products, vegetable oils, and sugar. Each evaluation can be visualized as a geometric system consisting of *m* points in an *n*-dimensional space. The TOPSIS method involves seven steps, as outlined below.

Step 1: The initial step in the TOPSIS method is to create a decision matrix. This matrix will consist of *m* options and *n* indicators. The overall structure of the matrix is as follows:

In the matrix above, A_i represents the i^{th} option and X_{ij} represents the numerical value obtained from the i^{th} option with the j^{th} index. The profit index includes the average daily per capita consumption of rice, Macaroni, legumes, potatoes, vegetables, fruits, red meat, poultry, eggs, and dairy products. The loss index includes the average daily per capita consumption of bread, vegetable oils, and sugar.

$$D = \begin{array}{c} \\ A1 \\ A2 \\ \cdot \\ \cdot \\ \cdot \\ Ai \\ \cdot \\ \cdot \\ \cdot \\ Am \end{array} \begin{array}{c} \begin{array}{cccccccccc} X1 & X2 & \cdot & \cdot & \cdot & Xj & \cdot & \cdot & \cdot & Xn \end{array} \\ \begin{bmatrix} X11 & X12 & \cdot & \cdot & \cdot & X1j & \cdot & \cdot & \cdot & X1n \\ X21 & X22 & \cdot & \cdot & \cdot & X2j & \cdot & \cdot & \cdot & X2n \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ Xi1 & Xi2 & \cdot & \cdot & \cdot & Xij & \cdot & \cdot & \cdot & Xin \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ Xm1 & Xm2 & \cdot & \cdot & \cdot & Xmj & \cdot & \cdot & \cdot & Xmn \end{bmatrix} \end{array} \quad (2)$$

Step 2: In this step, the decision matrix is normalized. The scales in the decision matrix are converted to dimensionless scales, where each value is divided by the size of the component corresponding to the same index. This division results in obtaining each element r_{ij} from equation (3).

$$r_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^{\,2}}} \quad (3)$$

Step 3: The third step in the TOPSIS method involves weighting the normalized matrix. The decision matrix is defined parametrically, so it must be quantified. To do this, the decision maker assigns a weight to each indicator. These weights (w) are then multiplied by the normalized matrix (R). It is important to note that the sum of the weights assigned to the indicators must equal one. In this study, different weights were assigned to the goods based on their share in the standard basket of goods proposed by the Ministry of Health (Table 2).

$$W = (w_1, w_2, \dots, w_j, \dots, w_n) \quad \sum_{j=1}^{n} w_j = 1 \quad (4)$$

Before multiplying the normalized decision matrix ($n \times n$) by the $Wn \times 1$ matrix, the weight matrix must first be converted into a $Wn \times n$ diagonal matrix, with the weights placed on the main diagonal.

Step 4: In this step, we determine the positive ideal solution (A^+) and the negative ideal solution (A^-). To do this, we define two virtual options, A^+ and A^-, as shown in equation (5):

$$\begin{aligned} A^+ &= \{(\max v_{ij} | j \in J), (\min v_{ij} | j \in \acute{J}) \mid i \\ &= 1,2,\dots,m\} = \{v_1^+, v_2^+, \dots, v_j^+, \dots, v_n^+\} \\ A^- &= \{(\min v_{ij} | j \in J), (\max v_{ij} | j \in \acute{J}) \mid i \\ &= 1,2,\dots,m\} = \{v_1^-, v_2^-, \dots, v_j^-, \dots, v_n^-\} \\ J &= \{j = 1,2,3,\dots,n\} \\ \acute{J} &= \{j = 1,2,3,\dots,n\} \end{aligned} \quad (5)$$

The two virtual options actually represent the worst and best solutions.

Step 5: The fifth step in the TOPSIS method is to calculate the distances. In this step, the distance of each n-dimensional option is measured using the Euclidean method. In other words, the distance of option i from the positive and negative ideal options is calculated using equations (6) and (7).

$$S_{i+} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2}, \quad i = 1,2,3,\dots,m \quad (6)$$

$$S_{i-} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, \quad i = 1,2,3,\dots,m \quad (7)$$

Step 6: In this step, we calculate the relative proximity of each option to the ideal solution. The TOPSIS method utilizes equation (8) to determine the relative proximity to the ideal solution.

$$C_{i*} = \frac{S_{i-}}{S_{i+} + S_{i-}}, \quad 0 < C_{i*} < 1 \quad (8)$$

In the given relationship, if $A_i = A^+$ then $C_{i*} = 1$, and if $A_i = A^-$ then $C_{i*} = 0$.

Step 7: Finally, the last step in the TOPSIS method involves ranking the options. In this step, the options are sorted and ranked in descending order (Yoon & Hwang, 1995; Yue, 2011).

K-means Clustering Algorithm

This study applied K-means clustering algorithm to analyze food consumption patterns in rural areas and identify provinces with

similar behavioral patterns. In this method, *K* random members are selected from among the members as the coordinates of the cluster centers. Then, the distance of the points (members) from the centers is calculated, and each member is assigned to the cluster with the closest center. The steps for performing the *K*-means clustering method are summarized as follows (Luo, 2022):

- First, the value of *k* is determined, and then *k* sets are extracted through clustering. Depending on the volume of data, the value of *k* can vary between 3 and 6.
- By determining the value of *k*, data is randomly selected from the data set and assigned to cluster centers (c_i's).
- Then, the Euclidean distance of each point from the cluster center is calculated. If this distance is small, that point is assigned to the set to which that center belongs.
- After the data set is allocated, a total of *k* clusters is formed. At this stage, the center of each cluster is recalculated.
- If the distance between the newly calculated center and the previous center is less than a certain threshold, this indicates a small change in the center and a tendency to converge; hence, it can be concluded that the clustering was performed satisfactorily and the results of the algorithm are optimal.

The *K*-means clustering algorithm can be represented as Equation (9).

$$SSE = \sum_{i=1}^{k} \sum_{x \in c_i} dist(c_i, x) \qquad (9)$$

In the above relation, *k* represents the number of clusters, while c_i represents the center of cluster *i*. Finally, *dist* represents the Euclidean distance between two points (Liu, 2022).

In this study, the household calorie intake criterion from ten commodity groups, including bread and cereals, fish and shellfish, oils and fats, vegetables and legumes, red meat and poultry, milk, cheese and eggs, fruits and nuts, sugar and sweets, beverages and non-alcoholic beverages, and food products not elsewhere classified, was used to cluster provinces and identify provinces with similar patterns of food consumption in rural areas. The study followed common approaches for clustering. First, the number of clusters was determined using the hierarchical cluster analysis method, and then the K-means method was used to form the clusters. Initially, the principal component score (PCS) was obtained using the principal component analysis (PCA) method. The PCS was then used in the framework of hierarchical cluster analysis and the Ward clustering method to calculate Agglomerative clustering. In aggregate clustering, the data was initially considered as separate clusters, and during an iterative process at each stage, the clusters that were more similar to each other were combined to finally determine the number of clusters.

After clustering the provinces, the study finally analyzed the reasons for the distribution of food consumption patterns in rural areas of Iran. To achieve this, the relationship between food consumption patterns and the infrastructural, economic, and social indicators of the provinces was examined. It is important to note that the research conducted by Parsipoor *et al.* (2022) was used to determine the status and ranking of the provinces in terms of infrastructural, economic, and social indicators[۱].

Results and Discussion

Current Food Consumption Pattern in Rural of Iran

Fig. 1 depicts the distribution of various commodity groups in the dietary habits of rural areas in Iran in the year 2023. According to the data presented, in 2023, 60.3% of an adult's caloric intake in rural Iran originated from bread and grains, 5.6% from red meat and poultry, 0.2% from fish and seafood, 5.1% from dairy products and eggs, 12% from oils and fats, 3.7% from fruits and nuts, 6.3% from vegetables and legumes, 6.2% from sugar and sweets, 0.01% from non-alcoholic beverages like tea and coffee, and a mere 0.7% from other

۱- In the study by Parsipoor *et al.* (2022), 8, 12, and 6 sub-indices were defined for infrastructural, economic, and social indicators, respectively, to determine the rank of different provinces.

food products. The data from Fig. 1 highlights that the predominant dietary pattern in rural Iranian households revolves around various cereal types, accounting for over 60% of an adult's daily energy intake. Comparatively, globally, cereals typically contribute 50% of daily calorie requirements, with percentages varying at 30%, 55%, and 70% in high-, middle-, and low-income countries, respectively. This disparity between Iran's rural areas and the global average suggests a reliance on cereals, which are deemed low in nutritional value, to fulfill a significant portion of daily caloric needs. Rather than incorporating more nutrient-rich foods like fruits, vegetables, and meats, individuals have leaned heavily on grains. Research by Shabanzadeh-Khoshrody *et al.* (2024) suggests that this phenomenon may stem from a mix of economic and non-economic factors, including cultural eating habits, easy grain accessibility, and cost comparisons between grains and other food items. Identifying and analyzing the food basket in different provinces of Iran, especially in rural areas, can help us better understand the challenges and opportunities in ensuring food security and promoting community health. Provinces with a standard food basket can not only indicate access to diverse and nutritious food sources but also serve as models for improving food systems in other regions. Additionally, the consumption pattern and corresponding diet of each province can directly impact the overall health of the people in that region. Understanding consumption patterns can help identify health and nutritional problems, allowing the government and relevant institutions to make better plans to ensure food security, improve nutrition, and address health issues.

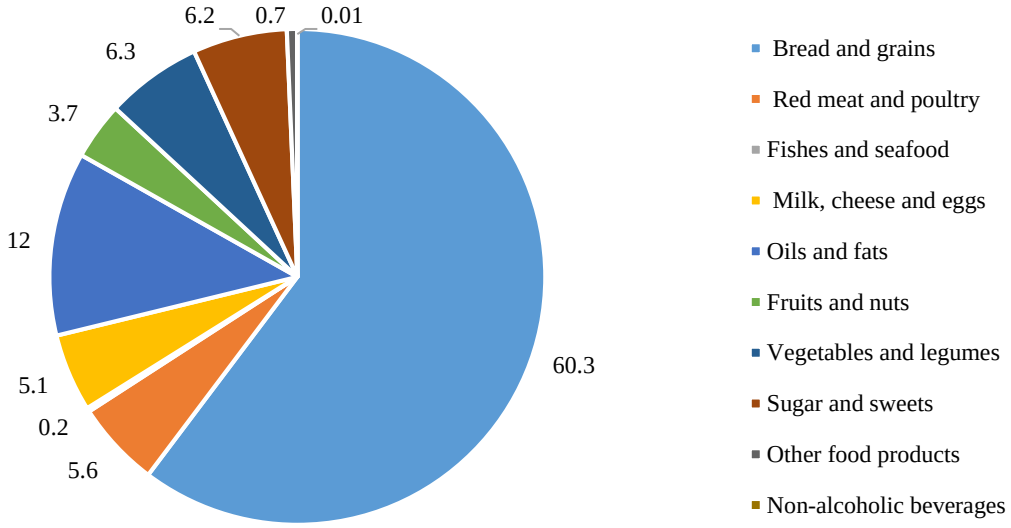

Figure 1- The share of commodity groups in the consumption of Iranian rural households in 2023

Comparative Analysis of Current and Standard Food Basket

A proper food basket helps meet the body's basic needs, such as protein, vitamins, minerals, and energy, and prevents health problems. Accordingly, in this section, the current food basket is compared with the standard food basket proposed by the Ministry of Health and Medical Education of Iran. It is designed to meet 100 percent of the household's energy needs and at least 80 percent of the five key nutrients. If a person consumes the items in this basket, they will consume 1563 grams of food daily and receive 2573 kilocalories of energy. However, as is clear from the information in Table 2, in the current situation, consumption does not follow the standard pattern. People in rural areas of Iran, on average, obtain only 2162

kcal of energy by consuming 1119 grams of food. In other words, we can say that people are currently consuming 28.4% less of the standard food basket and receiving 16% less of the required amount of energy. In this context, as is clear, only in the area of bread consumption do people consume more than the standard amount, and the consumption of other foods is less than the standard level.

According to a study by Vaez Mahdavi *et al*. (2022), the high consumption of bread in Iran has various reasons, with the most important being its affordability compared to other food items. This situation also applies, to some extent, to vegetable oils and sugar. In Table 2, lower per capita consumption of sugar, flour, and oil than the standard level does not necessarily mean that households consume less of these items. This discrepancy arises because the calculations only consider direct household consumption. Households also consume sweets, fast foods, and other products that use significant amounts of sugar and oil in their production process. Therefore, when considering these factors, it becomes evident that the per capita consumption of sugar and oil is higher than indicated in Table 2, if indirect consumption is taken into account. A review of Iran's laws, policies, and programs reveals that a significant portion of the country's resources are allocated each year to direct and indirect subsidies for essential foods and major energy-producing goods such as bread, sugar, and oil. These items benefit from special government support policies aimed at stabilizing prices and protecting consumers. This focus on these staple foods has resulted in an increase in the prices of meat and dairy products, which have replaced starchy and energy-rich products in the household food basket. Table 2 illustrates a concerning trend, showing a significant disparity between per capita and standard consumption of dairy products, fruits, and red meat. The data indicates that the recommended daily intake for each person is 250 grams of dairy products, 280 grams of fruit, and 38 grams of red meat. However, current consumption levels in rural areas of Iran fall short of these standards by 64.4 percent, 52.1 percent, and 50 percent, respectively. Given the nutritional value of these foods, the reduced consumption levels raise serious health concerns for individuals in rural areas of Iran.

The results of Table 2 show that the current food consumption pattern in rural areas of Iran significantly deviates from the standard pattern.

Ranking Consumption Pattern

According to the results of Table 3, six provinces - Chaharmahal and Bakhtiari, Markazi, Isfahan, Hamedan, Zanjan, and Mazandaran - have the highest ranking in terms of dietary patterns in rural areas, being closer to the standard dietary pattern provided by the Ministry of Health. Conversely, among the provinces of Iran, the dietary pattern in rural areas of Hormozgan, Semnan, Kerman, North Khorasan, Ilam, and Sistan and Baluchestan is the furthest from the standard food basket recommended by the Ministry of Health. A study of these provinces reveals that those with consumption patterns closer to standards have a relatively better economic situation, with higher purchasing power among residents. Additionally, weather conditions, climatic, and geographical characteristics have contributed to the diversity in agricultural and livestock production in these regions, leading to a more balanced consumption pattern.

Food consumption patterns in different provinces typically vary due to cultural, climatic, economic, and social distinctions. Understanding these patterns can assist policymakers in better planning for food supply, ensuring food security, and reducing food price volatility.

Table 2- Comparison of the current and standard food basket in rural areas of Iran

Food	Current situation		Standard situation		Difference	
	Consumption per capita (grams per day)	Energy (kilocalorie)	Consumption per capita (grams per day)	Energy (kilocalorie)	Consumption per capita (%)	Energy (%)
Bread	335	950	310	879	8.1	8.1
Rice	79	282	95	339	-16.8	-16.8
Macaroni	11	40	20	72	-45	-44.4
Legumes	17	60	26	91	-34.6	-34.1
Potato	60	49	70	57	-14.3	-14
Vegetables	234	66	300	85	-22	-22.4
Fruits	134	67	280	141	-52.1	-52.5
Red meat	19	53	38	106	-50	-50
Poultry	55	70	64	82	-14.1	-14.6
Egg	20	26	35	45	-42.9	-42.2
Dairy products	89	74	250	207	-64.4	-64.3
Vegetable oils	33	297	35	315	-5.7	-5.7
Sugar	33	128	40	155	-17.5	-17.4
Total	1119	2162	1563	2573	-28.4	-16

Source: Ministry of Health, Treatment and Medical Education of the Islamic Republic of Iran (2012) and research findings.

Table 3- The degree of proximity to the desired food basket in rural areas of Iran

Province	Score	Rank
Chaharmahal and Bakhtiari	0.851	1
Markazi	0.689	2
Isfahan	0.610	3
Hamadan	0.570	4
Zanjan	0.561	5
Mazandaran	0.560	6
Kurdistan	0.560	7
Qazvin	0.548	8
Yazd	0.542	9
Kohgiluyeh and Boyer-Ahmad	0.529	10
Alborz	0.525	11
Fars	0.523	12
Tehran	0.514	13
Khuzestan	0.507	14
South Khorasan	0.505	15
Lorestan	0.487	16
Bushehr	0.486	17
Ardabil	0.478	18
Kermanshah	0.476	19
West Azerbaijan	0.459	20
Golestan	0.422	21
Qom	0.406	22
Gilan	0.401	23
East Azerbaijan	0.400	24
Razavi Khorasan	0.393	25
Hormozgan	0.392	26
Semnan	0.302	27
Kerman	0.293	28
North Khorasan	0.265	29
Ilam	0.262	30
Sistan and Baluchestan	0.229	31

Source: Research findings

Cumulative clustering

The results of cumulative clustering are presented in Table 4. In this study, a notable mutation was observed at stage 26 out of 31

provinces, suggesting 5 clusters as the optimal number based on the difference between these two numbers.

Table 4- Results of cumulative clustering

Stage	Combined cluster		Coefficients	Difference of coefficients
	Cluster 1	Cluster 2		
1	1	19	2082	-
2	20	27	4252	1147
3	4	5	6439	1320.5
4	24	25	8701	1570
5	23	26	11000	1691.5
6	18	31	13760	1725
7	17	30	16907	1801
8	2	13	20199	1918
9	11	21	24288	2183
10	14	20	28703	2266.333
11	10	18	33461	2880.334
12	2	22	39704	3049.333
13	6	12	47228	3369
14	8	14	55470	4139.667
15	6	15	65368	4827
16	17	28	76025	5260.333
17	4	10	86697	5991.367
18	23	24	98924	6565.25
19	2	29	111454	6868.416
20	11	16	124693	7155
21	7	8	146421	9625.4
22	3	6	169700	10848
23	1	7	194210	14875.53
24	1	23	229489	15750.37
25	4	17	270423	26543.09
26	2	9	283889	32333.05
27	1	11	1019361	50075.1
28	2	4	2598150	56660.81
29	1	3	2792260	98166.19
30	1	2	2808681	292320.7

The third column of the table represents the coefficients, while the fourth column shows the differences between coefficients at various clustering stages. Significant changes in mutation coefficients between stages indicate the optimal number of clusters.
Source: Research findings

Table 5 identifies the provinces located in different clusters. Meanwhile, Fig. 2 shows a map of food consumption in urban areas of various provinces of the country based on the clustering in Table 5. It is evident from the Table 5 and Figure 2 that the food consumption patterns in rural areas of different provinces of the country are diverse and heterogeneous, with five distinct behavioral patterns. The food consumption pattern in rural areas of Iran appears to have little correlation with the geographical location of the provinces. For instance, provinces in the third cluster, such as Ardabil, Ilam, and North Khorasan, are situated in the western and eastern parts of the country and do not share a common border with each other. Additionally, as indicated in Table 6, a common characteristic of rural areas in all provinces is the below-standard consumption of essential food items like fruits, vegetables, meat, and dairy products. Provinces in the first cluster align more closely with the standard food consumption pattern than those in the other clusters, while those in the fifth cluster deviate the most from the standard pattern recommended by the Ministry of Health.

Table 5- Provinces located in different clusters

Clusters	The number of cluster members	Provinces
Cluster 1	9	Bushehr, Tehran, Zanjan, Fars, Kurdistan, Lorestan, Mazandaran, Markazi, Hamedan
Cluster 2	4	West Azerbaijan, Chaharmahal and Bakhtiari, Khuzestan, Kohgiluyeh and Boyer-Ahmad
Cluster 3	6	East Azerbaijan, Ardabil, Ilam, North Khorasan, Semnan, Qom
Cluster 4	10	Isfahan, Alborz, South Khorasan, Razavi Khorasan, Qazvin, Kermanshah, Golestan, Gilan, Hormozgan, Yazd
Cluster 5	2	Sistan and Baluchestan, Kerman

Source: Research findings

Table 6- The state of the food pattern of different clusters (grams per day)

Clusters	Sugar	Vegetable oils	Dairy products	Egg	Poultry	Red meat	Fruits	Vegetables	Potato	Legumes	Macaroni	Rice	Bread
Cluster 1	37	36	106	22	61	21	158	296	68	20	15	94	356
Cluster 2	31	31	102	17	52	12	128	243	63	12	11	76	133
Cluster 3	32	30	90	19	50	20	121	214	63	17	9	62	526
Cluster 4	29	32	83	21	58	20	144	209	57	17	11	75	300
Cluster 5	39	29	39	10	44	7	50	152	39	16	5	56	354

Source: Research findings

Relationship between Food Consumption Patterns and Infrastructural, Economic and Social Indicators

The distribution of food consumption patterns in rural areas of Iran can have various reasons. In Table 7, the relationship between food consumption patterns and the infrastructural, economic and social indicators of the provinces is examined. Table 7 is divided into two sections; values above the average and values below the average. Values above the average indicate provinces that rank higher than the overall average in the desired indicator, and vice versa. As is clear from the table, on average, provinces with higher infrastructural, economic, and social indicators have higher average scores in the TOPSIS ranking and therefore have a more standardized food consumption pattern. Regarding the results obtained, it should be noted that infrastructure indicators, especially the existence of appropriate transportation infrastructure, facilitate access to markets and distribution of products. This can lead to a variety of food standards. Economic indicators, including higher income levels, usually lead to better food security and the ability to purchase a wider variety of products. In addition, strong local markets, diverse jobs, support for diverse agriculture, and appropriate government policies can contribute to adequate food consumption. Ultimately, social indicators, including the food culture and customs of each region, have a great impact on food consumption patterns. Some regions may have a richer food culture that contributes to the production and consumption of more diverse foods. Awareness, education, family, and social patterns are other cultural factors that can influence dietary behaviors by contributing to healthy nutrition and dietary diversity.

Conclusion and suggestions

A detailed study and analysis of food consumption patterns in rural areas of Iran can not only help identify standard patterns, but also serve as a tool for developing innovative strategies to improve the quality of nutrition and livelihoods in these areas. As a result, paying special attention to this issue can be considered a key measure towards sustainable development and improving the quality of life in different parts of the country.

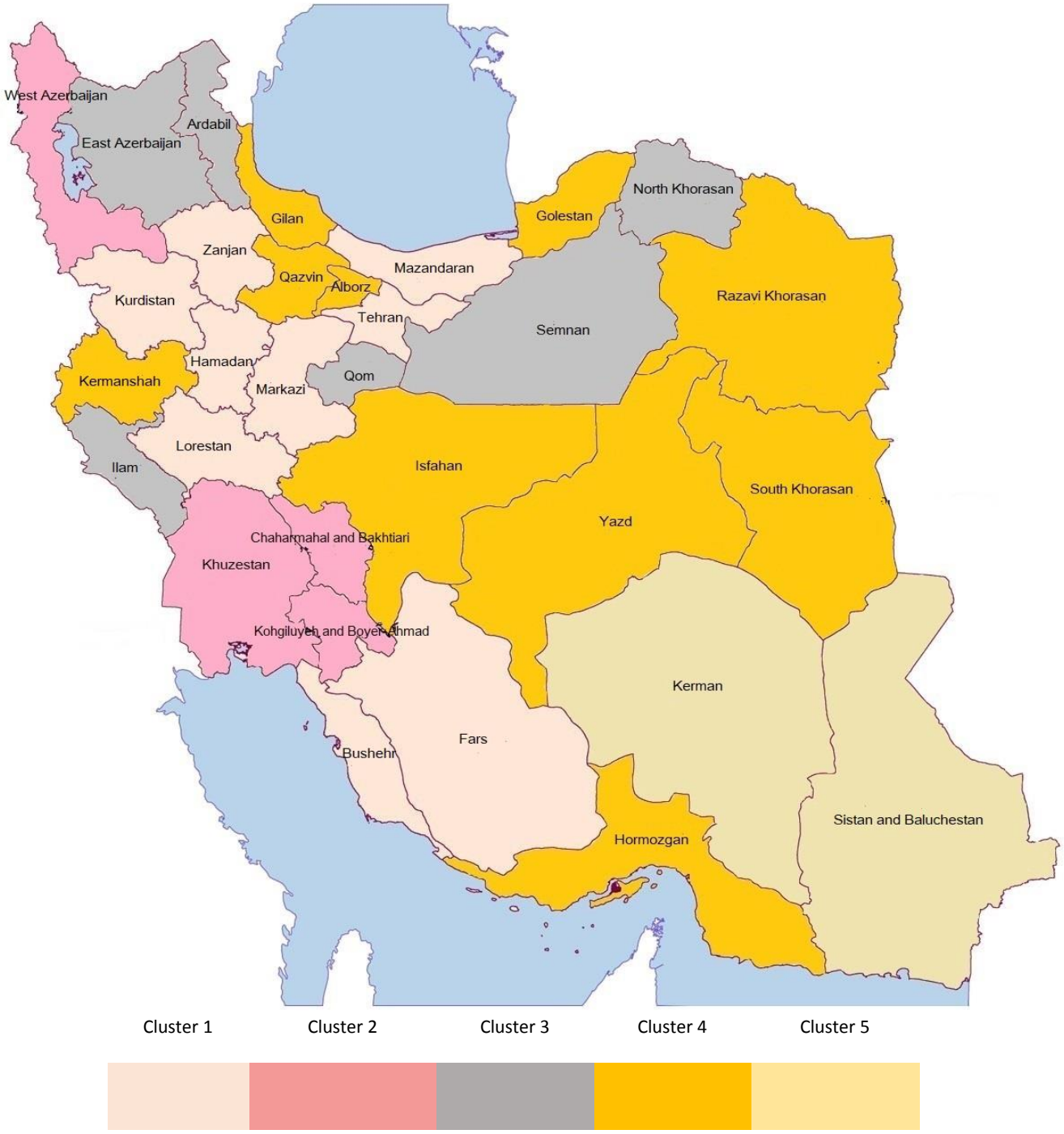

Figure 2- Map of food consumption pattern in rural areas of Iran

In this study, household income-expenditure data from the Statistical Center of Iran was used to examine the current pattern of food consumption in rural areas of Iran for the year 2023 and compare it with the standard pattern.

Table 7- Relationship of the food consumption patterns and infrastructural, economic and social indicators of provinces in Iran

Indicators	Upper of average		Under of average	
	Provinces	TOPSIS Score in TOPSIS ranking	Provinces	TOPSIS Score in TOPSIS ranking
Infrastructure indicators	Tehran, Isfahan, Khorasan Razavi, Bushehr, Fars, Alborz, Khuzestan, Mazandaran	0.515	East Azerbaijan, Yazd, Kerman, Gilan, Hormozgan, Semnan, Qazvin, Markazi, Qom, Hamedan, West Azerbaijan, Kurdistan, Kermanshah, Chaharmahal and Bakhtiari, Ardabil, Zanjan, Golestan, Lorestan, Ilam, South Khorasan, North Khorasan, Kohkiluyeh and Boyer Ahmad, Sistan and Baluchestan	0.462
Economic indicators	Tehran, Isfahan, Khorasan Razavi, Bushehr, Fars, Alborz, Khuzestan, Mazandaran, East Azerbaijan, Yazd, Kerman, Hormozgan	0.479	Gilan, Semnan, Qazvin, Markazi, Qom, Hamedan, West Azerbaijan, Kurdistan, Kermanshah, Chaharmahal and Bakhtiari, Ardabil, Zanjan, Golestan, Lorestan, Ilam, South Khorasan, North Khorasan, Kohkiluyeh and Boyer Ahmad, Sistan and Baluchestan	0.474
Social indicators	Tehran, Isfahan, Khorasan Razavi, Bushehr, Kurdistan, Alborz, Khuzestan, Mazandaran, East Azerbaijan, Yazd, Semnan, Qom, Zanjan, Markazi, Hamedan, Qazvin	0.508	Gilan, Kerman, Hormozgan, Fars, West Azerbaijan, Kermanshah, Chaharmahal and Bakhtiari, Ardabil, Golestan, Lorestan, Ilam, South Khorasan, North Khorasan, Kohkiluyeh and Boyer Ahmad, Sistan and Baluchestan	0.446

Source: Research findings

Provinces whose dietary patterns are closest to the standard pattern were identified and ranked using the TOPSIS method. Additionally, using the k-means clustering method, provinces with similar food consumption patterns were extracted, and a map of the food consumption patterns of rural areas of Iran was drawn. Finally, the relationship between food consumption patterns and the infrastructural, economic, and social indicators of the provinces was examined. The results showed that the current dietary pattern of households in rural areas of Iran mainly consists of various types of cereals, providing more than 60% of the daily energy needs of an adult. Globally, cereals contribute to 50% of daily calories, with proportions of 30%, 55%, and 70% in high-, middle-, and low-income countries, respectively. Currently, food consumption in rural Iran deviates from the standard pattern, with individuals consuming 28.4% less food items than recommended and receiving 16% less energy than needed. While bread consumption exceeds the standard amount, dairy products, fruits, and red meat consumption fall short by 64.4%, 52.1%, and 50% respectively. These findings align with a study by Forouhesh & Soltani (2024) on changing food consumption patterns in Iranian households since the 1960s. The incorrect food consumption pattern in Iran stems from economic and non-economic factors. To address this, efforts should focus on increasing income, stabilizing food prices, and implementing programs to improve physical access and promote healthy eating habits. Experiences from other countries suggest that these strategies can effectively shift consumption patterns and increase food intake, particularly of nutrient-rich foods. Based on the results, the dietary pattern in rural areas of six provinces - Chaharmahal and Bakhtiari, Markazi, Isfahan, Hamedan, Zanjan, and Mazandaran - is closer to the standard dietary pattern provided by the Ministry of Health. Conversely, the dietary pattern in rural areas of the provinces of Hormozgan, Semnan, Kerman, North Khorasan, Ilam, and Sistan and Baluchestan is the farthest from the recommended standard food basket by the Ministry of Health. The results suggest that provinces with dietary patterns aligning with the Ministry of Health's standards should be highlighted as successful examples. Analyzing the factors contributing to the success of these provinces can assist policymakers in implementing solutions to improve food consumption in other regions. Based on the results of the study, the food consumption patterns in rural areas of different provinces in

the country are heterogeneous and highly diverse, with five distinct behavioral patterns identified. Interestingly, the food consumption patterns in rural areas of Iran do not seem to be closely tied to the geographical location of the provinces. On average, provinces with higher infrastructural, economic, and social indicators exhibit a more standardized food consumption pattern. These findings closely align with a study conducted by Rastegaripour *et al*. (2021) on the impact of economic and social factors on the consumption habits of rural and urban households in Iran. The results suggest that improving infrastructure indicators, such as developing economic infrastructure like processing industries and markets in rural areas, can lead to the creation of new job opportunities. With increased employment, people's purchasing power rises, subsequently influencing their food consumption choices. In addition, improving social indicators, such as increasing levels of education and access to information in rural areas, can lead to improved dietary patterns and healthier food choices. People who are more aware of healthy eating and the importance of dietary diversity are able to improve the quality of the food they consume. Improving transportation infrastructure also provides rural residents with access to larger markets, which can increase food diversity and availability. Considering the positive impact of infrastructure, economic, and social indicators on food consumption in rural areas of Iran, it is suggested to strengthen the transformation and processing industries by supporting the establishment of food processing workshops in rural areas. Additionally, increasing employment opportunities, especially through the creation of non-agricultural jobs in handicraft industries, tourism, and services in rural areas, should be prioritized. Furthermore, increasing investment in infrastructure, such as building and improving roads and bridges, to facilitate access to markets and shopping centers is recommended. Enhancing access to education and information through nutrition classes and educating on smart food purchasing methods, as well as utilizing media and cyberspace to raise awareness of healthy eating, are crucial factors to consider due to their impact on people's nutritional habits and culture.

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تحلیل الگوی مصرف مواد غذایی در مناطق روستایی ایران: شناسایی استان‌های با مصرف استاندارد و همگن

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چکیده

بررسی الگوی مصرف غذا در مناطق روستایی ایران برای درک وضعیت امنیت غذایی و رفاه اجتماعی در کشور ضروری است. شناسایی استان‌های دارای الگوی مصرف استاندارد و همگن، نه تنها به برنامه‌ریزی برای تأمین نیازهای غذایی کمک می‌کند، بلکه می‌تواند به تدوین سیاست‌های مناسب و مؤثر در راستای حل مسائل مرتبط با تغذیه و بهداشت عمومی نیز منجر شود. با این رویکرد در این مطالعه، ابتدا الگوی فعلی مصرف غذا در مناطق روستایی ایران در سال ۱۴۰۲ مورد بررسی قرار گرفت و با الگوی استاندارد مقایسه شد. سپس، استان‌هایی که الگوی غذایی آن‌ها شباهت بیشتری به الگوی استاندارد دارد، با استفاده از روش TOPSIS شناسایی و رتبه‌بندی شدند. پس از آن، با بهره‌گیری از روش خوشه‌بندی k-means، استان‌های با الگوی مصرف مشابه استخراج و نقشه‌ی الگوی مصرف غذا برای مناطق روستایی ایران ترسیم گردید. در نهایت، رابطه بین الگوی مصرف و شاخص‌های زیرساختی، اقتصادی و اجتماعی استان‌ها مورد تحلیل قرار گرفت. نتایج نشان داد که الگوی غذایی کنونی خانوارها در مناطق روستایی ایران عمدتاً شامل غلات است و این گروه بیش از ۶۰ درصد انرژی روزانه را تأمین می‌کند. در حالی‌که در سطح جهانی، سهم غلات در تأمین کالری روزانه معادل ۵۰ درصد است و این نسبت در کشورهای با درآمد بالا، متوسط و پایین، به‌ترتیب ۳۰، ۵۵ و ۷۰ درصد می‌باشد. علاوه بر این، در شرایط کنونی، مصرف غذا در ایران مطابق با الگوی استاندارد نیست و ساکنان مناطق روستایی کشور ۲۸/۴ درصد کمتر از مواد غذایی سبد استاندارد استفاده می‌کنند و همچنین ۱۶ درصد کمتر از انرژی مورد نیاز را دریافت می‌نمایند. افراد بیشتر از نیاز خود نان مصرف می‌کنند، اما در خصوص لبنیات، میوه‌ها و گوشت قرمز، مصرف کنونی به‌ترتیب ۶۴/۴، ۵۲/۱ و ۵۰ درصد پایین‌تر از مقدار استاندارد است. الگوی غذایی در مناطق روستایی شش استان چهارمحال و بختیاری، مرکزی، اصفهان، همدان، زنجان و مازندران به استاندارد تعیین‌شده توسط وزارت بهداشت نزدیک‌تر است. در مقابل، الگوی غذایی در نواحی روستایی شش استان هرمزگان، سمنان، کرمان، خراسان شمالی، ایلام و سیستان و بلوچستان بیشترین فاصله را با سبد غذایی استاندارد دارد. از سوی دیگر، الگوی مصرف مواد غذایی در مناطق روستایی استان‌ها متنوع و ناهمگون است و می‌توان پنج نوع الگوی رفتاری را شناسایی کرد؛ بر اساس نتایج، الگوی مصرف در مناطق روستایی ایران با موقعیت جغرافیایی ارتباط چندانی ندارد و استان‌هایی که شاخص‌های زیربنایی، اقتصادی و اجتماعی مناسب‌تری دارند، از الگوی مصرف غذایی استانداردتری برخوردار هستند. با توجه به تجربیات کشورهای مختلف، بهبود تغذیه در مناطق روستایی فرآیندی چند بعدی است و تحت تأثیر مجموعه‌ای از متغیرها شامل عوامل اقتصادی (مانند درآمد، قیمت مواد غذایی، نرخ بیکاری و ...)، عوامل منطقه‌ای (از جمله دسترسی به غذا، توسعه زیرساخت‌های حمل و نقل، شرایط آب و هوایی و ...)، عوامل اجتماعی و فرهنگی (شامل فرهنگ و باورهای اجتماعی، سطح آموزش و آگاهی، شبکه‌های اجتماعی و ...) و نهایتاً عوامل فردی (مانند سلامت فردی، عادات و رفتارهای غذایی، دانش شخصی و ...) قرار دارد و برای دستیابی به یک الگوی تغذیه‌ای سالم و متوازن، باید به تعامل و هم‌افزایی میان این عوامل توجه جدی نمود.

واژه‌های کلیدی: سبد غذایی فعلی و استاندارد، نواحی روستایی ایران، الگوی رفتاری مشابه، روش TOPSIS، خوشه‌بندی k-means

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