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Fruit and Vegetable Nutrition Value Assessment and Replacement Based on the Principal Component Analysis and Cluster Analysis

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Abstract

Utilizing principal component analysis (PCA) and cluster analysis, the standardization, dimension-reduction and de-correlation of multiple evaluation index system for fruit and vegetable nutrition are performed to assign principal component factor based on cluster analysis of loading matrix and combining with actual meaning and evaluation direction of index categories. To evaluate the richness of its nutrition according to the score of nutrition of fruit and vegetable, finally equivalent replacement suggestions are given in different seasons of vegetables & fruits according to the result of clustering. Studies show that principal component cluster method can not only carry on the reasonable classification of multivariate data effectively, but also make reasonable evaluation on the sample object, and provide powerful basis for evaluation of fruits and vegetables' nutrition.

Keywords

Principal Component Analysis, Cluster Analysis, Multivariate, Classification

1. Preface

People's nutrition improvement depends on economic development. At the same time, it also can promote the development of social economy. But with the development of social economy and the increase of income as well as the improvement of living standards, there are still people especially kids who have one-side diet and ignore the development of the human body health. Especially now, with more meat consumer, more and more

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elders turn to spoil their children. Indulging their children in monophagia will lead to the phenomena such as over nutrition or nutritional deficiencies in parts of human body. Yi-yong Cheng [1] pointed out in "Chinese residents of nutritional status and related health problems" that when the body has a good nutrition condition, it can promote growth, improve brain development and enhance immune function, thus creating more excellent human resources to promote the growth of economic development. Therefore, the development of the body's nutritional status is especially important.

Lacking of iron, zinc, vitamin A and other micronutrients is a main problem of residents in our country [1]. The minerals that human body needs can be divided into common elements such as calcium, phosphorus, sodium and trace elements such as iron, zinc and iodine. As these minerals can't be synthesized in the human body, if you want to gain all the kinds of mineral elements, you must make supplements through dietary. Fruits and vegetables are the main element sources such as vitamin C, calcium and sodium for human body, and they contain organic acids which are beneficial for people to increase appetite, promote digestion, etc.

On the table, children regard the vegetables as their enemy, no matter what the elder say, they don't yield a little. While coming to the junk foods in shops, they treat them as treasures. At the same time, along with the preference of people for some vegetables and fruits, in order to meet the needs of the market, the anti-seasonal [2] fruits' and vegetables' production is constantly increasing. So, what characteristics do vegetables and fruits have? Zhi-hong Fan [3] pointed out that the nutrition of anti-seasonal vegetables and fruits is discounted; Tan Duimin [4] pointed out in his study of "counter-season fruits and vegetables' problems" that most of anti-seasonal vegetables' pesticide levels are over the criterion, and they may cause chronic poisoning and acute poisoning; Lv Bin's [5] study of how it is safe to eat revealed that the anti-seasonal vegetables and fruits are grown in the artificial intervention which will ultimately lead to their loss of nutrients with an expensive price; Yang Bo [6] pointed out that the counter-seasonal fruits and vegetables not only are expensive, but also have an exquisite taste and less nutrition content than the seasonal fruits and vegetables. At the same time, he also pointed out that children should not take anti-seasonal vegetables and fruits for a long term which may do harm to their growth and development and may become a potential danger to their health. Accordingly, anti-seasonal vegetables and fruits are less tasted, and the content of nutrition is much less than the seasonal fruits and vegetables. Therefore, the research on the nutritional content of fruits and vegetables and the similarity between them is particularly important to ensure human nutrition balance.

PCA and cluster analysis [7] is a very effective method in studying the similarity between these samples, which has been successfully used by scholars in many fields. For example, Hong-jian Chen [8] had successfully applied this method in the optimization of mining. It is shown that the PCA and cluster analysis not only can classify the multivariable data reasonably, but also can make a comprehensive assessment of the performance of various types to fully reflect the actual situation of the mine. Xin-hua Gao used principal component analysis and cluster analysis method in Comprehensively Assess Smart Grid Construction, and it assessed the general development and construction level of smart grid reasonably and accurately. There are also many successful examples in logistics planning [9], evaluating ecological safety of land use [10], assessment of student's grade [11], etc.

Therefore, in order to study the similarity of nutrient content between fruits and vegetables and to ensure the balance of nutrition in human body, this paper will use the principal component analysis method to divide fruits' and vegetables' indicators into some unrelated composite indicator variables, and then use the cluster analysis to make a group classification according to the new comprehensive index and the degree of feeling of differences between fruits and vegetables. Finally, combining the different proposals of various fruits and vegetables replaced in different seasons, the demand of all kinds of nutrition in the human body can be met in a more affordable price on the premise of their favorite fruits and vegetables.

2. Principal Component Analysis and Cluster Analysis

Basic Thought of Principal Component Analysis and Cluster Analysis

By using the method of dimension reduction of Principal Component Analysis (PCA) [12], the original multiple indexes are recombined to be a few unrelated comprehensive indexes under the premise of guaranteeing the main information of original data being not discarded, which simplifies the complex problem. Commonly used mathematical processing method is to combine the original p index linear into the new comprehensive index, but if this linear combination is not limited, a lot of new composite indicators can be put forward. Therefore, in or-

der to ensure the new comprehensive index which can reflect the information of original indexes as much as possible, a principal component extraction principle should be abided by when extracting the new indicators. Namely, when extracting a new composite indicator, only those maximum principal ingredients whose cumulative contribution rate reaches 85% are available, which help us seize the principal contradiction under the loss of a few information. This method of reducing the number of variables and seizing the main contradiction is helpful for us to analyze and handle the question, and it makes the following cluster analysis results more exact.

Cluster analysis [13] refers to the process of grouping the set of physical or abstract objects into categories so that objects with similar feature are in the same class. Objects in the same category have a lot of similarities and objects between different clusters have great differences. It is a kind of exploratory analysis. In the process of classification, people don't have to give a classification standard in advance but cluster analysis can start from sample data and make automatic classification. Different method of cluster analysis is used, which is likely to get different conclusions. Therefore, in the cluster analysis, we should choose the appropriate clustering method according to the research needs.

Principal component analysis and cluster analysis [11]-[14] is a new comprehensive evaluation method which combines principal component analysis with cluster analysis. The method carried out principal component analysis on the samples first, and then extracted several principal components as variables of cluster analysis. Specific steps are as follows:

1) selecting *m* principal component according to the cumulative variance contribution rate (usually greater than 85%) and then calculating samples' scores under each principal component;

2) putting *m* principal components as *m* variables for samples and taking cluster analysis;

3) evaluating the results of clustering and giving the relative suggestion.

3. Modeling for Principal Component Analysis and Cluster Analysis

Although there are many types of vegetables and fruits, they contain similar nutrients. In order to digitize the samples, we should make the definitions as follows.

Definition 1. Let *n* be the kind of fruits and vegetables, each fruit or vegetable contain *p* nutrient elements, each kind of fruits and vegetables can be seen as a point with *p* dimension, then the *p*-th fruit or vegetable can be defined as

$$x_i = \left(x_1(1), x_1(2), \cdots, x_1(p)\right),$$

Then *n* kinds of fruits and vegetables can be expressed as a matrix

$$X = \left(x_i(j)\right)_{n\times p}$$

Standardized matrix is obtained by normal distribution standardized processing of the original data

$$Z = \left(z_i(j)\right)_{n\times p} = \begin{bmatrix} z_1(1) & \cdots & z_1(p) \\ \vdots & \ddots & \vdots \\ z_n(1) & \cdots & z_n(p) \end{bmatrix}$$

Calculating the correlation coefficient between samples according to the calculated standardized matrix ρ_{ij}

$$\rho_{ij} = \frac{\operatorname{cov}\left(z_i, z_j\right)}{\sqrt{\operatorname{var}\left(z_i\right)\operatorname{var}\left(z_j\right)}}$$

where $\operatorname{cov}\left(z_i, z_j\right)$ refers to covariance of standardized sample x_i and x_j and $\operatorname{var}\left(x_i\right)$ refers to the variance of sample x_i. Then we can get the correlation coefficient matrix *R*

$$R = \begin{bmatrix} \rho_{11} & \cdots & \rho_{1p} \\ \vdots & \ddots & \vdots \\ \rho_{n1} & \cdots & \rho_{np} \end{bmatrix}$$

It is known that matrix *R* is symmetrical and it can be transformed into a diagonal matrix Λ

$$\Lambda = U^{\mathrm{T}} RU = \begin{bmatrix} \lambda_1 & & \\ & \ddots & \\ & & \lambda_n \end{bmatrix}$$

where $U = (u_1, u_2, \cdots, u_n)$ is an orthogonal matrix referring to the eigenvectors related to eigenvalue $\lambda_1, \lambda_2, \cdots, \lambda_n$ $(\lambda_1 > \lambda_2 > \cdots > \lambda_n)$.

The *j*-th principal component's variance contribution ratio a_j and the accumulation of variance contribution ratio are calculated as follows

$$a_j = \lambda_j \Big/ \sum_1^n \lambda_j$$

$$a = \sum_1^m \lambda_j \Big/ \sum_1^n \lambda_j$$

where $m < n$. To ensure the original variables lose less information and use less comprehensive index variables to analyze original data information, we will extract several principal components according to the principle of cumulative variance contribution rate (usually greater than 85%). These principal components will be regarded as new comprehensive variables.

Considering the front *m*-th principal component scores of every sample as the *m*-th variable, we can make a cluster analysis.

Definition 2. The distance between the samples. The distance between the samples is defined as follow:

$$d(x_i, x_j) = \sqrt{(x_i(1) - x_j(1))^2 + \cdots + (x_i(p) - x_j(p))^2}$$

Definition 3. The distance between the categories. The distance between the categories is defined as

$$D_{pq}^2 = \frac{1}{n_p n_q} \sum_{i \in G_p, j \in G_q} d_{ij}^2, p \neq q$$

Merge category G_p and category G_q and then we get a new category G_r, the distance between G_r and any other category can be calculated as follow:

$$\begin{aligned} D_{rk}^2 &= \frac{1}{n_r n_k} \sum_{i \in G_r, j \in G_k} d_{ij}^2 \\ &= \frac{1}{n_r n_k} \left(\sum_{i \in G_p, j \in G_k} d_{ij}^2 + \sum_{i \in G_q, j \in G_k} d_{ij}^2 \right) \\ &= \frac{n_p}{n_r} D_{pk}^2 + \frac{n_q}{n_r} D_{qk}^2 \end{aligned}$$

4. Examples of Application

The experiment selected the Chinese residents most often eating 30 kinds of fruits and vegetables including 14 kinds of vegetables and 16 kinds of fruits. With reference to 2014 China food composition table [15], we select 11 kinds of nutrient element index to analyze the nutritional situation of fruits and vegetables. For convenient, we make the following definitions: x_1 refers to dietary fiber; x_2 refers to carbohydrates; x_3 refers to vitamin A; x_4 refers to vitamin B; x_5 refers to vitamin C; x_6 refers to vitamin E; x_7 refers to sodium (Na); x_8 refers to calcium (Ca); x_9 refers to iron (Fe); x_{10} refers to zinc (Zn); x_{11} refers to selenium (Se). Specific data is as **Table 1**.

4.1. Principal Component Extraction

Standardizing to 11 indexes of vegetables and fruits, according to the principle of principal component analysis,

how much information will each principal component provide be measured by the value of the variance (eigenvalue λ_i). Principal component analysis was carried out on the data in **Table 1**, and we got the eigenvalue and the principal components variance contribution rate and the cumulative variance contribution rate in **Table 2**.

Table 1. Data of vegetables and fruits.

Species	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}
Carrot	1100	7700	0.688	0.67	13	0.41	71.4	32	1	0.23	0.63
Radish	600	4000	0.003	0.69	18	1	60	56	0.3	0.13	0.6
Cabbage	600	3100	0.042	0.93	47	0.92	89.3	69	0.5	0.21	0.33
Cauliflower	1200	3400	0.005	0.71	61	0.43	31.6	23	1.1	0.38	0.73
Lettuce	700	1300	0.298	0.49	13	1.02	32.8	34	0.9	0.27	1.05
Leaf lettuce	1100	2700	0.103	0.85	36	0.88	55.8	108	1.2	0.33	0.79
Wax gourd	700	1900	0.013	0.32	18	0.08	1.8	19	0.2	0.07	0.22
Tomato	500	3500	0.092	0.66	19	0.57	5	10	0.4	0.13	0.15
Eggplant	1300	3600	0.008	0.66	5	1.13	5.4	24	0.5	0.23	0.48
Cucumber	500	2400	0.015	0.25	9	0.46	4.9	24	0.5	0.18	0.38
Balsam pear	1400	3500	0.017	0.46	56	0.85	2.5	14	0.7	0.36	0.36
Pumpkin	800	4600	0.148	0.47	8	0.36	0.8	16	0.4	0.14	0.46
Towel gourd	600	3600	0.015	0.46	5	0.22	2.6	14	0.4	0.21	0.86
Potato	700	16,500	0.005	1.22	27	0.34	2.7	8	0.8	0.37	0.78
Apple	1200	12,300	0.003	0.28	4	2.12	1.6	4	0.6	0.01	1
Pear	2000	7300	0.1	0.15	1	1.46	3.9	11	0.7	0.1	0.98
Peach	1300	10,900	0.003	0.74	7	1.54	5.7	6	0.8	0.15	0.1
Apricot	1300	7800	0.075	0.65	4	0.95	2.3	14	0.6	0.2	0.2
Grape	400	9900	0.008	0.26	25	0.7	1.3	5	0.4	0.02	0.5
Banana	1200	20,800	0.01	0.76	8	0.24	0.8	7	0.4	0.17	0.87
Strawberry	1100	6000	0.005	0.35	47	0.71	4.2	18	1.8	0.11	0.7
Orange	600	10,500	0.027	0.39	33	0.56	1.2	20	0.4	0.14	0.31
Watermelon	200	5500	0.035	0.36	4	0.13	2.4	4	0.2	0.05	0.08
Hami-melon	200	7700	0.153	0.01	12	0.2	26.7	4	0.3	0.13	1.1
Litchi	500	16,100	0.002	1.24	41	0.12	1.7	2	0.4	0.17	0.14
Longan	400	16,200	0.003	1.45	43	0	3.9	6	0.2	0.4	0.83
Mango	1300	7000	1.342	0.35	23	1.21	2.8	15	0.2	0.09	1.44
Pineapple	1300	9500	0.033	0.26	18	0	0.8	12	0.6	0.14	0.24
Coconut	4700	26,600	0.021	0.52	6	0	55.6	2	1.8	0.92	6.21
Lemon	1300	4900	0.004	0.67	22	1.14	1.1	101	0.8	0.65	0.5

Table 2. Eigenvalue and cumulative variance contribution.

Component	Eigenvalue	% of Variance	Cumulative %
Y_1	3.424	31.125	31.125
Y_2	2.093	19.028	50.153
Y_3	1.732	15.745	65.898
Y_4	1.006	9.141	75.040
Y_5	0.820	7.456	82.496
Y_6	0.749	6.807	89.303
Y_7	0.509	4.629	93.931
Y_8	0.290	2.636	96.567
Y_9	0.202	1.835	98.402
Y_{10}	0.112	1.019	99.421
Y_{11}	0.064	0.579	100.000

The eigenvalue distribution is shown in **Figure 1**. From **Figure 2**, we can see that there is an obvious polyline from the λ_8, so the number of principal components should be less than 8. Combined with the **Table 2**, we can know that the front 5 principal component cumulative variance is 89.303% and it is bigger than 85%, so we choose front 5 principle components as variables. **Table 3** reveals the relations between the linear combination of principal component and the original variables, and the relationship can be described with specific function expression as follows:

$$F_1 = 0.31zx_1 + 0.133zx_2 - 0.004zx_3 + \cdots + 0.299zx_9 + 0.198zx_{10} + 0.268zx_{11}$$

$$F_2 = -0.071zx_1 - 0.271zx_2 - 0.028zx_3 + \cdots - 0.06zx_9 + 0.144zx_{10} + 0.022zx_{11}$$

$$F_3 = -0.06zx_1 + 0.438zx_2 + 0.051zx_3 + \cdots - 0.272zx_9 + 0.14zx_{10} - 0.057zx_{11}$$

$$F_4 = -0.031zx_1 - 0.138zx_2 + 0.115zx_3 + \cdots + 0.419zx_9 - 0.016zx_{10} - 0.131zx_{11}$$

$$F_5 = 0.154zx_1 + 0.042zx_2 + 0.024zx_3 + \cdots + 0.155zx_9 - 0.065zx_{10} - 0.151zx_{11}$$

$$F_6 = 0.009zx_1 + 0.066zx_2 + 0.919zx_3 + \cdots - 0.118zx_9 - 0.133zx_{10} + 0.125zx_{11}$$

and comprehensive score formula

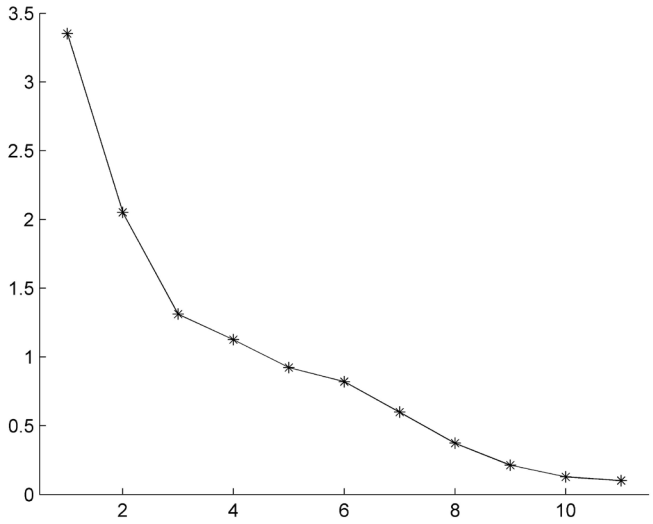

Figure 1. Distribution of eigenvalue.

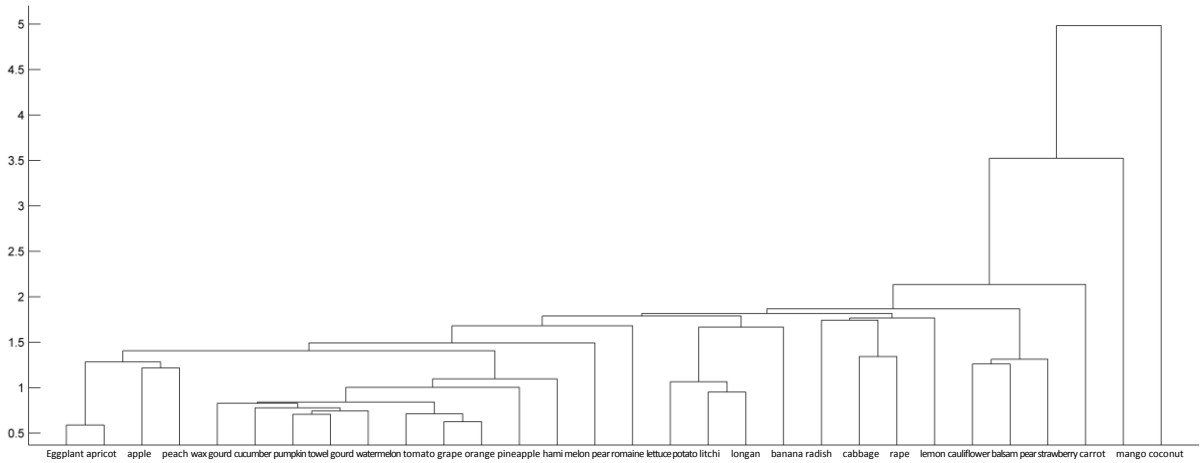

Figure 2. Dendrogram of 30 kinds of vegetables and fruits.

Table 3. Component score coefficient matrix.

	Component					
	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
zx_1	0.310	−0.071	−0.060	−0.031	0.154	0.009
zx_2	0.133	−0.271	0.438	−0.138	0.042	0.066
zx_3	−0.004	−0.028	0.051	0.115	0.024	0.919
zx_4	−0.095	0.045	0.758	−0.003	0.140	0.032
zx_5	0.022	−0.165	−0.037	0.874	−0.018	0.130
zx_6	0.043	−0.078	0.168	−0.027	0.900	0.030
zx_7	0.022	0.518	0.021	−0.175	−0.249	0.177
zx_8	−0.051	0.517	0.069	−0.127	0.125	−0.144
zx_9	0.299	−0.060	−0.272	0.419	0.155	−0.118
zx_{10}	0.198	0.144	0.140	−0.016	−0.065	−0.133
zx_{11}	0.268	0.022	−0.057	−0.131	−0.151	0.125

$$F = 0.29758F_1 + 0.16171F_2 + 0.12103F_3 + 0.10869F_4 + 0.10556F_5 + 0.09845F_6$$

Finally, we can calculate comprehensive scores of vegetables and fruits and make an order as **Table 4**.

4.2. Cluster Analysis

Principal component analysis was carried out on the fruits and vegetables, and we have extracted six principal components. Using systematic clustering method to cluster the six indexes, we get the final result in **Figure 2**.

From **Figure 2**, we know that the 30 kinds of vegetables and fruits can be divided into 7 clusters. The above table shows the scores of all kinds of fruits and vegetables in each principal component, their composite scores and comprehensive rankings. As in the common 14 kinds of vegetables and 16 kinds of fruits, the scores of the first principal components, namely dietary fiber, carbohydrate, iron, zinc and selenium, in coconut are highest, and the scores of those components in lettuce are lowest. While the scores of the second principal components, namely sodium and calcium, in the lettuce are highest, and the scores of those components in coconut are lowest. From the angles of composite scores and comprehensive ranking, coconut, banana and potato get the higher score and are located in the top three, which means their comprehensive nutritional value is very high; and the composite scores of cucumber, wax gourd and lettuce are in the last three, which means their comprehensive nutritional value is low. In the top 15 fruits and vegetables, there are 13 fruits and just 2 vegetables. Therefore, fruits' nutritional value is slightly higher than vegetables. It can be seen that an overall and systematic comprehensive evaluation should be considered rather than part of the nutrient elements when evaluating the nutrition content of fruits and vegetables.

Among the 30 kinds of vegetables and fruits, coconut and mango are separately divided into the same category, and the rest can be divided into five categories, we can see it clearly in **Table 5**.

From the classification of vegetables and fruits in **Table 5**, we know that there are a lot of similarities in the nutritional content between vegetables and fruits. For example, in the third cluster, grape, wax gourd, watermelon, pineapple and other 10 kinds of fruits and vegetables contain the similar nutritional content. If you want to get the nutrition of this type, you can either intake from the fruits or from vegetables. It provides a wider choice for eaters so that they can make a choice according to season. Under the condition of guarantee for the same amount of nutrition, you can choose the tastier and more secure seasonal vegetables and fruits instead of anti-seasonal vegetables and fruits.

According to seasonal fruits and vegetables' list in Zhao Peng's [16] "anti-season vegetable and fruit, harmful or harmless", we can make a table for the 30 kinds of vegetables and fruits.

Table 4. Comprehensive scores and order.

Name	F_1 Score	F_2 Score	F_3 Score	F_4 Score	F_5 Score	F_6 Score	F Score	Comprehensive Ranking
Coconut	4998	−7513	11369	−3821	1826	1808	160,405	1
Banana	3138	−5719	9039	−2901	1059	1383	103,578	2
Potato	2412	−4520	7185	−2276	801	1098	80,177	3
Litchi	2297	−4403	7021	−2201	752	1072	76,702	4
Longan	2279	−4420	7071	−2211	741	1078	76,336	5
Apple	2008	−3416	5315	−1731	703	823	65,558	6
Peach	1853	−3041	4697	−1539	658	732	60,232	7
Pineapple	1666	−2663	4083	−1337	600	639	54,046	8
Orange	1582	−2882	4563	−1441	535	700	52,586	9
Pear	1591	−2112	3078	−1070	616	499	50,219	10
Grape	1441	−2712	4311	−1357	477	659	48,002	11
Apricot	1440	−2198	3339	−1115	529	525	46,371	12
Carrot	1365	−2113	3310	−1101	479	528	44,819	13
Mango	1334	−1984	2988	−988	495	476	42,975	14
Strawberry	1140	−1700	2561	−823	422	410	36,974	15
Hami melon	1087	−2087	3360	−1063	347	515	36,473	16
Lemon	1050	−1371	2074	−710	419	323	34,095	17
Balsam pear	900	−1048	1448	−479	363	249	28,447	18
Pumpkin	859	−1296	1967	−654	318	309	27,730	19
Eggplant	881	−1053	1500	−536	354	247	27,690	20
Cauliflower	825	−988	1417	−461	322	245	26,543	21
Watermelon	793	−1502	2397	−762	261	365	26,410	22
Radish	717	−1069	1721	−572	253	274	24,024	23
Rape	697	−731	1124	−398	282	187	23,031	24
Towel gourd	664	−1010	1541	−513	244	242	21,489	25
Cabbage	598	−808	1327	−429	209	222	20,510	26
Tomatoes	620	−979	1503	−483	224	237	20,276	27
Cucumber	473	−672	1022	−342	179	161	15,361	28
Wax gourd	469	−556	791	−270	189	131	14,885	29
Romaine lettuce	389	−369	530	−199	159	95	12,486	30

Table 5. Fruits and vegetables' classification.

Category	First category	Second category	Third category	Fourth category	Fifth category	Six category	Seventh category
Species	Eggplant, Apricot, pear, apple, peach	Grape, orange, tomatoes, wax gourd, cucumber, pumpkin, towel gourd, watermelon, pineapple, Hami melon	Carrot, cabbage, rape, radish, romaine lettuce, lemon,	Potato, litchi, longan, banana	Cauliflower, Balsam pear, Strawberry	Mango	Coconut

Table 6. 30 kinds of vegetables and fruits distributed in seasons.

Category	Spring	Summer	Autumn	Winter
First category		Eggplant, peach, apricot	Apple, pear	
Second category		Wax gourd, cucumber, pumpkin, towel gourd, tomatoes, pineapple, watermelon	Wax gourd, hami melon, grape	Orange
Third category	Rape	Romaine lettuce, lemon	Cabbage	Carrot, cabbage, radish
Fourth category		Litchi, banana, longan	Potato	
Fifth category	Cauliflower	Balsam pear, strawberry		Cauliflower
Sixth category		Mango		
Seventh category		Coconut		

The nutritional value and taste of anti-seasonal vegetables and fruits are less inferior than seasonal vegetables and fruits, because anti-seasonal cultivation is a kind of artificial intervention means used in vegetables' and fruits' growth. Its growth condition such as temperature and moisture, making its own accumulation of nutrition can't keep up with growth. The market price of this anti-seasonal inverse grow vegetables is not only more expensive than the seasonal vegetables, but it affects the taste and nutrition. As is known to all, the price of anti-seasonal vegetables and fruits is much higher than the price of the seasonal vegetables and fruits. Therefore, in order to guarantee good nutritional status, we should realize which vegetables are in season, and try to get the vegetables and fruits that contain more nutrition and more safety and healthy with a more affordable price. In guaranteeing of intaking the similar nutrition, seasonal vegetables and fruits can be replaced with each other in different seasons. As shown in **Table 6**, nutrient contents of the seasonal vegetables and fruits in the second category are similar and replaceable with each other. In summer, the types of nutrients can be derived from white gourd, cucumber, pumpkin, sponge gourd, tomato and pineapple instead of the anti-season wax gourd, cantaloupe, grape and orange with expensive price and less nutritional value and taste.

5. Conclusions and Recommendations

Based on the principal component analysis, the original data of dietary fiber, carbohydrates, vitamin A, vitamin B, vitamin C, vitamin E, sodium, calcium, iron, zinc, selenium, totally 11 evaluation indexes could be recombined into 6 unrelated comprehensive indexes. It makes the result of cluster analysis more reasonable and real. When combined with seasonal fruits and vegetables, consumers can purchase the corresponding fruits and vegetables more reasonably according to their needs.

Fruits and vegetables are closely related to the healthy development of our bodies, and they do not belong to high-fat, high-sugar and high-calorie food. Eating fruits and vegetables frequently can help people get dietary fibers which could improve digestive health and prevent them from cardiovascular diseases, vitamin C which could make a lower incidence of cataracts and enhance immunity, and other healthy nutrient elements. But with China's growing in storage technology and plant growth hormone, the wide use of ripening agent, anti-seasonal vegetables and fruits has been deeper into our daily life. Anti-seasonal fruits and vegetables are not only more expensive in price, but also are lower nutritional value. Therefore, we should have a correct understanding of what anti-seasonal fruits and vegetables are and what seasonal fruits and vegetables are, and then make replacements between them in different seasons.

Now there is a common social phenomenon that the vegetables have nutrient elements which have contributed to the development of human health. However, the children and the adults don't like to eat green vegetables. What's more, most children treat green vegetables as their enemies. When their parents force them to eat vegetables, they think their parents do not love them. In addition, some families cherish their children carefully so that they can allow their children not to eat vegetables. The behavior of the anorexia will lead to the malnutrition, diabetes, hypertension, hyperlipidemia and so on. The children and the adults who do not like the vegetables can eat fewer vegetables but eat more fruits that have the same nutrition as the vegetables, which can ensure people have the good nutrition.

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